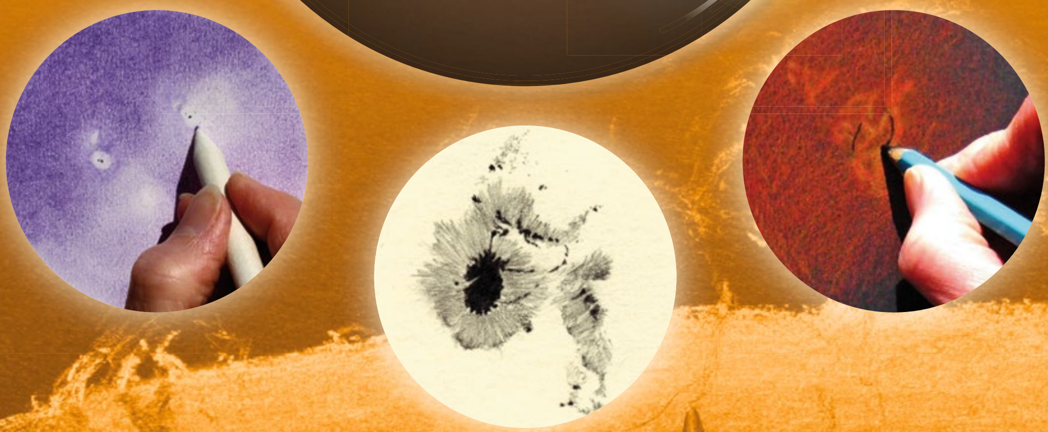
Erika Rix · Kim Hay
Sally Russell · Richard Handy

Solar Sketching



A Comprehensive Guide to Drawing the Sun

The Patrick Moore Practical Astronomy Series

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Springer

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To all who are drawn to the beauty and wonders of our nearest star, may the sunny days be plentiful and your pencils never dull. And to my mother, Suzanne, who shared her love of drawing with her children.

Erika Rix

To Linda, whose eternal light shone through the darkness to help illuminate my path. To Kim, whose heart in laughter restored my smile. To Sally, whose bright vision stayed true throughout. To Chas and the brothers, for the quiet courage to care for a brother when his path seemed uncertain. To Wendy and John, for the strength of spirit to help me hang in there. To Jeff, brother in my heart. To my dear family, for their love and understanding in the difficult times as this book came together. To Steve, for your ear in tough times. To Tim, may your path be in orbit of the Sun. To Tom, for quiet friendship and a common love. To David, your deep love permeates space-time. To Dee, your excitement and energy continue to feed my soul. To Frank, for enduring kindness, and a heart with a hand to match. To Erika, who never lost sight of me. To Sol, for being the genesis of my writing. To Rony, may your path wend through the stars. To Jeremy, when words fail to express it, your sketches do. To Linda and Roland, deepest love for hearts of compassion. To Rocky and Cathy, the faithful ones who provided me peace in moments of conflict. To Michael, who opened my eyes to astronomical sketching and opened my soul by your friendship. To Mom, whose spirit is embodied in the sacred stratigraphy and the ancient bird, now one with the living spirit. To Grandpa, on whose knee I am still listening, and to the Great Spirit of which he sung. Thanks and my best always.

Richard Handy

To Iris, with love and thanks for always being like a Mum to me.

Sally E. Russell

This book is dedicated to everyone who turns their face to the Sun, feels its warmth, and opens their mind to the wonder of the universe. To Kevin, my soul mate, your constant support and encouragement have kept me grounded and focused. And finally to Sara, my daughter, my Sunshine always.

Kim Hay

Preface

Less than 20 years have passed since the arrival of relatively low-cost, narrowband filters and dedicated solar telescopes to the marketplace. This affordability has opened a new window for solar observing and allows even casual amateur Sun gazers the opportunity to directly witness filaments, faculae, and active regions upon the face of our star as well as huge, arching prominences along its limb.

In conjunction with traditional white light-filtered, projection, and spectroscopic methods, amateur solar observing seems to have come of age. Two major approaches exist to document these phenomena—by utilizing cameras or by creating a sketch at the eyepiece. Both can produce superb results when skillfully applied, although a pencil and paper, along with an eye-hand-brain connection, are all that is needed to create a drawing. And that can be a very personalized experience. In addition, the more one engages in the act of sketching, the more refined one's observational abilities become. Subtle details, unnoticed with a quick inspection, can be recognized and recorded accurately using the straightforward procedures and simple techniques presented in this book. However, before we begin, a great benefit can be obtained by examining the past.

Beyond their artistic value, historical sketches of the Sun are a valuable resource for scientific studies of solar activity cycles and have been for the course of almost three centuries. As Randall Rosenfeld, RASC archivist attests:

"Observers have been sketching the Sun, its features, and phenomena through glass since nearly the dawn of the telescopic age. Thousands of historical solar sketches survive from the Enlightenment in the early seventeenth century, to the first age of astrophysics in the eighteenth century, and through (the modern age of astrophysics in) the twentieth century. Not only is this observational legacy of significance for those building astrophysical models of solar behavior through time, but it can also be a resource for modern astrosketchers endeavoring to refine and extend their craft.

"Earlier drawings present a range of techniques, some of which are relatively unfamiliar to contemporary astrosketchers (due to the astronomical conventions of the period)…past perceptions of solar phenomena may provoke an unanticipated glimpse of the Sun in a new light." This helps us understand how styles of historical solar sketches relate to the development of both the science and the technology available at the time. Rosenfeld continues, "It is useful to cultivate the habit of looking carefully and critically at observational art as a counterpart to patiently looking with discernment through an eyepiece."

Our modern understanding of past archival methods, coupled with a broad scientific insight into the materials that were used at the time, answers most questions relating to physical historical sketches. However, time spent exploring the digital archives of earlier sketchers' work, to witness *how* they were drawn in the past, will pay dividends when considering sketching techniques to record the modern Sun.

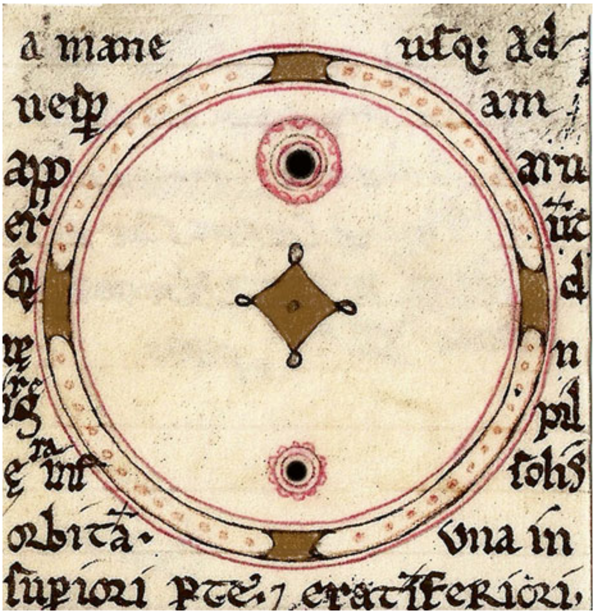

Fig. 0.1 Earliest known sunspot drawing, from *The Chronicle of John of Worcester*, circa 12th century. Prior to that, no actual drawings of sunspots were known to exist, and this illustration is thought to be the sole surviving sunspot drawing until the Chinese sunspot drawings in the 1400s. The naked-eye observation was December 8, 1128, Worcester, England. The description included, "...from morning to evening, appeared something like two black circles within the disk of the Sun, the one in the upper part being bigger, the other in the lower part smaller. As shown on the drawing." Sketch media consisted of ink, minium, and gold leaf on parchment, quill pen, and compass. For more information, see R.A. Rosenfeld, "Perception and Reflection: The Earliest Image of Sunspots?" in *JRASC* 108, 5 (2014 October), pp 211-213. (Image courtesy of *Specula astronomica minima*, image after Corpus Christi College, Oxford)

For more information on the history of astronomical sketching, an assortment of historical sketches is provided throughout this book with commentary from Rosenfeld. There is also a selection of references that we hope will be of use to you.

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Yarker, ON, Canada	Kim Hay
Wokingham, Berkshire, UK	Sally Russell
Jacumba, CA, USA	Richard Handy

Acknowledgments

Erika Rix

Rich, Kim, and Sally, thank you for embarking on this venture with me. Your expertise, hard work, and dedication were invaluable in seeing this project through to the end. I shall miss our numerous Skype meetings where business wasn't conducted without friendship and laughter thrown into the mix. For amateur astronomers involved in outreach or who gladly share their knowledge and techniques so that others may learn, thank you. You are the cornerstones of the astronomical community and appreciated beyond words. And to my husband, Paul, you'll once again start receiving your meals on time. Thank you for your everlasting support and patience during my astronomical endeavors.

Richard "Rich" Handy

Words do not convey the deep respect and admiration that I have for the principal coauthor and dear friend, Erika Rix. Her consistent and kind attitude of support and encouragement along the way made this book a possibility. Similarly, the dedicated and often exhaustive labors of my great friend and fellow astro artist, Sally Russell of the UK, gave me great heart to finish this book. Kim Hay has done a remarkable and tremendous job pulling together and expressing the science aspects of solar sketching, and besides that she is a hoot when she speaks of the Sun and Canadian weather and how it affects her observations.

There is a singular and remarkable website that has been the crucible of a number of new books on amateur astronomy. That website is Cloudy Nights. A number of us got our start there, and it has always been a comfortable place to lay our astronomical hats (and art tools, I suppose) while discussing our avocation. Without CN's support, there would be few opportunities to share our efforts. To the current amateur astronomy periodicals and magazines, thank you for extending the value of visual observation through wonderful astronomical sketching articles and columns.

There are two other individuals I would like to mention. Charles "Chuck" A. Wood has always encouraged sketchers to submit their work for inclusion on his website, LPOD (Lunar Photo of the Day). Thank you sir! And to my quietly spoken, yet deeply profound friend, Thomas Watson, thanks indeed.

To all contributors, the deepest respect for your techniques and your sketches.

Sally Russell

In my experience, solar astronomy is synonymous with *social* astronomy, as it's a pastime greatly enriched by sharing. So to start with, I must say a big thank you to Ian for enabling my first ever views of the Sun in Hydrogen-alpha, which ignited my passion for solar observing and started me on my solar sketching journey. My heartfelt thanks to my friends Erika, Rich, and Kim for working tirelessly to make sure that this project came to fruition. It has been an honor and a pleasure to work with you. To amateur astronomers everywhere who so generously share their time, expertise, and the fruits of their labors to inspire and encourage others, thank you. To my fellow astronomers with whom I've shared views of the Sun on so many happy occasions—Malcolm, John, Martin, and Peter, to name just a few—thank you for your splendid company, knowledge, and enthusiasm. Special thanks to my husband and son, Adam and Cameron, for supporting me in all my astronomical passions. And last but not least, for sheer exuberance and the generous sharing, and loan, of untold amounts of fabulous solar kit without which some of the tutorials in this book would not have been possible, my deepest thanks go to John, solar astronomer extraordinaire!

Kim Hay

Erika, Rich, and Sally, thank you for the honor and privilege to be able to share this wonderful opportunity to collaborate with you. Bringing solar sketching and science together, using your expertise in the various observing and sketching mediums, helps to show others how sketching can be fun, educational, and rewarding, and how this can contribute to solar science. I have truly enjoyed our Skype meetings and online discussions. Someday, hope to meet you all in person.

Thank you to all our contributors who, with their knowledge in specialized fields, helped to bring this book together. Also, thank you to many of my friends in solar astronomy circles who have provided answers to my many questions.

Thank you to the person reading this book. In your hands, you have a wealth of knowledge from many amateurs and professionals in the various fields, giving you an insight into solar sketching and observing techniques on how to capture the Sun. You have a piece of history in your sketching portfolio—welcome to data collection and science. Go observe the Sun, enjoy!

The four of us wish to thank the people and organizations whose contributions made this book possible. A special acknowledgment is for Randall Rosenfeld, RASC Archivist, for the use of the RASC historical solar sketches and excerpts from his terrific article, “Learning from the Past.” Thanks to our sketch and tutorial contributors, Dr. Jean Barbeau, Lennart van Sluijs, Juanchin Perez, Peter Grego, André Vaillancourt, Jeremy Perez, Alan Strauss, Dr. Hannák Judit, Deirdre Kelleghan, Jeff Young, Maurice Toet, Roel Weijenberg, Michael Rosolina, Les Cowley, Stephen W. Ramsden, Stratos Tsanaktsidis, Cindy Krach, and Serge Vielliard. Thanks to Tara and Emily Krzywonski for their help with photos for the Sunspotter tutorial and for the use of their Sunspotter outreach photos. Thanks to Dragan Nikin for the solar hood image, to David Knisely for his prominence classification artwork, and to Tony Broxton for his sunspot sketches for science. Thanks to Rik Hill for his *Zürich/McIntosh* classification images and to Michael Boschat for assistance with the BAA sunspot formulas. Special thanks for the use of solar sketching templates to Lyn Smith and Hazel McGee of the British Astronomical Association, to the Association of Lunar and Planetary Observers, and to The Astronomical League.

Finally, we would like to say a special thank you to John Watson, Astrobooks, for his guidance and to our editor, Maury Solomon, and assistant editor, Nora Rawn, Springer Science and Business Media, LLC, for their advice and support.

Contents

Chapter 1

Introduction to Solar Observing and Sketching

The Sun represents one of the most challenging and exciting astronomical objects to sketch. Noticeable changes can occur very rapidly, and the view is never the same twice. Regardless of where your interests lie, from the occasional view to daily sunspot tracking, or rendering the subtle complexity of prominences, the following techniques, hints and tips will help guide you to accurately sketch the Sun's ever-evolving features.

Warning!

Never look directly at the Sun with unaided eyes. While solar observing, do not use binoculars, finder scopes or telescopes unless they are dedicated solar telescopes or have been properly fitted with solar filters from reputable manufacturers. The consequences of even a brief view, particularly through an unfiltered telescope or finder scope, could result in severe eye damage or blindness.

Unless your finder scope is fitted with a solar filter, it should either be removed or covered to prevent both eyesight injury and damage to the instrument.

Before diving straight into sketching, it is worth reviewing the basics of solar equipment and observing. Also included are tips that we have picked up along the way.

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical Astronomy Series 178, DOI 10.1007/978-1-4939-2901-6_1

1.1 Basic Equipment

Equipment should be tailored to the needs and preferences of each individual. So let's consider the essentials and how they may apply to you.

1.1.1 Filters

Sketching the Sun in white light can be completed using several types of solar wedges and thin film acetate filters. In the past, projection techniques were used predominantly, and this method is still going strong today, especially during outreach events. Nowadays, thanks to the advent of thin film depositing technologies, polyvinyl acetate sheets can easily be obtained to fit large telescopes that otherwise would be impractical to use for projection. These thin filters come mounted in a metal ring, or you can purchase a sheet of the film to construct your own.

Multi-coated glass white light filters and energy rejection filters (ERFs) are also available. An ERF is designed to filter ultraviolet and infrared light so that light from the visual spectrum can pass through.

Band pass filters selectively reject most of the continuous solar spectrum and only allow through the light that occurs in a defined range of frequencies. Hydrogen-alpha (H-alpha) is perhaps the most frequently used band pass filter because it permits light from the chromosphere, where ionization of the hydrogen gases above the photosphere is emitted, to be viewed. These types of filters can be obtained separately or in the form of dedicated H-alpha telescopes as seen in Fig. 1.1.

Some manufacturers offer Calcium (Ca) II band pass filters in the K and H lines, which are similar to the H-alpha filters, except that the frequency of the radiation they selectively filter allows light from the calcium absorption line of the solar spectrum to be viewed. Because the K-line is at the far end of the visual frequencies, the light is more difficult to see visually. The H-line, however, is closer to the visible spectrum. As a result, it produces a brighter image at the eyepiece and is often the filter of choice for that range of frequencies.

Finally, a Sodium (Na) D-line filter is also available. It can be used to study super granulation and flare eruption kernels in the surface layers of the Sun.

Warning!

NEVER USE EYEPIECE SOLAR FILTERS! Some telescopes still come with solar filters that either screw into or are fitted over the eyepiece. The intense heat of the focused sunlight could cause them to crack during use, resulting in possible blindness. We recommend that the eyepiece filter be destroyed and thrown away to prevent anyone from using it.

Fig. 1.1 Internally double-stacked Coronado Maxscope 60 mm, 400 mm focal length, Hydrogen-alpha dedicated solar telescope. (By Erika Rix)

1.1.2 Telescopes

White light solar observing can now be done with just about any telescope type or design. Some designs are easier to use due to their portability, ease of set-up, and viewing comfort. Because of their size, refractors are the clear favorite, along with small reflectors. Refractors can be easily transported, the set up time is minimal, and the height of a typical mount can be adjusted to allow for either a standing or sitting position for viewing comfort. Because atmospheric turbulence, which is associated with daytime observing, is rarely good enough to allow full useful magnification with even modest-sized telescopes, large telescopes can seldom be used to their potential for solar observing.

1.1.3 Mounts

Mount choice for solar sketching is often dependent on the telescope's field of view (FOV) and your ability to keep the Sun, or its observed features, within that field for the duration of your observation. For example, short focal length, wide-field refractors often have a wide enough FOV that the observer can see the entire solar disk with plenty of room to allow for a slow drift, with only the occasional nudge to bring it back into view. As such, a manual-adjusting alt-azimuth mount will work just fine, with only a few corrections of its position required during a sketch.

Warning! ALWAYS use a suitable filter when directly observing the Sun

Keep in mind, however, that as the magnification increases, the FOV shrinks. The power required to discriminate fine details within the solar structures means that the Sun will appear to move quite rapidly across the FOV. Therefore, unless you are willing to make constant bumps in its position, following these features will prove difficult. And if you are making these adjustments, it will distract your concentration.

Consequently, equatorial mounts, or computer tracking mounts, are an ideal solution for sketching within a small FOV at high power. Equatorial mounts are designed to align one of the rotation axes of the telescope to the Earth's axis of rotation. By rotating with the axis, this motion through the field is eliminated and the feature will stay centered in the FOV throughout the course of the observation. Computerized tracking telescopes are basically computer driven motorized alt-azimuth mounts that make use of tiny movements of stepper motors to keep the telescope on target.

1.1.4 Eyepieces

Most eyepieces are interchangeable between nighttime and daytime observing. There are, however, eyepieces made specifically with solar observing in mind. Lunt Solar Systems manufactures flat-field eyepieces with 0.1 % anti-reflective coatings that reduce the ghosting and glow often seen around the Sun through an eyepiece. Similarly, Coronado CEMAX eyepieces have multiple-coating materials to enhance contrast in the H-alpha band pass region and eliminate internal reflections and scattered light. They also offer a 2x CEMAX Barlow.

Zoom eyepieces are handy when seeing is turbulent; adjustments for best magnification can be made quickly without the need to swap eyepieces. For the projection method of solar observing, use an inexpensive, simple eyepiece. Avoid those with plastic parts or cemented lenses, as they can become hot and melt while using.

1.1.5 Observing Chairs

Muscular strain can be a serious distraction while sketching. A good observing chair will help mitigate this stress during the course of your observation, allowing increased concentration at the eyepiece. There are several manufacturers and each have their pros and cons, but we recommend that the chair be variable in height with a relatively quick and secure adjustment. Be aware that some observing chairs require a hard, level surface for stability, so consider the ground where you frequently observe.

If you are seated high above the ground, try using a short step stool to raise your legs to a more comfortable position. Your lap can double as a sketching platform.

1.1.6 Media

No two media are the same. Each has unique qualities that should be taken into account when choosing the materials for a specific type of sketch. What archival qualities does it have? Will the drawing bleed or remain crisp? Will it tolerate erasures or combined media? Think about its blending characteristics, textures, colors, and messiness.

Consider the varieties of paper available for sketching the Sun. For instance, the texture (tooth) of the paper can be used for photospheric granulation or the mottled appearance of the chromosphere. Black paper preserves the dark adaptation necessary for H-alpha observing. White printer paper is inexpensive and readily available in most homes.

1.1.7 Templates

Plotting sunspots and other solar features within a blank sketch circle is very similar to plotting a star field. Visualizing a clock face, gridlines, or even cross hairs in both the field of view and the sketch circle helps. Using a template is even better.

The Sun has heliographic coordinates for longitude (L_o), latitude (B_o), and the position angle (P_o) of the solar rotation axis. Because sunspot locations are measured in degrees from these coordinates, using a template featuring gridlines or degree markings can help observers plot sunspots with higher accuracy. When using a template, it is important to match its orientation to that of your telescope. Also keep in mind that sunspots rotate onto the Sun from the east and rotate out of view to the west.

Three common templates are the Stonyhurst disk, the Porter disk, and a solar grid. Each is a guide tool that can be placed under your sketch paper. If you prefer to sketch directly on the template, simply create a photocopy for that purpose. A selection of templates is available for your use in Appendix A.

The angle of Earth's orbit varies just over 7° north and south of the Sun's equator throughout the year. This is represented by the heliographic latitude of the center of the Sun's disk. If the Sun's north pole is tilted toward Earth, B_o will be in positive degrees; tilted away from Earth, B_o will be negative. There are eight Stonyhurst disk templates, one to represent each ± degree variant, including 0°. Latitude of ±40° and longitude are included in grid format.

The range of dates associated with the Sun's apparent tilt is printed on the templates. Choose the template that corresponds with the date of your observation. Likewise, you could refer to the B_o value on an ephemeris.

For example, when observing at 13:00 UT on February 9, 2014, B_o is –6.57 from the Lat/Long coordinates inputted on the *TiltingSun* freeware program by Les Cowley (Fig. 1.2). The correct Stonyhurst disk to use for that observing date, time and location is the date range of February 9 through April 1 at –7°. The template will need to be rotated so that the correct date range is at the top (Fig. 1.3).

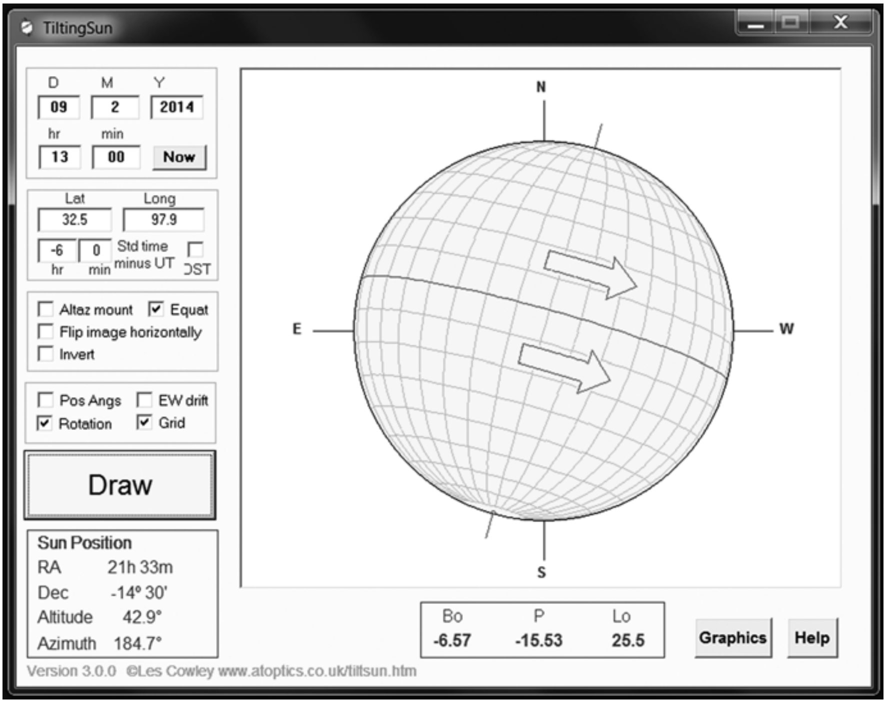


Fig. 1.2 Screenshot of *TiltingSun* freeware program by Les Cowley demonstrating heliographic coordinates for longitude (L_o), latitude (B_o), and the position angle (P_o). www.atoptics.co.uk/tiltsun.htm

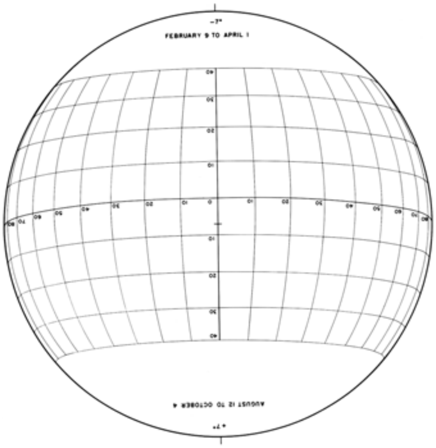


Fig. 1.3 Stonyhurst Disk 7°. (Shown by kind permission of the British Astronomical Association. www.britastro.org)

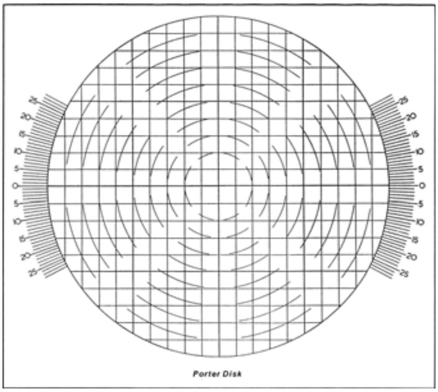


Fig. 1.4 Porter Disk. (Shown by kind permission of the British Astronomical Association. www.britastro.org)

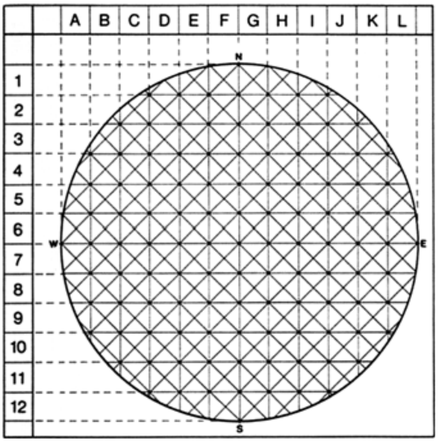


Fig. 1.5 BAA Solar Grid. (Shown by kind permission of the British Astronomical Association. www.britastro.org)

The Porter disk uses concentric circles for the locations of sunspots with degree markings on the western and eastern edges (Fig. 1.4).

The solar grid is marked in a graph arrangement with numbers down the *Y*-axis and letters across the *X*-axis (Fig. 1.5).

Creating daily sunspot sketches provides you with a first-hand view of the Sun's immense power and sunspot morphology. You will gain an understanding of how the upper layers of the Sun move with respect to its rotation and may even witness re-emergences of large sunspot groups!

Warning! ALWAYS use a suitable filter when directly observing the Sun

1.1.8 Solar Cloths

You are probably familiar with the idea of dark adaptation when observing at night—keeping extraneous light to a minimum to help with image contrast—but you might not have realized that it is also useful to keep the glare of the Sun to a minimum when solar observing to achieve similar benefits. The use of a cloth over your head when at the eyepiece, particularly when observing in H-alpha and CaK, will make a big difference to your observing experience and allow you to see finer detail in the image.

When using a solar cloth it helps to hold its edges together under your chin to block any glare from the ground, and if your cloth is big enough, you might be able to carry out your sketch while underneath it!

Making a solar cloth is straightforward, particularly if you have access to a sewing machine. The finished cloth needs to be black on one side (the *inside*) and white on the other (the *outside*) when the cloth is in use. The white surface will reflect the Sun's heat and light, not only reducing glare but also correspondingly making solar observing a cooler, more comfortable experience. Extra weight can be added to the cloth's corners so that it won't blow around in windy conditions.

Black and white double-sided fabric (where the white side is actually a blackout layer) is usually available from curtain fabric outlets and manufacturers. If commercial double-sided fabric cannot be obtained, then use white "blackout" curtain lining fabric stitched back-to-back onto a medium-weight black fabric instead.

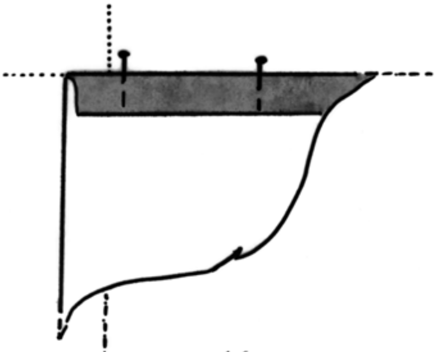
Suggested Materials

- A piece of black/white double-sided fabric, approx.1 yard squared
- Black thread
- Four small curtain weights

(Note: In the figures, the dotted lines indicate the position of the *first* fold made along each edge.)

Step 1

Lay out the fabric with the white side facing upward and turn a ½-in. hem along one edge. Press with a warm iron to reinforce the fold, and then pin to hold (Fig. 1.6). Repeat for the remaining three edges. At each corner, unfold the fabric and snip out the triangle of excess fabric as shown (Fig. 1.7).



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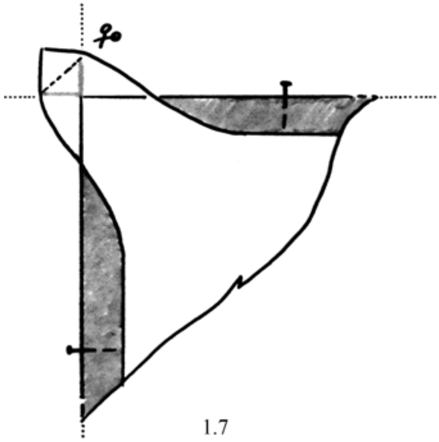

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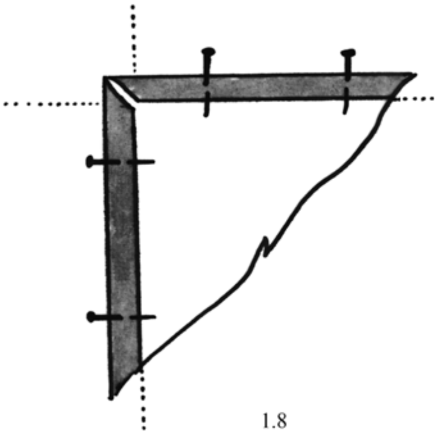

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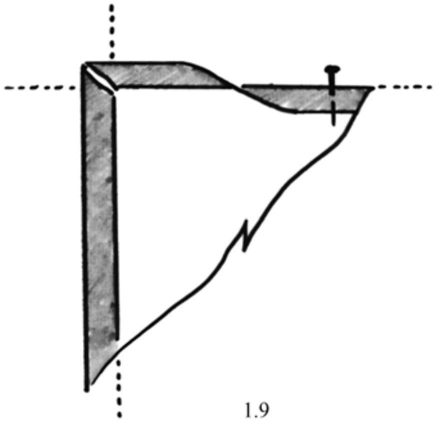

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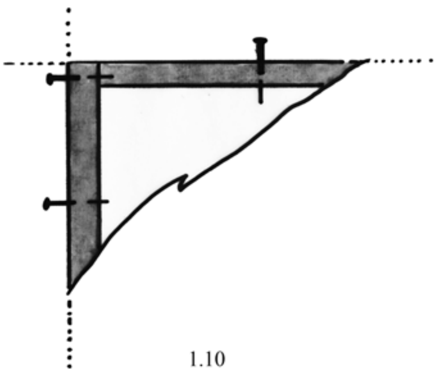

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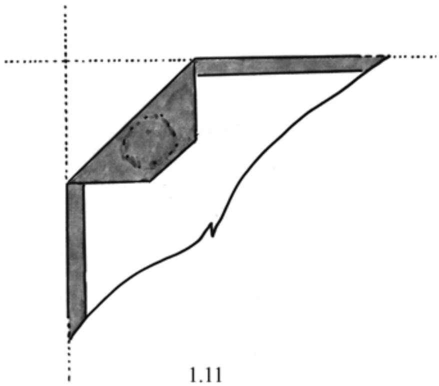

1.11

Fig. 1.6–1.11

Warning! ALWAYS use a suitable filter when directly observing the Sun

Step 2

Remove the pins and unfold the hems, then re-fold the fabric along each edge so that the raw fabric edge now touches the first fold line. Pin to hold. The hem will now be half its original width and the corners should lie flat, as they will be mitered (Fig. 1.8).

Step 3

Now fold the fabric along the original fold line again so that the raw edge of the fabric gets tucked underneath for a ¼-in. wide double-thickness hem (Figs. 1.9 and 1.10). Press with a warm iron and pin in place. Repeat for each edge.

Step 4

Using a medium-length stitch size (approx. 1/16–1/8 in.), machine stitch centrally along the length of each hem. Sew in any loose ends of thread.

Step 5

With the white side uppermost, place a small curtain weight approximately 1 in. from a corner, and then fold the cloth over to enclose it, tucking the point of the fabric underneath the weight. Stitch around the edges of the folded area containing the weight so as to hold it in place (Fig. 1.11). Repeat for each corner.

Figure 1.12 demonstrates how a drawing board can be placed under the solar cloth while rendering the Sun. Very little light is allowed through the opening above it so that the drawing can be seen while still preserving the dark adaptation needed to observe in H-alpha.

If sewing doesn't appeal to you, Dark Skies Apparel manufactures unique, quality observing hoods and vests that are designed with pockets to hold spare eyepieces, pencils and glasses. They offer versions specifically made for solar observing! (Fig. 1.13) (www.darkskiesapparel.com).

Another option is the TeleGizmos TGSO solar observing hood. It also uses a dual-layer design. The outer layer's aluminized surface reflects the Sun's light to keep you cooler. The opaque inner layer shuts out the daylight to improve the views. The hood is large enough that it slips over the rear end of the telescope in front of the focuser and forms a tent over the eyepiece holder to shield you from the Sun. It is equipped with Velcro closures to keep the cloth in place (www.telegizmos.com).

Fig. 1.12 Combining the use of a solar cloth with a sun shield preserves dark adaptation for sketching the faintest prominences. The sketch board is easily placed under the cloth with enough ambient light to sketch by. (By Erika Rix)

Fig. 1.13 Solar observing hood by Dark Skies Apparel. Solar observing vests are also available for purchase. http://www.darkskiesapparel.com/ (Courtesy of Dragan Nikin, Illinois, USA)

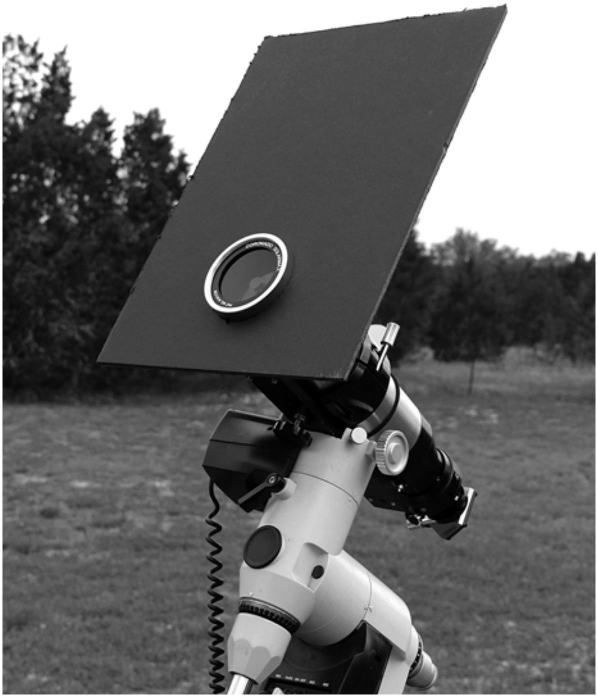

Fig. 1.14 Homemade sun shield fitted over a 60 mm Coronado Maxscope. (By Erika Rix)

1.1.9 Sun Shields

Sun shields block direct sunlight from the eyepiece. They are easily made and fit snug over the optical tube assembly (OTA) (Fig. 1.14).

Suggested Materials

- Black foam board, 20″ × 30″ × 3/16″
- White color pencil and graphite pencil
- Compass
- Tailor's tape measure

Fig. 1.15

- Measuring tape
- Craft knife
- Scissors
- Piece of cardboard or paper

Step 1

Create a template for the hole of the foam board that will fit over your OTA using the following formulas:

$$\mathbf{d = c / \pi}$$

$$\mathbf{r = d / 2}$$

First, measure its outer circumference. That value is 275 mm for the Coronado Maxscope in Fig. 1.15.

Fig. 1.16

Step 2

$$d = 275 / 3.14$$

$$\mathbf{d = 87.6\ mm}$$

$$r = 87.6 / 2$$

$$\mathbf{r = 43.8\,mm}$$

Set the compass to equal radius.

Step 3

Create the circle template with the compass, and then cut out the circle just inside the line with a pair of scissors (Fig. 1.16).

Tip

If you don't have a compass, fold a sheet of paper in half both vertically and horizontally. The center of the paper will be marked where the folds cross when you open the paper back up. Place the end of the tailor's tape at the center cross and mark the radius measurement on the paper with a pencil. Continue marking the radius until a complete circle is created onto the paper (Figs. 1.17 and 1.18).

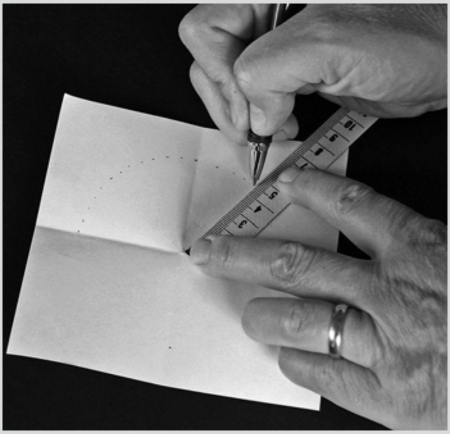

Fig. 1.17

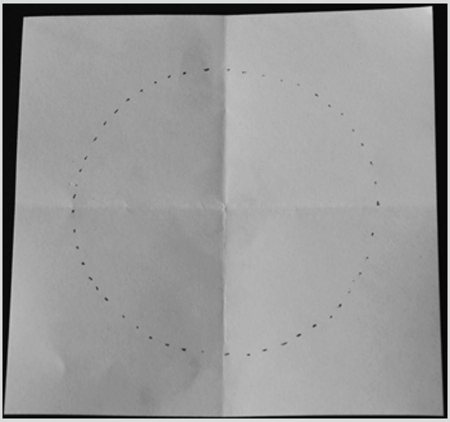

Fig. 1.18

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 1.19

Step 4

Use the measuring tape and white pencil to mark the dimensions of the sun shield onto the foam board. The dimensions used for the shield in Fig. 1.19 are 16 in. by 20 in., however you should adjust its size based on preference. If it's too large, the wind will become more of a factor; too small, it fails to serve its purpose.

Step 5

Use your circle cut out and white pencil to outline the OTA fitting onto the bottom of your foam board. It should be nearly 2 in. from the bottom edge (Fig. 1.20).

Step 6

Just inside the line, use the craft knife to cut out the circle. You may want to place a cutting board or something similar behind the foam board to protect the table surface (Fig. 1.21).

Step 7

If not using a dedicated solar telescope, attach your solar filter to the telescope. Align the telescope (see Sect. 1.2 *Finding the Sun*) so that the Sun can be seen

Fig. 1.20

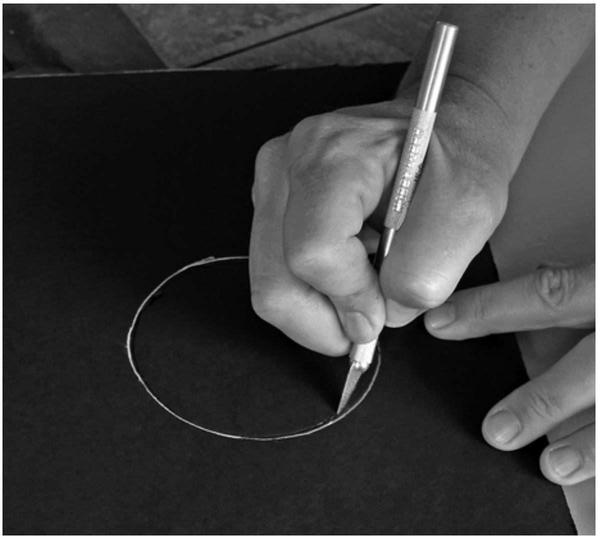

Fig. 1.21

through the eyepiece. Then, push the sun shield onto the OTA, and swivel it to the side of the telescope where you'll be observing.

Figure 1.22 demonstrates the effectiveness of a shield. The right side of the sketch paper is in the shaded area from the solar shade. The left side is still in the Sun's direct light. While observing in H-alpha or Calcium K bandpass, the glare

Fig. 1.22 Demonstrating the effectiveness of a sun shield. The right side of the sketch is shaded underneath the shield. The *left side* of the sketch remains within the glare of direct sunlight. (By Erika Rix)

from the sunlit portion of the sketch paper will produce white spots in your vision for several minutes after each addition to the sketch. When the sketch is shaded, dark adaptation is more preserved.

Like solar cloths, manufactured sun shields are available for purchase and are usually made of metal with mounting brackets.

1.2 Essential Tips

The best tips are the ones tried and tested and then shared for the benefit of all. Here is an assortment of ours for you.

1.2.1 When and Where

As the Sun rises and warms the ground, the warmth from the ground re-radiates heat back into the air. This process is called convection and results in atmospheric turbulence. With astronomy, the severity of the turbulence is called *seeing,* and it affects our view of the Sun. If the turbulence is extreme, a rippling effect causes the solar view to become out of focus and difficult to observe; when it is minimal, the image appears sharp and detailed.

Atmospheric turbulence is lesser when the ground is cooler, so observing in the early morning or evening hours generally provides the steadiest views of the Sun. However, if the Sun is below 20° above our horizon, Earth's atmosphere can change the color of the Sun; its upper limb can have a bluish hue while its lower limb appears red. Below 10°, Earth's atmosphere distorts the Sun's appearance.

Also, consider your observing location. For example, it's common to see heat distortions or a boiling effect over paved roads on a hot summer day. That same phenomenon occurs when observing over rooftops or in urban areas. Grassy fields provide a much cooler location, and therefore a steadier view (Fig. 1.23).

Recording the quality of seeing enables comparisons between observations. A popular scale used by solar observers comes from the Mount Wilson Observatory (www.mtwilson.edu).

Mount Wilson Solar Seeing Scale

1 Solar image resembles a circular saw blade. Completely out of focus. Limb motion and resolution greater than 10 arcseconds. Unable to see smaller sunspots.
2 Solar image consistently out of focus with no sharp periods. Limb motion and resolution ranging 5–10 arcseconds.
3 Solar image in focus ~50 % of the time, out of focus ~50 % of the time. Short periods of granulation visibility. Limb motion and resolution 3 arcseconds.
4 Solar image is sharper more often than not. Granulation nearly always visible. Limb motion and resolution ranging 1–2 arcseconds.
5 Solar image resembles an engraving. Limb motion and resolution 1 arcsecond or better.

It's no surprise that wind also plays a factor. Even the slightest breeze can joggle a telescope enough to make details disappear through an eyepiece. When possible, move your telescope to a location protected from the wind (Fig. 1.24).

1.2.2 Finding the Sun

Unless your finder scope is fitted with a solar filter, it should either be removed or covered to prevent both eyesight injury and damage to the instrument. Luckily, a finder scope isn't necessary. With a little practice and the right tools, aligning your telescope so that the Sun can be seen through the eyepiece is a simple task.

One method requires nothing more than placing a flat surface behind a solar-filtered telescope. Looking at Fig. 1.25, the refractor's shadow is skewed and elongated against a drawing board. The Sun and telescope are not aligned. So that the Sun will be viewable in the eyepiece, adjust the angle of the telescope in the opposite direction so that its shadow becomes minimized (Fig. 1.26).

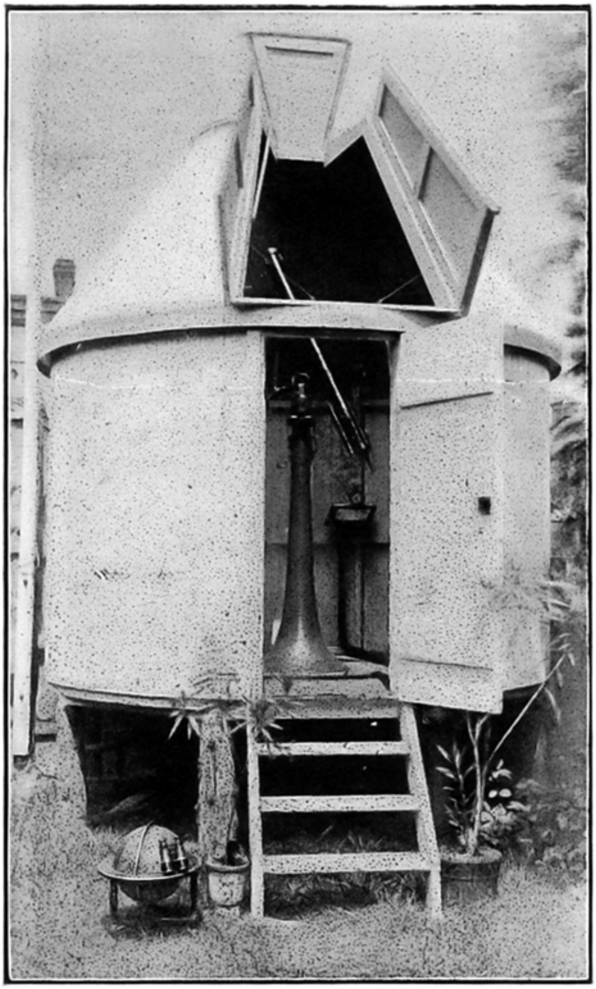

Fig. 1.23 Observatories offer protection from the elements as shown in this photo of Alan Frederick Miller's observatory and telescope in Toronto, Canada. The instrument is a 4-in. refractor on a clock-driven equatorial mount atop a substantial cast-iron pier. Wray (Optical Works) of London manufactured the objective lens. The mount was by Stewart of London, and the OTA by Foster of Toronto. The telescope could be fitted with a Herschel wedge that included several neutral filters and an adjustable neutral-tinted glass wedge. Other equipment included a Browning spectroscope with a Rowland-Brashear grating of 14,436 lines per inch, and a Simms filar micrometer. Miller purchased the telescope to observe the 1882 transit of Venus. The instrument and its accessories survive today in Victoria, BC. The observatory is the Berthon design (sometime called a *Romsey Observatory*), popular in its day among amateurs. Details for building one can be found in H. Thornthwaite, *Hints on Reflecting and Refracting Telescopes*, 4th ed. (London: Horne & Thornthwaite, 1880), pp. 72–78. https://archive.org/details/HintsOnReflectingAndRefractingTelescopes (Image courtesy of the Royal Astronomical Society of Canada)

Fig. 1.24 The solar telescope is set up in an observatory overlooking fields and protected from the wind to optimize observing conditions. (By Erika Rix)

Fig. 1.25 Lengthened shadows indicate that the telescope is not in alignment to the Sun. (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

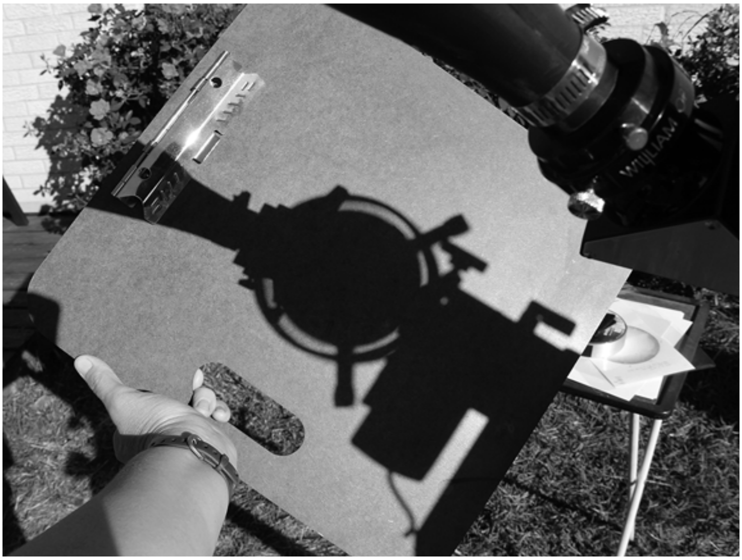

Fig. 1.26 Minimal telescope shadow on the sketch board indicates alignment to the Sun. (By Erika Rix)

Tip

Depending on the magnification, the Sun may lie just outside of your field of view after alignment. Use a low-powered eyepiece to broaden the field, which in turn speeds up the alignment process. Once the Sun is centered in the field of view, swap out the eyepiece for higher magnification.

Another method of alignment involves using a solar finder. There are several available for purchase, or you can construct your own. They are small devices that attach to your telescope tube. One type uses a gnomon. Its shadows are cast on an opaque disk, and the alignment is achieved when moving the telescope opposite to the direction of the gnomon's shadows (Figs. 1.27 and 1.28). Other varieties use solar projection between two disks.

1.2.3 Determining Disk Orientation

When solar observing, how do we find out the orientation of the Sun as it appears in our eyepiece? There are simple manual methods we can use to discover the

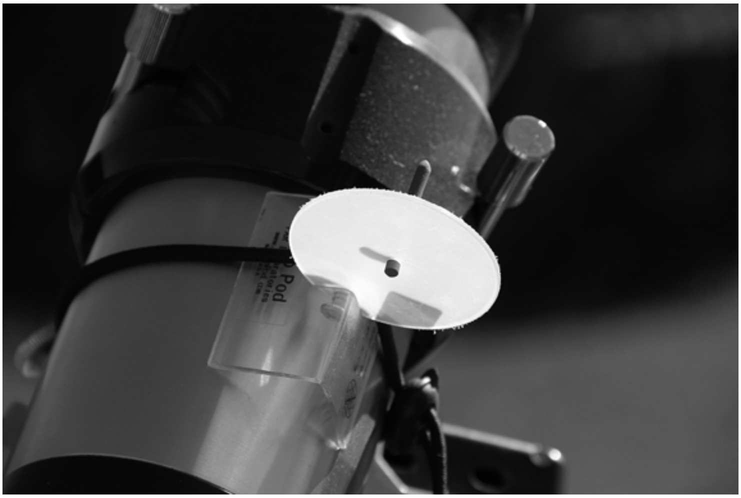

Fig. 1.27 The elongated shadow on a Helio-Pod Solar Finder (FAR Laboratories, www.dyna-pod.com/dyna-hp1.html) shows that the Sun and telescope are not aligned. An angle adjustment of the telescope must be made in the opposite direction to bring the Sun into view. (By Erika Rix)

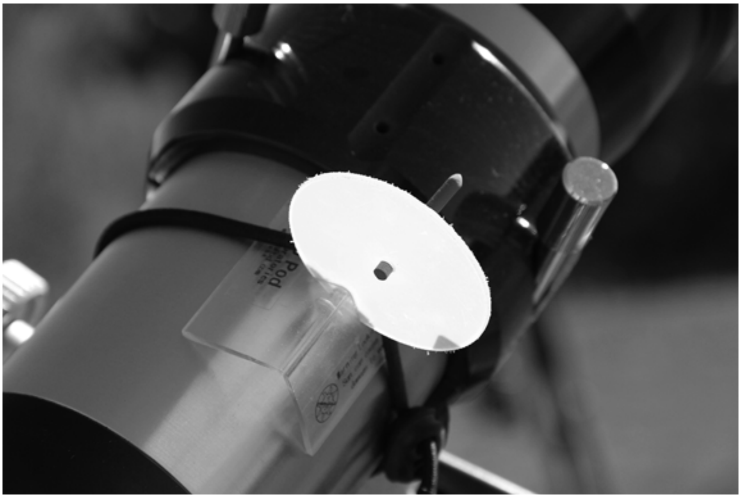

Fig. 1.28 Minimal or no shadow on the Helio-Pod Solar finder indicates alignment to the Sun. (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

cardinal directions of our observed field of view, and with the help of excellent freeware, we can embellish that basic data with a wealth of additional solar information.

TiltingSun

It might seem odd to discuss planets in a book solely concerned with the Sun, but in this instance, they illustrate a crucial point. If you have ever observed the planets Jupiter or Saturn, you will know that they have features that help define how they are oriented in the telescope field. Jupiter has its Galilean moons and cloud belts, and Saturn its ring system; all of which indicate the equatorial plane of the planet. But sometimes Jupiter's moons are strung out in a line at a bizarre angle in your eyepiece, and Saturn can appear to be standing sideways on its rings. The telescope you use, the type of mount, a mirror diagonal in the optical train rotated to permit more comfortable viewing through the eyepiece—all of these factors influence the appearance of the planet at the moment that you are observing it. However, because we know that Jupiter's moons and Saturn's rings inhabit their equatorial regions, those are built-in yardsticks for determining their orientations.

The Sun, by contrast, has no fixed markings, so the orientation of the solar disk is not obvious when first glancing through the eyepiece. This does not matter to the casual observer but *is* problematical for the sketcher (or photographer) who wishes to record the view accurately and allow it to be compared with the sketches or photographs of others. To gain the maximum value from your sketches it is essential to record the date and time of the observation and the solar orientation.

Tip

For the basic manual method to determine disk orientation, allow the Sun to drift out of your field of view. If you are using a tracking mount, it will be necessary to turn off the drive. The direction of the drift is celestial west. With regards to solar rotation, west is also the preceding limb. Celestial north will either be 90° clockwise or counterclockwise from west depending on the instrument you use.

Sunspot groups roughly run parallel just north or south of the Sun's equator. They follow one another as they rotate into view from the eastern limb and then rotate out of view on the western limb.

So, the type of telescope you use will determine certain aspects of the view. Some telescopes, like the Coronado PST or a Newtonian telescope, invert the view, so that north is 90° counterclockwise from west. Others, like the Coronado SolarMax series, have erect views but their fields are flipped from right to left, making north 90° clockwise from west. Some telescopes do both.

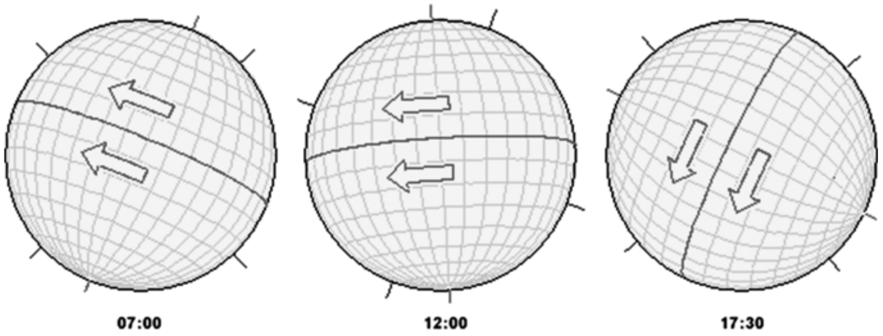

Fig. 1.29 Composite of screenshot images from *TiltingSun* freeware program by Les Cowley showing relative solar orientation at 07:00, 12:00 and 17:30 on March 15, 2006, at Toronto, as seen through a Coronado SolarMax 60. www.atoptics.co.uk/tiltsun.htm

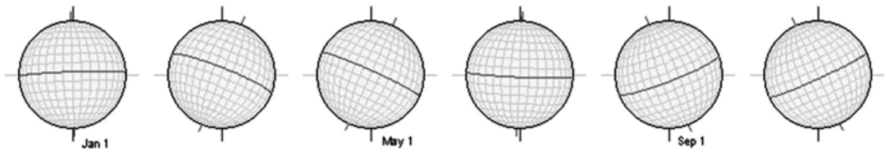

Fig. 1.30 Composite of screenshot images from *TiltingSun* freeware program by Les Cowley showing the changing orientation of the Sun's poles and equator relative to celestial north, throughout the course of a year. www.atoptics.co.uk/tiltsun.htm

If you use an alt-azimuth mount and maintain a constant viewing stance, you will notice that the whole sky field of view, including the Sun, tilts in different directions throughout the day. Figure 1.29 shows the Sun at three times on March 15, 2006, from Toronto as seen through a Coronado SolarMax 60. This calculated view assumes that the observer has adopted the standard viewing stance of looking through the eyepiece from behind the telescope with his or her head always in a vertical plane—more on this later.

In addition, the rotation axes of the Earth and Sun are tilted relative to each other, and neither is perpendicular to the ecliptic (the plane of Earth's orbit around the Sun), which in its turn is tilted relative to celestial north. As a result, the orientation of the Sun's poles and equator relative to celestial north change throughout the course of the year (Fig. 1.30). This is somewhat analogous to the changing, albeit much slower, aspect of Saturn's rings during one Saturnian year (around 29.5 Earth years) as viewed from Earth.

Luckily for solar observers and sketchers, there is an extremely useful piece of freeware called *TiltingSun* (written and developed by Les Cowley, http://www.atoptics.co.uk/tiltsun.htm) that enables us to escape all these factors and quickly and easily calculate solar orientation. With the input of relevant local data, *TiltingSun* will calculate the orientation of the Sun's disk *precisely* as it appears through any solar telescope, however mounted, at any time and date anywhere on Earth.

To be exact, *TiltingSun* shows the:

- Position of the Sun's poles and equator
- Direction of the Sun's rotation
- Path a sunspot will take across the disk, from day to day
- Angular positions of prominences
- Direction that the Sun drifts through the telescopic field of view

There are simple, but important, caveats to ensure that the *TiltingSun*'s calculated view corresponds accurately with your observed view. Although they sound restrictive, they are only necessary during the initial or final orientation, and can then be abandoned—you do not have to maintain the neck-cricking antics! When making a sketch, adopt whatever viewing position is most comfortable for you and only follow these tips to determine orientation. Figure 1.31 gives an overview of these points, illustrated with an equatorially-mounted refractor that is fitted with a mirror diagonal.

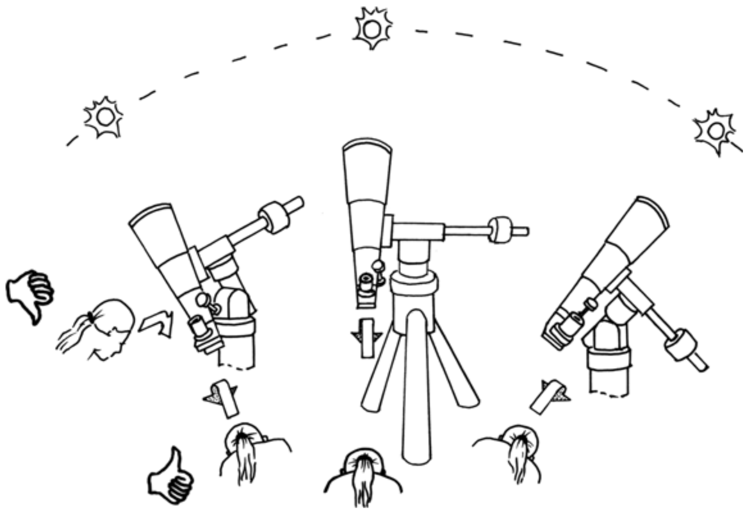

Fig. 1.31 Diagram showing how the eyepiece tilts as a telescope swings across the sky while tracking the Sun. If the observer leans over at the same angle as the eyepiece is tilting, the view will match that generated by the *TiltingSun* freeware program. (By Sally Russell)

Tip

Any diagonal should be set so that the eyepiece is upright when the telescope is pointing to the meridian. For example, on an equatorial mount, the mirror diagonal should be rotated so that the eyepiece tube lies in a plane perpendicular to the declination axis, as illustrated by the middle telescope in Fig. 1.31. This is the standard configuration for an alt-azimuth mounted telescope. The situation is identical for an equatorially mounted telescope with a mirror diagonal rotated in a similar fashion.

Stand behind the telescope so that it points straight forward away from you. The side view would be rotated by approximately 90° compared to the view from the back. If using an alt-azimuth mount, keep the plane of your head vertical.

While calculating your orientation with an equatorially mounted telescope, you will need to lean over at the same angle at which the telescope (and therefore the eyepiece) is tipping in order to get the correct viewing angle with the eyepiece. If you observe the Sun with an equatorially mounted telescope for any length of time, there will be a temptation to rotate the diagonal every so often to keep the eyepiece in a comfortable, usually upright, position. Keep in mind that the result of rotating the diagonal is that the whole field of view including the Sun also rotates. Simply rotate your sketch to match the view.

Of course, there is no right or wrong way to view the Sun when using a properly filtered telescope, but if you wish to know the Sun's orientation, remember that *TiltingSun* is written assuming the above simple guidelines are followed at the point when you ascertain the orientation data for your sketch.

So how is the Sun's orientation determined at any given moment? On opening *TiltingSun*, the default view is exactly as you would see the Sun through an alt-azimuth mounted Coronado PST located in Toronto, Canada, at your computer's current date and time (Fig. 1.32).

An explanation of the graphical display (for the same default view, but now with the graphics options switched on) is given in Fig. 1.33. Note that the zero of the circular position angle scale, which is useful for measuring the positions of prominences, is at *Celestial North* rather than at the *Sun's North Pole. TiltingSun* uses the position angle in the exact same sense as that for measuring double stars. Over several days, the rotation of the Sun will carry features along lines of latitude in the direction of the two red arrows. The grid showing the Sun's latitude and longitude system has 10-degree spacing.

All the necessary controls and settings are visible and self-explanatory, allowing you to customize *TiltingSun* for your own location, telescope, and graphics preferences. Once the settings are personalized, they are remembered. The next time that

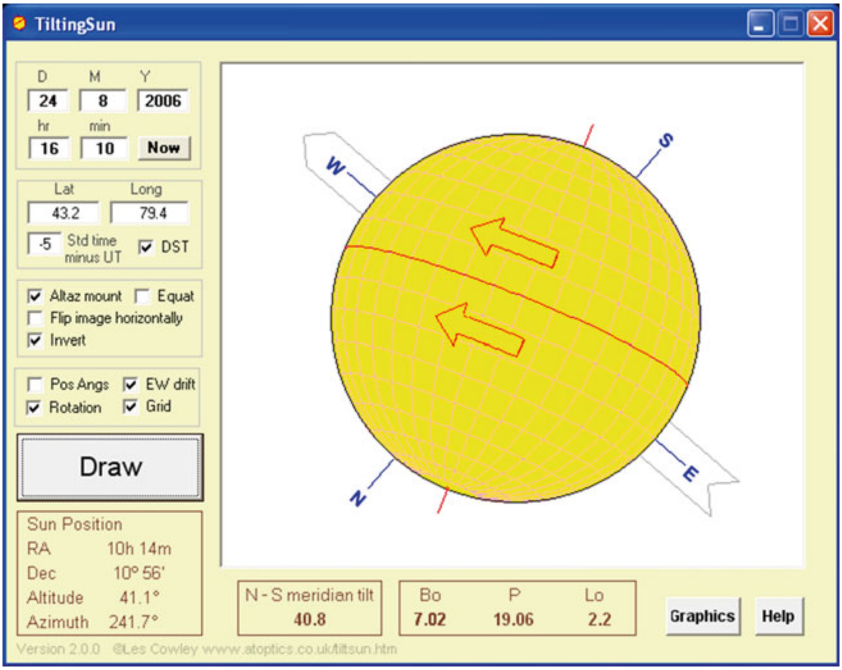

Fig. 1.32 Screenshot of *TiltingSun* freeware program by Les Cowley showing the default view—the Sun as seen through an alt-azimuth mounted Coronado PST located in Toronto, Canada, at the computer's current date and time. www.atoptics.co.uk/tiltsun.htm

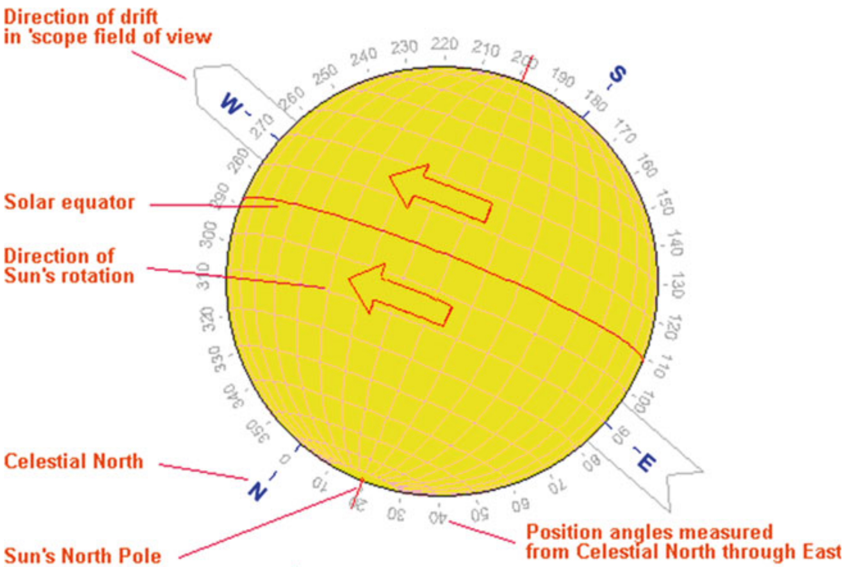

Fig. 1.33 Screenshot of *TiltingSun* freeware program by Les Cowley showing the default view (see Fig. 1.32) with all graphics options switched on. www.atoptics.co.uk/tiltsun.htm

you open the program, the time and date will be that of your computer's clock, and you can then alter it to your chosen, custom time.

The input required:

Date and Time

Manually enter the values for the date (Day:Month:Year) and time (hours:minutes) of your observation. Click *Now* for your computer's current time and date.

Standard Time Minus UT at Your Location

Enter your standard time difference from Greenwich Mean (Universal) Time. For example, Sydney is +10; San Francisco is −8 h. If your clocks are on Daylight Saving Time then tick the *DST* box. *TiltingSun* will internally convert your time to standard time.

Your Geographical Location

Enter your latitude in degrees. This value will be positive for the Northern Hemisphere and negative for the Southern Hemisphere. Next, input the longitude in degrees. Locations west of Greenwich will be positive; i.e., all of North America has positive longitudes.

The Type of Mount Being Used (Alt-Azimuth or Equatorial)

Check *Altaz* when using a camera tripod as a mount.

Whether the Type of Telescope You are Using Flips or Inverts the Image

A Coronado SolarMax 40/60/90, for example, has an erect image that is flipped right to left—tick the *Flip image horizontally* box. A Coronado PST inverts the image—tick the *Invert* box.

For other telescopes, watch how the image shifts when the scope is raised or lowered. If the Sun moves upwards when you lower the telescope, then it has an erect image. If the Sun moves downward, tick *Invert*. If the telescope has a diagonal or prism, then it likely needs the *Flip image horizontally* box ticked. By turning off the drive, if a tracking mount is used, you can check if the direction of drift corresponds with the drift direction arrow on the *TiltingSun* display.

> *Tip*
>
> To produce the display for your selected settings you must click *Draw* as the display does not change automatically.

Additional solar orientation information is given. Refer to the *TiltingSun* help pages by clicking on the *Help* button for more information.

The *Sun Position* box displays the Sun's position on the celestial sphere as right ascension (*RA*) and declination (*Dec*), and its actual altitude and azimuth in the sky. Note: the *Azimuth* is measured from geographical north around the horizon. East is 90°, south is 180°, and west is 270°.

The *N–S meridian tilt* is the angle at which the celestial north–south line is tilted in the field of view. This is always zero for an equatorial mount and so is not shown for that option.

B_o and P describe the orientation of the Sun's equator and poles relative to the celestial sphere. B_o describes the tilt of the Sun's N–S rotation axis *out of the plane of the display (or sky). P* is the angular tilt of the projection of the Sun's rotation axis to the celestial north–south line. This and the meridian tilt help when marking the Sun's poles on a sketch with a protractor. L_o is the longitude of the central meridian of the solar disk in the Carrington rotation system.

TiltingSun-G

As mentioned previously, it is beneficial to indicate the orientation of a sketch or where a selected feature is located on the Sun's disk. A special version of *TiltingSun*, called *TiltingSun-G*, lets you create custom graphics of the Sun's orientation to transfer into image manipulation software for use as stand-alone figures, or for overlays onto scanned sketches or photographic images. The graphics, which are based on those displayed in *TiltingSun*, can be customized in size, color and font size, as well as in the individual features displayed.

The program can be accessed by clicking the *Graphics* button from within the *TiltingSun* display or directly by double-clicking on *tiltingsun_g.exe* in the program folder. There is a comprehensive help document (accessed by clicking on the *Help* button from within *TiltingSun-G*) to guide you through the process of producing your custom graphics.

> *Tip*
>
> The *Copy to Clipboard* function copies the whole *TiltingSun* screen. This can then be cropped within image manipulation software to show just the solar disk. Diffuse, shaded circles can be added to note the locations of the active regions and prominences.

TiltingSun and *TiltingSun-G* will run alongside each other without interaction.

Once your sketch is completed, you can compare it with other images by matching orientations. Full disk images of the Sun, like those provided by Solar Dynamics Observatory (SDO), have celestial orientation. North is up; west is on the right.

(Many thanks to Les Cowley for his help and advice, and for permitting the use of the *TiltingSun* information and images throughout this section.)

1.2.4 Preparing Media

Active areas on the Sun can change very rapidly. Even quiet regions evolve right before our eyes, although usually at the pace of clouds on a calm day. But even so, if you're not prepared, you can find yourself reaching for an eraser more often than a pencil by simply trying to keep up with the changes.

Find a Container and Fill It with Essentials

Lay out your sketch media in a container next to you for easy access. Make sure that you have several pencils already sharpened and ready to go, and include sharpening tools in your kit. All blending stumps and tortillons should be cleaned and sharpened with sandpaper. How about packing a bulb blower? It blows excess pastel dust and eraser debris off of paper without the risk of smudging your drawing.

How to Sharpen Pastel or Charcoal Pencils

Sharpening pastel pencils can be tricky. The pastel center breaks easily when applying pressure to the pencil's wood casing, and before you know it, you've sharpened it nearly to the nub in one sitting! Here's a tip on how to prevent breakage.

First, use an artist's or utility knife to expose the pastel (Fig. 1.34). The wood should be whittled smooth to prevent snagging. Try to make the casing circumference slender so that it fits easily in a normal-sized pencil sharpener. This especially holds true for larger pastel pencils like Conté. If you like, you can use the knife to roughly sharpen the pastel tip prior to using the sharpener (Fig. 1.35). Next, use the smaller hole of the pencil sharpener to shape the tip, and then finish it off in the larger hole for a precise point (Fig. 1.36).

Alternatively, forgo the pencil sharpener for a block of sandpaper. Once the wood is shaved to expose a small portion of the pastel center, rub the blunt tip against the sandpaper to sharpen and shape it without breakage. The excess pastel dust can be saved in a container and used later.

Fig. 1.34 Use a craft knife or utility knife to shave the wood of a pencil, exposing the pastel center. (By Erika Rix)

Fig. 1.35 The pastel pencil is prepared for sharpening. (By Erika Rix)

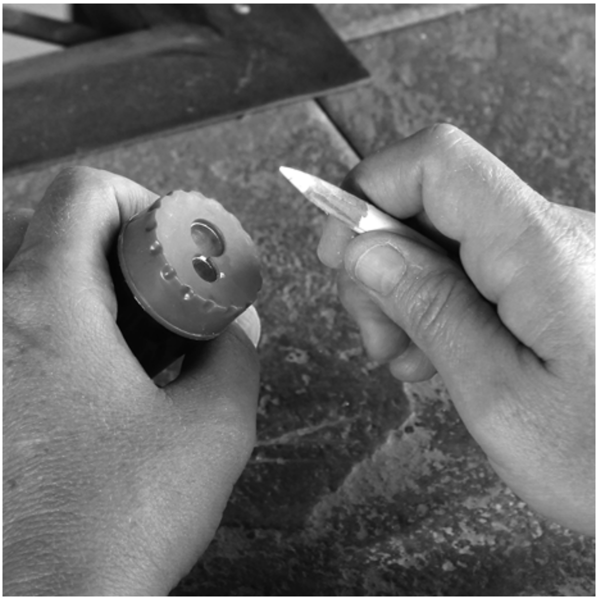

Fig. 1.36 Carefully sharpen the prepared pastel pencil to prevent breakage. (By Erika Rix)

Taping paper

Most drawing boards and clipboards have at least one attachment clip to hold your sketch paper in place. But that won't prevent a gust of wind from whipping up the unsecured edge of your paper. That can result in smeared pastel or the paper flapping against your pencil and creating stray markings. To prevent that from happening, some manufacturers furnish their drawing boards with elastic bands to hold the unclipped edge of the paper in place. If yours isn't equipped with one, masking tape, artist tape, or a large rubber band can be used instead. Even a few clothesline pegs come in handy! (Fig. 1.37).

1.2.5 Observing and Sketching Tips

In order to capture the evolving view of the Sun, the prime focus should be the observation itself rather than the multitude of distractions that arise from being unprepared. The bottom line is to build experience so that pulling detail from the view, and indeed the sketching process itself, becomes second nature.

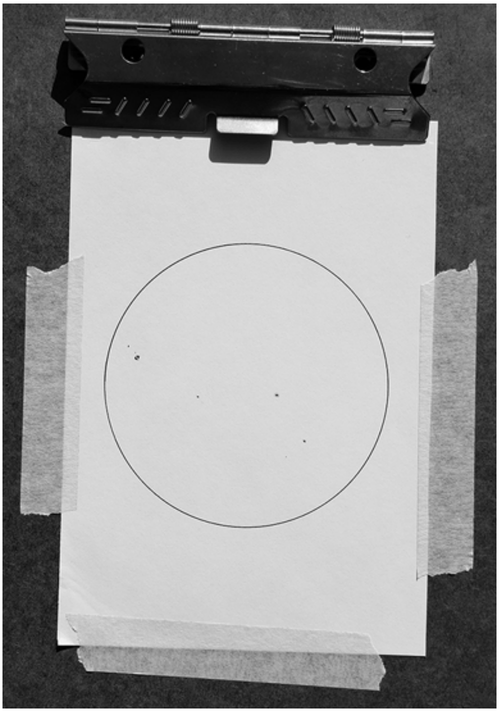

Fig. 1.37 Tape the unclipped edges of the paper to prevent wind from lifting it off the drawing board. (By Erika Rix)

Minimizing Distractions

Sore neck and back, too hot or cold, tired eyes, leg cramps—does any of this sound familiar? Preparing an ergonomic observing spot will help reduce discomforts.

One of the easiest ways to prevent neck and back strain is sitting comfortably without leaning over for long periods of time. This means having the ability to adjust the height of your observing chair during the course of your observing session so that your back remains straight. If you're using a diagonal, rotate it so that your neck is in a comfortable position rather then bent over the eyepiece. Using a small stool for your feet helps in keeping your back upright and has the added benefit of leveling your lap. A sketch board can rest on your lap, to give your arms a break.

As for eyestrain, using an eyepiece with good relief goes far when it comes to comfort. But that's not the only component. The Sun's glare on white paper, or changing from the bright surroundings away from the eyepiece to the darker view through it, can make your eyes very tired and irritated. Using a solar cloth or sun shield helps to prevent this.

Just as with nighttime observing, it is important to dress accordingly when observing the Sun. Dress in layers so that you can easily remove or add clothing during your session. Use a solar cloth that has a light or reflective outer side. Heat radiating from cement not only produces turbulent seeing conditions, but it can also raise the temperature around you. A grassy field would be much cooler for comfortable viewing. And finally, it's important to stand up and walk around a little bit. Time slips by quickly, so once a sketch is completed, stretch those legs and rejuvenate before starting the next one.

Know Your Equipment

Next to unexpected inclement weather, there is little more frustrating than dealing with equipment malfunctions. The better understanding you have of your gear, the smoother your observing session will run.

Utilize the specialized features of your equipment. Those knobs and buttons were put there for a purpose and could be the determining factor of the amount of detail you see! (Fig. 1.38).

Scanning the Disk

A first look at the Sun in white light might suggest a quiet disk of activity with only one or two small sunspots on view. But then on closer inspection, many other features such as pores and subtle faculae might be discernable. In H-alpha, by contrast,

Fig. 1.38 Take advantage of the buttons and knobs on your telescope. They will help you pull more details from the view. (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

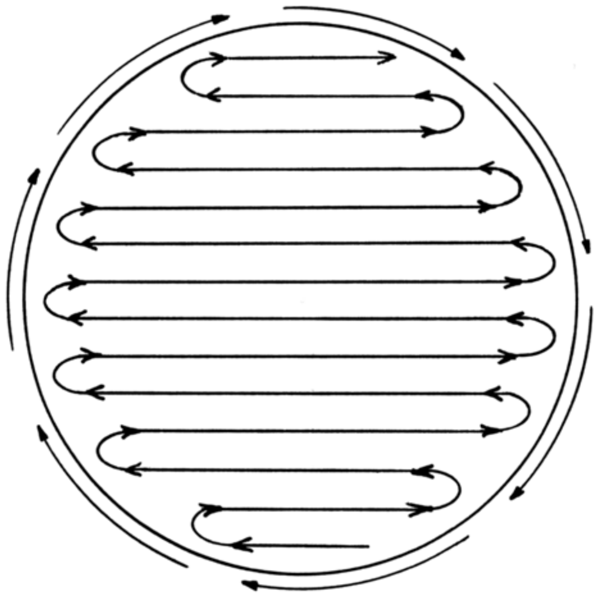

Fig. 1.39 Scan the solar disk and limb methodically to check for detail. (By Sally Russell)

the view might be overwhelming with prominences, filaments, active regions, plage and sunspots vying for attention.

By scanning the solar disk methodically, you can ensure that neither subtle nor obvious details are overlooked. Starting at the lowest section of the disk, work across it from east to west, gradually moving upwards as you go until you have surveyed the entire solar surface. Starting from the same point, look all the way around the solar limb. By employing this technique you should be able to spot all visible solar features (Fig. 1.39).

Sweet Spots

Some H-alpha filtered telescopes, in particular the Coronado PST, are described as having 'sweet spots' in their field of view. A sweet spot is a zone where the band pass filters work to their maximum capability and produce the sharpest view with maximum contrast, however this means that the entire solar disk is therefore not evenly illuminated; e.g., prominences will only be visible on one limb of the Sun. To get around this problem, the telescope can be moved slightly to center the area of interest in the sweet spot.

Sweet spots result from off-axis tuning positions, and the issue varies with the telescope type and manufacturer. Lunt Solar Systems now offers pressure-tuned instruments that flatten the band pass and deliver an even illumination across the field of view.

You can determine if your telescope has a sweet spot by moving it in a systematic fashion so that the whole of the solar disk is eventually moved through all parts of the field of view. A manual mount with slow motion controls is ideal for this process. Prominences are especially good indicators of sweet spots, as they tend to respond very well to the increased contrast. Conversely they are all but invisible when out of the sweet spot zone.

Building Up Speed

Although active regions are known for producing fast-moving events like erupting prominences or flare activity, never underestimate the steady, yet swift, movements of quiet regions. Quiet region filaments may appear to change little or not at all during the course of your observation. However, if you were to make a series of sketches over an hour's time, you might be surprised at the differences. This is especially so along the limb where a prominence is observed nearly on its side, allowing more of its complex structure to be seen.

If too much time has passed to complete the sketch, the prominence will evolve. You run the risk of chasing its changes, likely with an eraser and then redrawing, rather than capturing the view for that specific moment. Think of what it would be like to sketch a cloud on a fairly calm day. It may not appear to move quickly, but if you concentrate on sketching the faint whips of structure within it, you discover it's not as easy as it seems.

Depending on the complexity of your technique, a full disk sketch could take 15–30 min to complete. For a prominence, strive for 2–3 min per sketch during an eruptive event, 5–10 min per sketch for a slow moving one. It takes practice to reach these speeds, but you'll hit those targets eventually as your experience grows.

Other factors affect the amount of time it takes to complete a sketch, e.g., clouds passing in front of the Sun, distractions, and waiting for your eyes to become adapted to the darker view of the eyepiece after adding to the sketch. Plan ahead and take measures where you can to prevent them from becoming a factor.

Plotting Solar Features

To determine the correct positions when plotting solar features on your sketch, it is helpful to liken the Sun's disk to a clock face. By determining the o'clock position of features lying near or at the Sun's limb, it becomes easier to transfer them onto your sketch. To make the 'clock face' method easier, you can place an appropriately sized solar grid behind your paper to help you get the positions exact. Also, see Fig. 5.106 in Sect. 5.3 *Whole Disk: Graphite on White Paper (by Sally Russell)* of Chap. 5, which explains a method for visualizing and transferring features that are further inward on the Sun's disk.

1.2.6 Preserving and Storing Sketches

Once you start building up a collection of sketches, you will likely want to preserve and store the hard copies for posterity. It is best to be organized and develop good storage habits from the outset. That way, you will always be able to locate any specific sketch. The media used will have a bearing on which preservation method is best to use, but remember, in almost all cases, sketches can also be scanned (or photographed) and saved as electronic copies. Here are some of our tried and tested methods for preserving the original hard copy sketches.

Fixatives

For sketches made using soft media such as charcoal, pastel, Conté and, to a lesser extent, graphite, it is usually preferable to use a fixative to help bind the medium to the paper. Doing so protects them and helps to prevent smearing. Some are labeled as workable fixatives so that the drawings can be reworked if needed after being sprayed (Fig. 1.40). Spray cans of fixative are widely available from art and craft stores. Alternatively, un-perfumed hair spray can be used, but be sure to select a variety that is free of conditioner additives which might put oily spots onto your sketch.

Use the fixative outdoors if possible, as its flammable vapors can be quite irritating when inhaled, and can also damage furniture and floor coverings. To fix your sketch, start by placing it onto a flat surface such as a clipboard. Shake the can vigorously, then point it well off to one side of the sketch and start spraying (Fig. 1.41). The idea is to get a good flow mist spraying before using it on your sketch. Then, hold the can at least 15 in. from the paper while using a sweeping motion to lightly coat your sketch (Fig. 1.42). It is important that you continue spraying across and beyond the edge of the paper, as larger droplets will often form as the flow slows down. If the droplets land on your sketch, they can remove the medium and leave bare spots. Repeat the spray passes until you feel there is adequate fixative on your sketch.

Tip

Try not to be too over-zealous with the fixative spray, as it can take the medium down into the paper, and fine detail will become lost in the process!

Fig. 1.40 Fixative spray is widely available from art and craft stores. (By Erika Rix)

Fig. 1.41 Start spraying well away from the sketch. (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

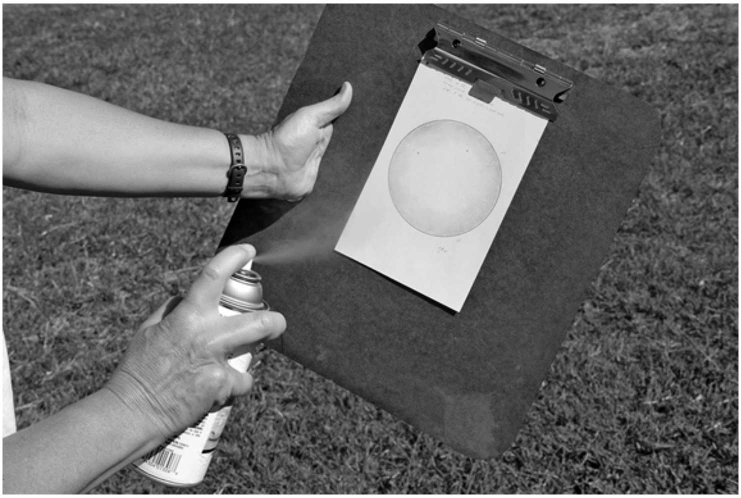

Fig. 1.42 Sweep across the sketch while spraying steadily. (By Erika Rix)

Fig. 1.43 Turn the can upside down and spray to clear the nozzle. (By Erika Rix)

When you have finished fixing your sketch, turn the spray can upside down and spray to clear the nozzle (Fig. 1.43). Allow the sketch to dry completely before bringing it indoors. It usually dries within 10–15 min and can be handled after an hour.

If you use a sketchbook rather than loose sheets of paper for your sketches, the same fixative method can be used to protect them if desired. Alternatively, acid-free layout or tracing paper can be interleaved between the pages to prevent unfixed drawings from smearing.

Binders

It is preferable to use a binder for sketches that are produced on individual sheets. Many different types and sizes are available from most reputable art and hobby stores. The majority of binders have clear plastic inserts that can be added or removed individually, making it easy to manage the storage of your sketches. To further protect your sketch from smearing, place a piece of acid-free layout or tracing paper over the sketch before it is put into the plastic sleeve.

One advantage of this method of storage is that the sketches can easily be displayed without disturbing them. Sketches can also be stored in an envelope folder, again interleaved with acid-free layout or tracing paper, depending on the medium used.

Boxes and Containers

Similar in concept to using binders, sketches can be stacked in boxes or containers for safekeeping. The type you use should be made of durable material such as plastic, metal, or heavy cardboard. Each can be labeled for a specific time range or by object type.

If the sketches are drawn on $5'' \times 7''$ card stock, or similar sizes, they can be filed upright in index card file boxes for easy access. For long-term storage, larger sketches can be placed flat in a container. Be sure to spray your sketches with a fixative and use acid-free layout or tracing paper in between each sketch to prevent smearing.

Laminating

Another option is to laminate sketches. During the laminating process, the sketch paper is placed into a laminating ‘pocket’ made of two very thin leaves of plastic joined at one end. The filled pocket is then subjected to heat in a specialized machine that welds the plastic together around the edges of the paper to create a permanent seal (Fig. 1.44). The advantage of this procedure is that the sketch is fully protected and can be handled without fear of the medium smearing. There are

Fig. 1.44 Laminating machines use heat to permanently seal sketches between thin layers of plastic. (By Erika Rix)

disadvantages, however. The heat that is applied during the process can melt and flatten the medium, depending on the type used. This would only be an issue if the sketch has heavy application of oil-based media. Also, laminated sketches are very glossy in appearance and do not scan well. If you wish to make a high-resolution electronic copy of your sketch remember to do so *before* the laminating process is carried out!

Frames

The ultimate, but most expensive way to store your favorite sketches is to frame them behind glass. Pastel sketches should be mounted such that the sketch is kept well away from the glass, and all framed sketches should be hung so that they are never in direct sunlight, which can cause fading of the image over time.

Chapter 2

Sketching for Science

The Sun is a very powerful, dynamic source of energy with a host of features to observe at any given time. Learning the fundamentals of solar morphology, including how to observe and sketch the Sun with an objective eye, provides the foundation necessary to put your sketches to scientific use. Once you have an understanding of the basics, you'll be able to submit your sketches and reports to organizations that gather scientific research data for astronomy professionals and other amateur astronomers.

2.1 Solar Facts

From NASA and Space.com

- Distance of the Sun to the Earth is 93 million miles (about 150 million kilometers)
- 10,000 Earths could be lined up side by side before they would reach the Sun
- Diameter of the Sun is 563,000 miles (1,390,000 km)
- 109 Earths lined up side by side would fit across the face of the Sun
- Mass of the Sun is 10^{24} kg (about $333{,}000 \times$ Earth's mass)
- The Sun is a type G2V, yellow dwarf main sequence star

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical Astronomy Series 178, DOI 10.1007/978-1-4939-2901-6_2

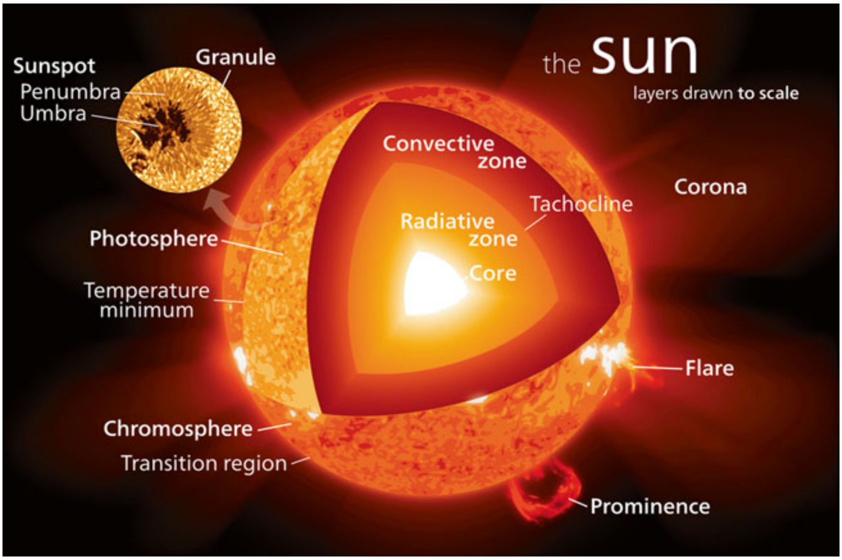

Fig. 2.1 "The Sun". (Image courtesy of Kelvinsong, own work, CC BY-SA 3.0. http://creativecommons.org/licenses/by-sa/3.0, via Wikimedia Commons)

The Sun Is Composed of Many Layers and Zones (Fig. 2.1)

Core	Produces energy through fusion
Radiative zone	Hot and dense, produces thermal radiation
Tachocline	The line between the Radiative and Convective zones where successive horizontal layers slide by each other
Convective zone	Outer layer
Photosphere	Lowest layer of the Sun's atmosphere
Chromosphere	Middle layer of the Sun's atmosphere
Transition region	Upper layer of the Sun's atmosphere

Sunlight Consists of the Total Electromagnetic Spectrum and, With Special Filters, Can Be Viewed in Many Wavelengths

White light	Visible spectrum from 390 to 700 nm
Calcium	393.3 nm
Hydrogen alpha	656.285 nm

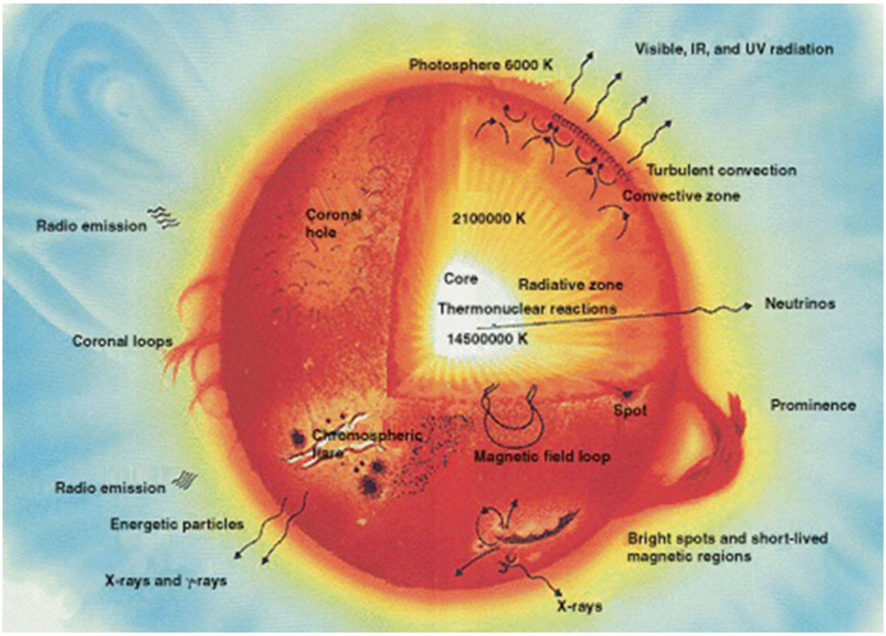

Fig. 2.2 The Sun is in constant motion and can be viewed in many wavelengths. (Image courtesy of NASA; Project leader: Dr. Jim Lochner; Curator: Meredith Gibb; Responsible NASA Official: Phil Newman [Public domain], via Wikimedia Commons)

The Sun is also observed in gamma ray, X-ray, microwave and radio wavelengths. These are mainly used by professional observatories and space telescopes (Fig. 2.2).

The sunspot portrayed in Fig. 2.1 consists of umbra and penumbra. The umbra appears darker in appearance because it is cooler in temperature than the surrounding area. The penumbra is lighter in comparison, although still darker than the granulated appearance of the surrounding area. Filamentary lines can sometimes be observed within the penumbra.

Strong magnetic lines are in constant motion within the northern and southern regions of the Sun. Plasma forms along these lines and can extend outward from the Sun's surface to form filaments, otherwise known as prominences when observed extending from the solar limb. When the magnetic forces are strong enough, the filaments explode, shooting ejecta into space—an occurrence known as a coronal mass ejection (CME).

If the CME is directed toward Earth, auroral phenomena near the magnetic poles may occur. The charged particles from the Sun's atmosphere collide with the gaseous particles of Earth's atmosphere, emitting colorful displays known as Northern (Aurora Borealis) or Southern (Aurora Australis) Lights. Color variations depend on the types of gas molecules and altitude. For example, high concentrations of

Fig. 2.3 Aurora produced from a coronal mass ejection that hit Earth at 05:00 UT on October 8, 2012. Its global geomagnetic storm index was moderate at K-index 6 (from a scale of 0-9). Left image is the northern view; right image is the western view. (Courtesy of Starlight Cascade Observatory)

oxygen molecules near 60 miles above Earth produce green (557.7 nm) emission, whereas red (630.0 nm) is produced at higher altitudes where oxygen is less condensed (Fig. 2.3).

Along with auroras, malfunctions with satellites and telephone communications or power outages may occur if the CME is severe. One such event occurred on March 13, 1989, when a severe geomagnetic storm struck Earth and induced a series of satellite communication disruptions as well as a massive blackout in Québec, Canada.

2.2 Sketching the Sun for Science

Sketching the Sun for science is fun and educational. A single historical document for a specific time and date can be produced, or you can create a series of sketches over several hours or even daily. Doing so allows you to witness the morphological changes that occur within the sunspot and sunspot groupings. If continued for a long enough period, you'll have data for a complete solar rotation or even an entire solar cycle, allowing you to produce your own graph of sunspot numbers!

A telescope fitted with a white light solar filter will be needed, or you may use solar projection.

Suggested Materials

- Disk grid template (Stonyhurst, Porter and disk grid templates are available in Appendix A)
- Data forms (AL, A.L.P.O., and BAA submission forms are available in Appendix A)

- Clipboard or drawing board
- 2B and 2HB graphite pencils
- Eraser
- Pencil sharpener

For best results, try to use a full-aperture filter with a minimum 100 mm focal length for your telescope/eyepiece combination. Your sketch circle for the solar disk should be 4 in. in diameter or larger to provide ample room for drawing the details within the active regions. If possible, observe at the same time each day. This will provide consistent results as you follow the changes in sunspots and sunspot groups.

Step 1

Place a disk grid template behind the data form and then attach both to your clipboard. If needed, the forms can be resized in photo editing software so that the circle sizes match.

Step 2

Solar orientation is necessary to accurately identify and plot sunspots. Once the Sun is centered in your eyepiece, note the direction that it drifts out of the field of view. Turn off the motor drives for this step if a tracking mount is used. The direction of drift is west, and depending on the type of telescope used, north will either be 90° clockwise or counterclockwise. Check that your templates align properly with the Sun's orientation.

Write down useful information concerning your observation. Your notes should include weather conditions and sky quality, equipment used, location, as well as the date and Universal Time (UT) of the observation. Make sure to note whether you use the projection or direct observing method.

Step 3

Before you begin the sketch, study the Sun as a whole to see its activity. Starting at the limb, scan the solar disk in grid formation. If the Sun is active, you may see faculae and possibly granulation or pores under steady, clear seeing. The sunspot groups will be visible with or without penumbra.

Step 4

Imagine the solar grid superimposed on the Sun through the eyepiece. Then, in small sections at a time, draw the sunspots on your data form using the underlying disk grid template for assistance. With time, you may find that you no longer require the support of the template.

Warning! ALWAYS use a suitable filter when directly observing the Sun

Plot the darker umbra of the sunspots first, and then add the outline of the penumbra if observed. For submission as scientific data, do not color or shade in the penumbra. Look closely, there may be spots in one or both hemispheres (northern and southern).

Sunspots can appear alone or in groups called active regions. Official numbers for the active regions are designated by the National Oceanic and Atmospheric Administration (NOAA).

Step 5

When the sketch is complete, scan the solar disk once more. Features may pop in and out of view when seeing is turbulent. Once you are satisfied with the sketch, count the sunspots and sunspot groups, and then calculate the relative sunspot number (also known as International sunspot number, Wolf number, or Zürich number) using the following formula:

$$\begin{aligned}\text{Relative sunspot number}\,(\mathrm{r}) &= \text{number of sunspot groups} \times 10 \\ &\quad + \text{the number of sunspots}\end{aligned}$$

See Fig. 2.7 as an example.

Observation by Tony Broxton on August 23, 2014 at 08:16 UT
Northern sunspot groups = 5
Southern sunspot groups = 5
Northern sunspots = 33
Southern sunspots = 17

$r = (5 + 5) \times 10 + (33 + 17)$
$r = 10 \times 10 + 50$
$r = 150$

The relative sunspot number that was submitted by Tony Broxton for this day was 150. Submissions are collected daily and sent in to various groups for scientific data collection.

2.3 Solar Programs for Data Collection

Several astronomy solar groups and associations welcome sketches to be used as historical data on relative sunspot numbers. Awards may also be given for the completion of solar programs they offer. The Astronomical League, American Association of Variable Star Observers, Association of Lunar and Planetary Observers, and British Astronomical Association are four such groups.

2.3.1 Astronomical League

The Astronomical League (AL) is an organization comprised of over two hundred amateur astronomical societies in the United States, dating back to 1939. It offers observing programs designed to provide its members with direction and goals for their observations. Its Sunspotters Program encourages solar observing while educating the participant about the Sun and how to safely observe it.

Two sets of drawings are required to complete the program. The first set is comprised of twenty or more sketches of the solar disk during two solar rotations. The second consists of five detailed sketches of sunspot groups.

To complete the first, the observer sketches the Sun on a circle template with degree markings. Additional information is requested such as the observer's name, location, date and time, sky conditions, and equipment used. The total sunspot count is included on the form along with the relative sunspot number. See Fig. A.1 in Appendix A.

The second set is for drawing detailed individual sunspots using the McIntosh sunspot classification. See Fig. A.2 in Appendix A.

Once both sets of drawings have been completed, copies of the observing forms (keep your originals!) may be submitted to your club's AL representative, or sent directly to the AL's Sunspotters Program coordinator via postal service or email.

The AL published a very good reference book that was edited by Richard E. Hill titled, *The New Observe and Understand the Sun*. Made available on their website, it is a guide to solar terminology, sunspot classification, observing methods, and how to use their Sunspotter observing forms. To participate in the Sunspotters Program, Amateur astronomers must be a member of the AL (www.astroleague.org).

2.3.2 American Association of Variable Star Observers

Founded in 1911, the American Association of Variable Star Observers (AAVSO) is an international non-profit organization that enables people to participate in scientific discovery through variable star astronomy. Its solar section includes a web-based sunspot data entry program called *SunEntry*. The reports and counts that observers enter are used in the AAVSO American Relative Sunspot Program as well as its monthly publication, *Solar Bulletin*. Solar scientists and students then use the results for research.

AAVSO membership isn't required, however, you will need to create an AAVSO website account and an AAVSO Observer Code to gain access for participation. Once *SunEntry* is installed on your computer, you'll be able to upload your observations by marking the date, time, observing conditions, total sunspot groups and spots. This will calculate your relative sunspot number.

Observations are based on a calendar month and are due by the 10th of the following month for inclusion. The AAVSO awards certificates after 500 observations are submitted, and then in increments of 500 thereafter (www.aavso.org).

2.3.3 Association of Lunar and Planetary Observers

The Association of Lunar and Planetary Observers (A.L.P.O.) was established in 1947. It is an international scientific and educational organization dedicated to solar system studies with works contributed by both professional and amateur astronomers. Its solar section collects and archives sketches and images for the Carrington rotation group and also places the submissions online for others to view and observe the ever-changing morphology of sunspot groups.

Drawing report forms are available on the A.L.P.O. website. Additionally, see Figs. A.3 and A.4 in Appendix A.

To participate, scan and save your solar sketches as JPEG, BMP, or GIF files, up to 250 kb in size, and then submit the files by email to the A.L.P.O. Solar Section Coordinator. Be sure to include your name, the date, Universal Time (UT), observing location, transparency, seeing, observing method (projection/direct), telescope, and eyepiece used. Your submission should also include the heliographic coordinates of the Sun—L_o, the heliographic longitude of the center of the disk; B_o, the heliographic latitude of the center of the disk and the apparent diameter of the Sun; and P_o, the position angle of the north end of the axis of rotation. Lastly, include the Carrington rotation number, which is found on the A.L.P.O. Solar Section Ephemerides webpage (www.alpo-astronomy.org).

2.3.4 British Astronomical Association

The British Astronomical Association (BAA) was formed in 1890 and promotes all aspects of solar astronomy and studies of the Sun. The solar section's monthly report form, in spreadsheet format, is used to record Active Areas (active regions) and Relative Sunspot Number counts. See Fig. A.5 in Appendix A. Participants should send their completed forms to the director at the end of each month.

Whole disk drawings are encouraged to show the positions and types of sunspots. Relative information about the observation should be included; i.e., Carrington rotation number, seeing conditions, L_o, B_o, and P_o information, and active areas. The Mean Daily Frequency (MDF) is calculated by dividing the total number of active areas by the number of days observed. See Fig. A.6 in Appendix A (www.britastro.org).

2.4 Carrington Rotation

The Sun rotates on its axis. The rate of its rotation varies with latitude, time, and depth. One of the ways rotation rate can be determined is by how long it takes a sunspot to rotate around the Sun and then return to its starting position. This is known as sidereal rotation. If the sunspot is positioned along the Sun's equator, the rotation rate is 24.47 days. But because the Sun isn't a solid body, the solar rate decreases as the sunspot position tends to move towards either pole.

Something else to consider is that the Sun revolves in the same direction as Earth's orbital movement, making the rotation period longer as seen from Earth. This is known as synodic or apparent rotation.

While observing sunspot movements in the early 1850s, English amateur astronomer Richard Carrington determined the sidereal rotation rate to be 25.38 days for low-latitude groupings. The synodic rotation, therefore, was an average of 27.2753 days and became known as the Carrington rotation.

Numbering Carrington rotations began on November 9th, 1853, and it became a system for comparing the locations of solar features over a period of time. For example, the time range for Carrington rotation number 2154 (CRN 2154 or CR 2154) is 2014 Aug 21 at 1100 UT through 2014 Sep 17 at 1709 UT. That means there were a total of 2154 Carrington rotations since the numbering system was created.

2.5 Solar Cycle

The Sun undergoes, on average, an 11-year variation in activity known as a solar cycle. These changes include levels of solar radiation, ejected material, sunspots, and other visible features. It's called a sunspot cycle when speaking more specifically about sunspots.

Figure 2.4 is a graph of Cycle 24. As you can see by the peaks, Cycle 24 was not predicted to be as strong as the previous two cycles, Cycle 22 and Cycle 23. As you count and record sunspot numbers during your observations, you too can create a graph and then compare it to NASA's.

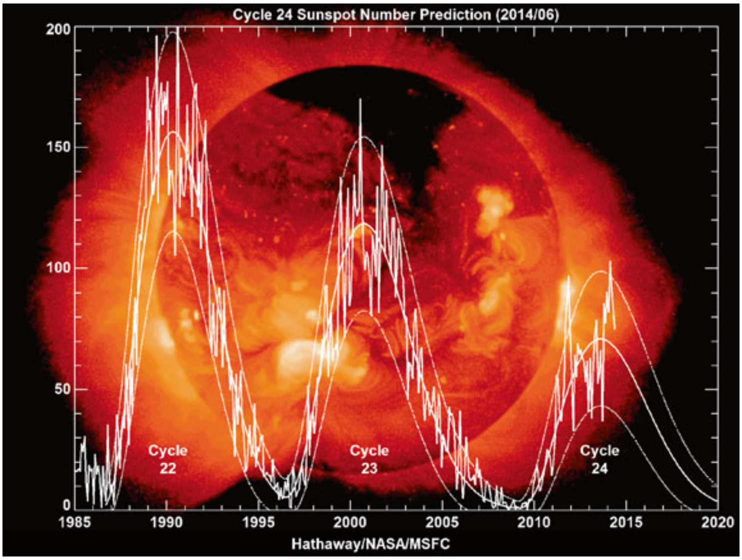

Fig. 2.4 Graph of sunspot predictions for Cycle 24. (Courtesy of Hathaway NASA/ARC)

Warning! ALWAYS use a suitable filter when directly observing the Sun

2.6 McIntosh Classification System

The McIntosh classification system grades sunspot activity using three components, each represented by a letter. The first letter is from a modified Zürich one-letter system and indicates the configuration of the group (Fig. 2.5). The second letter describes the type of the largest spot. And the third represents the sunspot distribution within the group.

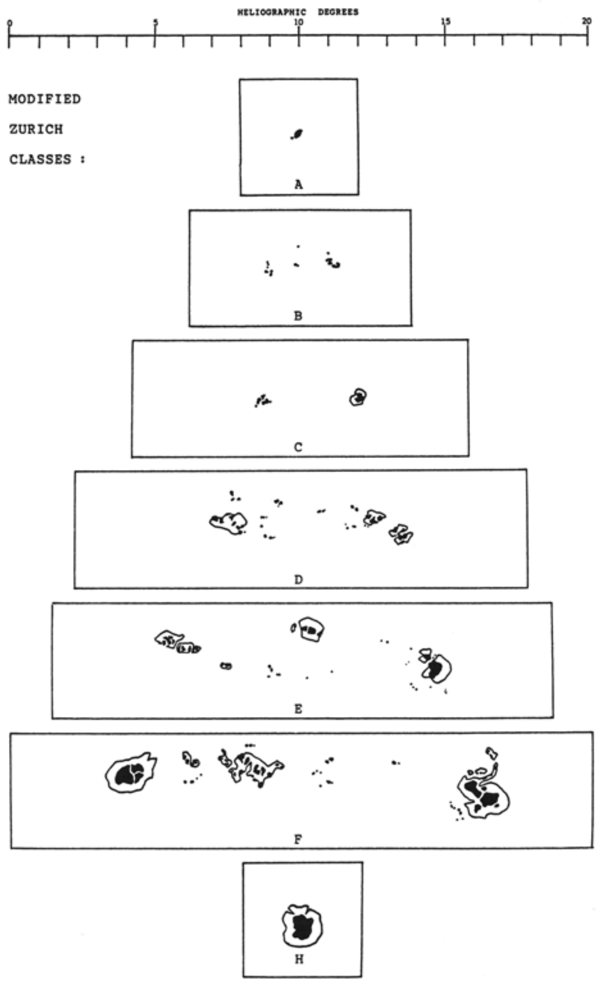

Fig. 2.5 Modified Zürich classification system. (Used with permission and copyright by Rik Hill from *Observe and Understand the Sun*, AL and ALPO, 1983)

To understand the McIntosh system, you must be familiar with two types of sunspot groups. The unipolar group contains a single spot, or a compact cluster of spots with the greatest separation between two spots of the cluster not greater than 3 heliographic degrees. The bipolar group has two or more spots that form an elongated cluster extending the length of 3 or more heliographic degrees. If there is a large principle spot, the cluster should then extend more than 5° (Fig. 2.6).

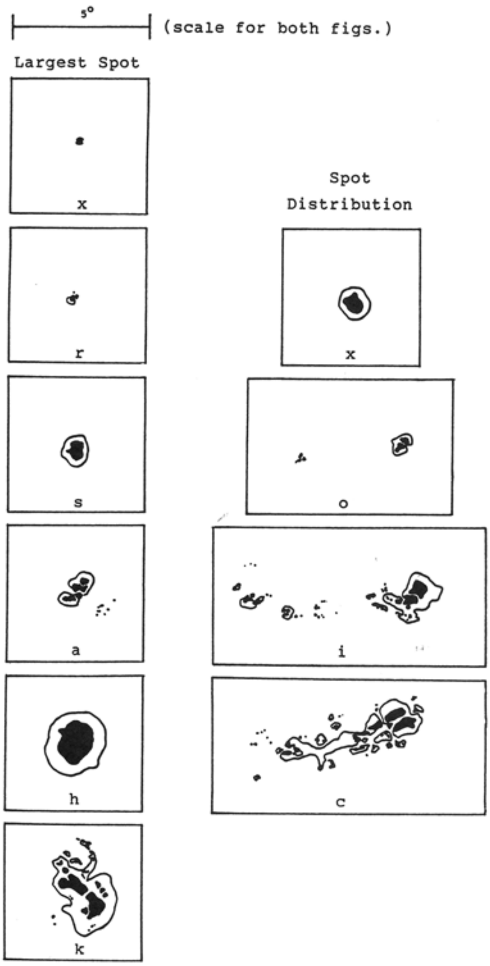

Fig. 2.6 McIntosh classification system. (Used with permission and copyright by Rik Hill from *Observe and Understand the Sun*, AL and ALPO, 1983)

Warning! ALWAYS use a suitable filter when directly observing the Sun

Modified Zürich Class: Configuration of the Group

A	Unipolar group with no penumbrae
B	Bipolar group with no penumbrae on any spots
C	Bipolar group with penumbrae on one end of the group, usually surrounding the largest leader umbra
D	Bipolar group with penumbrae on spots at both ends of the group, length is less than 10°
E	Bipolar group with penumbrae on spots at both ends of the group, length is greater than 10–15°
F	Bipolar group with penumbrae on spots at both ends of the group, length is greater than 15°
H	Unipolar group with penumbrae, usually the remains of a bipolar group

Type of the Largest Spot in the Group

x	No penumbra (for groups in classes A and B)
r	Young penumbra that usually only partially surrounds the largest spot, is only a few photospheric granules wide, may either be forming or dissolving, may appear more granular than filamentary
s	Small symmetrical spot with a darker, mature filamentary penumbra of circular or elliptical shape and a clean border, umbrae will form a tight cluster of 2.5° or less north–south diameter if several are present within the penumbra
a	Small, symmetrical spot with irregular penumbra, umbrae within is separated, north–south diameter of 2.5° or less
h	Large, symmetric spot, similar to type “s” but with a north–south diameter greater than 2.5°
k	Large, asymmetric spot, similar to type “a” but with a north–south diameter greater than 2.5°

Sunspot Distribution Within the Group

x	Undefined for unipolar group of modified Zürich class A or H, single spot
o	Open distribution with a leader and follower spot, will have few very small umbral spots or no spots in-between
i	Moderate distribution with a leader and follower spot, will have many umbral spots in-between
c	Compact distribution with a leader and follower spot, will have many umbral spots with at least one having penumbra, whole group may be encompassed in one complex penumbra

Using Fig. 2.7 as an example, the observer used the McIntosh system to classify each sunspot group (small upper drawing). He also included the NOAA designated active region numbers (large lower drawing), and wrote *U/K*, indicating unknown or unregistered, next to the sunspots without number designations at the time of his observation. Refer to Fig. 2.8 to view the heliographic data for the date and time of the observation.

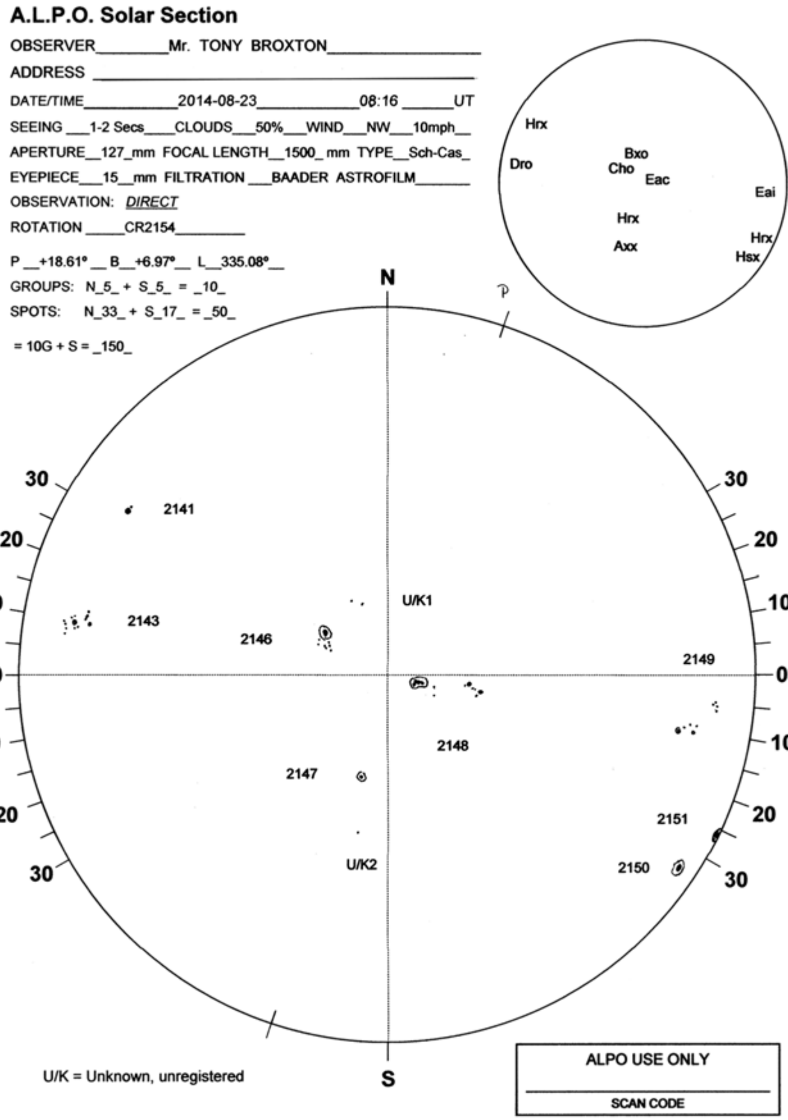

Fig. 2.7 Completed A.L.P.O. Solar Section observing form. (Courtesy of Tony Broxton)

ALPO Solar Section 2014 Solar Ephemeris
Ephemeris Computed by Brad Timerson, A.L.P.O. Solar Section

CALENDAR DATE	JULIAN DATE	ROTATION NUMBER	HELIOGRAPHIC Lo	Bo	Po	DIAMETER (arcmin)	RA (HH:MM)	DEC (deg)
8/18/2014	2456887.5	2153	45.72	6.77	16.94	31.600	09:49.5	13.20
8/19/2014	2456888.5	2153	32.50	6.81	17.26	31.607	09:53.2	12.88
8/20/2014	2456889.5	2153	19.28	6.85	17.58	31.613	09:56.9	12.55
8/21/2014	2456890.5	2153	6.06	6.89	17.89	31.619	10:0 .6	12.22
8/22/2014	2456891.5	2154	352.84	6.93	18.20	31.625	10: 4.3	11.89
8/23/2014	2456892.5	2154	339.62	6.96	18.51	31.632	10: 8.0	11.55
8/24/2014	2456893.5	2154	326.41	6.99	18.81	31.639	10:11.7	11.21
8/25/2014	2456894.5	2154	313.19	7.03	19.10	31.645	10:15.3	10.87
8/26/2014	2456895.5	2154	299.97	7.05	19.39	31.652	10:19.0	10.52
8/27/2014	2456896.5	2154	286.76	7.08	19.68	31.659	10:22.7	10.17
8/28/2014	2456897.5	2154	273.55	7.11	19.95	31.666	10:26.3	9.82
8/29/2014	2456898.5	2154	260.33	7.13	20.23	31.673	10:30.0	9.47
8/30/2014	2456899.5	2154	247.12	7.15	20.50	31.681	10:33.6	9.11

Fig. 2.8 Section of the A.L.P.O. Solar Ephemeris that shows the heliographic data for the date and time of Tony Broxton's observation. (Permission granted by the Association of Lunar and Planetary Observers, www.alpo-astronomy.org)

In summary, this is simply a small introduction to the Sun, including sunspot morphology during solar cycles and Carrington rotations. There are many more observational elements and radio wavelengths to explore. To assist you in studying the Sun, several resources are included in the reference section.

We've mentioned just a few programs that collect and use submissions for science. There are others that welcome data and sketch contributions from amateur astronomers. Remember to relax during your observing session. Let your eyes fully take in the Sun. Observe its magnificent magnetic storms and try to comprehend its enormity compared to Earth and our neighboring planets.

Through sketching, you can preserve a moment in time of the Sun, and then collect and submit data to be used for historical records and science. It is our hope that, like us, you find the process very gratifying.

Chapter 3

White Light Filters

The white light Sun is actually a view of the visible spectrum emitted from the photosphere. The solar interior is opaque to light beyond this visible surface, which is not really a surface at all because it is composed of hot gas 4500–6000 degrees Kelvin. Within this shell a mere few hundred kilometers deep, we can view sunspots, granulation, and faculae. Using simple optical projection techniques or a solar filter, we can observe and record these intriguing features.

3.1 Whole Disk

A great way to learn about the Sun's photosphere is to sketch the full disk. Using the techniques shown here, you can observe, recognize, and accurately record solar detail using a white light filter.

3.1.1 Graphite (By Richard Handy)

The following technique concentrates on recording sunspots and their heliographic coordinates. Although specific paper and pencil types are suggested, they can easily be substituted with printer paper and an ordinary writing pencil for simplicity.

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical Astronomy Series 178, DOI 10.1007/978-1-4939-2901-6_3

Suggested Materials

- Strathmore 400 series medium white drawing paper, 9″ × 12″
- H graphite pencil
- Art gum eraser

Step 1

To represent the solar disk, trace the edge of a round dish onto the paper with a graphite pencil. Limb darkening is rendered with light, short pencil strokes concentric to the disk. This narrow band of graphite can be smoothened with a blending stump if desired (Figs. 3.1 and 3.2).

Step 2

The dark umbrae of the sunspots are carefully positioned on the solar disk, using firm pencil pressure with a controlled scribbling stroke. Errors can be cleanly erased and then corrected by redrawing (Figs. 3.3 and 3.4).

Step 3

Penumbrae surrounding the umbral portions of the sunspots are added next. The pencil should be held with light pressure while using small, curved strokes (Fig. 3.5).

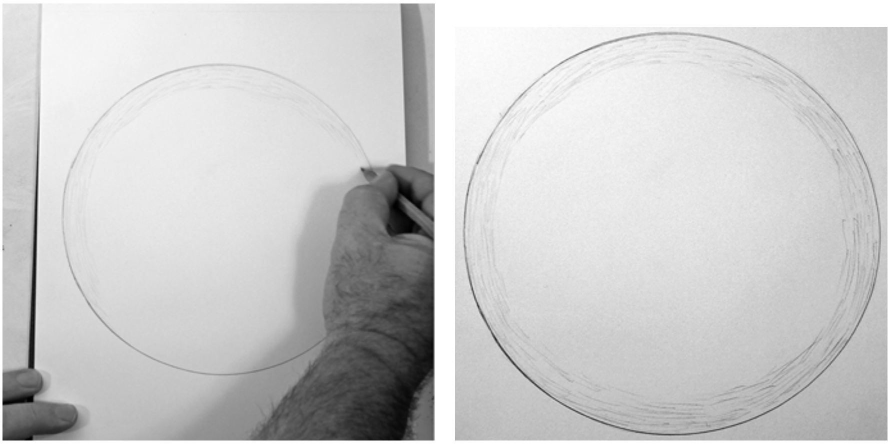

Fig. 3.1–3.2

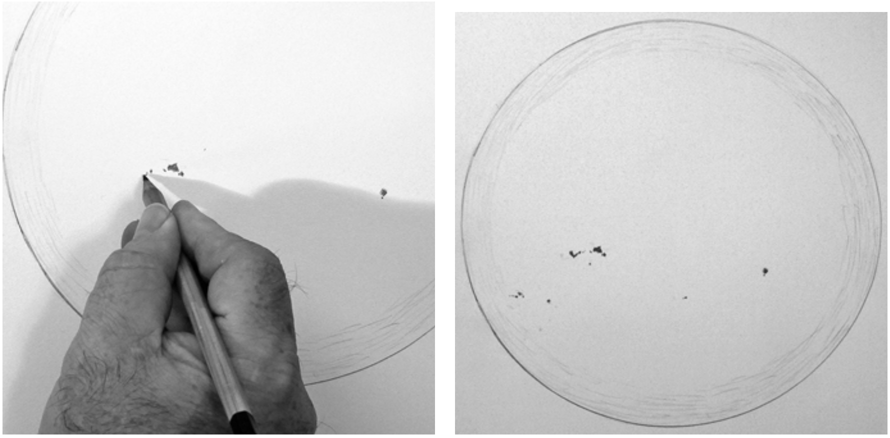

Fig. 3.3–3.4

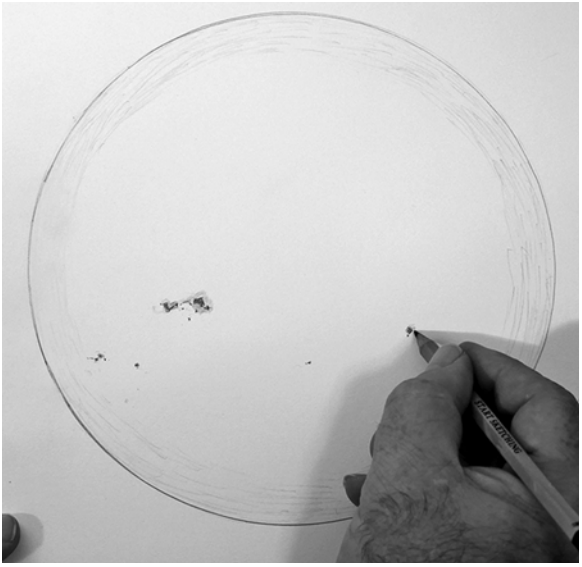

Fig. 3.5

Thoroughly scan the solar disk through the eyepiece once more for missed spots to complete the sketch (Fig. 3.6).

The full disk sketch in Fig. 3.7 is very similar, however, the observed limb darkening, seen to be narrower from the observation, was blended smooth. Depending

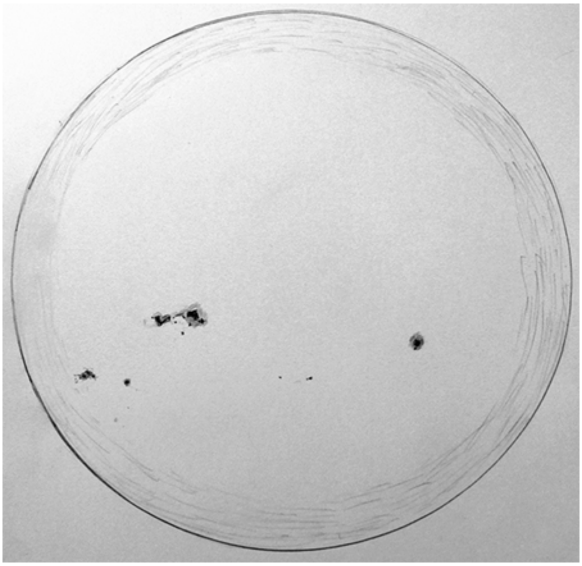

Fig. 3.6 Active region 11861—October 10, 2013, 21:15–21:45 UT. Maksutov Cassegrain 203/3048 Alter M815 f/15, 35 mm TeleVue Panoptic, 87×, Astrozap Baader solar filter. Antoniadi III. Strathmore 400 series drawing paper, H graphite pencil, art gum eraser. (By Richard Handy)

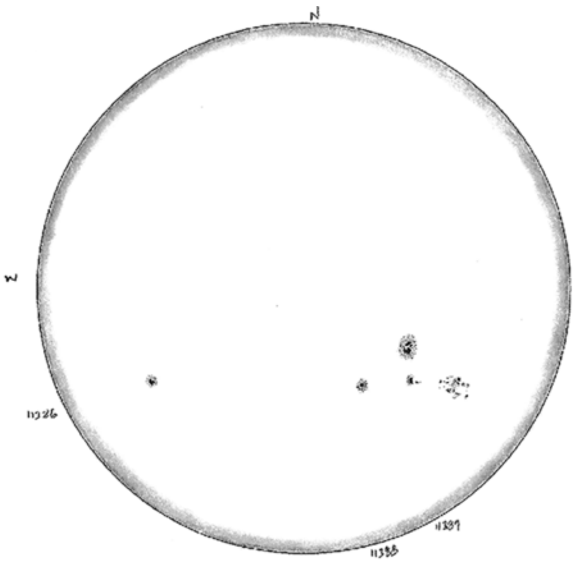

Fig. 3.7 Active regions 11386, 11388, and 11389. Refractor 102 mm f/11, Lunt Solar Systems Herschel Prism, Baader 8–24 Zoom. Full disk white light sketch on regular white copy paper and HB pencil. (Courtesy of Alan Strauss, Arizona, USA)

on the atmospheric turbulence and equipment used during an observation, penumbrae may appear fibrillar with jagged edges or smooth.

3.1.2 *Graphite (Technique of Lennart van Sluijs)*

To include faculae, the observer for this tutorial added a soft gray solar background with additional graphite to render limb darkening. The finished sketch was then scanned and polished using GIMP (GNU Image Manipulation Program).

Suggested Materials

- White acid free paper, 9″ × 12″ (75 lbs.)
- 2H and 2B graphite pencils
- Large blending stump or chamois
- Circle template (a saucer or circular protractor can be used)
- Rubber or plastic eraser

Step 1

Lightly trace a 5-in. to 6-in. diameter circle onto the paper using the 2H pencil and the circle template.

Step 2

Holding the 2B pencil at a shallow angle and using soft pressure, fill the circle with a light layer of graphite.

Step 3

Blend the graphite evenly within the circle using a large blending stump or a chamois.

Step 4

Use the 2B pencil, again at a shallow angle, to add another layer of graphite for the limb darkening. It should be approximately one inch wide. Smoothen with a blending stump so that the darker, outer edge gradually transitions to the brighter tones toward the center of the disk.

Step 5

Holding the 2B pencil more upright, carefully sketch the umbrae of the observed sunspots. Once their positions are in place, darken them with increased pencil pressure.

Step 6

Draw the lighter surrounding penumbrae with the 2H pencil.

Step 7

Visible faculae near the limb are added by removing previously applied graphite with an eraser. If needed, hold the 2H pencil at a very shallow angle and lightly add more graphite around the erased areas that represent the faculae, then blend. Doing so can add more definition to the edges of the faculae.

> *Tip*
>
> Try sharpening a rubber eraser to a point or an edge with a utility knife to create precise linear erasures.

Step 8

The finished sketch is then scanned. Using photo editing software, the area outside of the solar disk is darkened to represent the eyepiece view. Contrast adjustments for limb darkening and sunspots can be made at this time (Fig. 3.8).

Figures 3.9 and 3.10 also include limb darkening and shaded solar disks, but their presentations, and indeed their techniques, are very individualized. The first sketch has a soft graphite background; the second uses an actual image of the Sun for the granulated background texture that is sometimes observed in the photosphere. The orange color represents the hue seen through that particular make of white light filter.

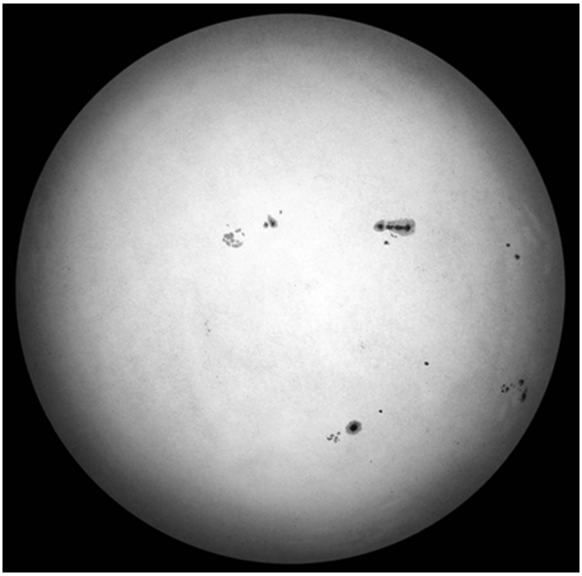

Fig. 3.8 The Sun in white light—May 19, 2013, 14:00 UT. Sky-watcher 102 mm refractor with 500 mm focal length. Graphite pencils, processed with GIMP. (Courtesy of Lennart van Sluijs, Koudekerke, Netherlands)

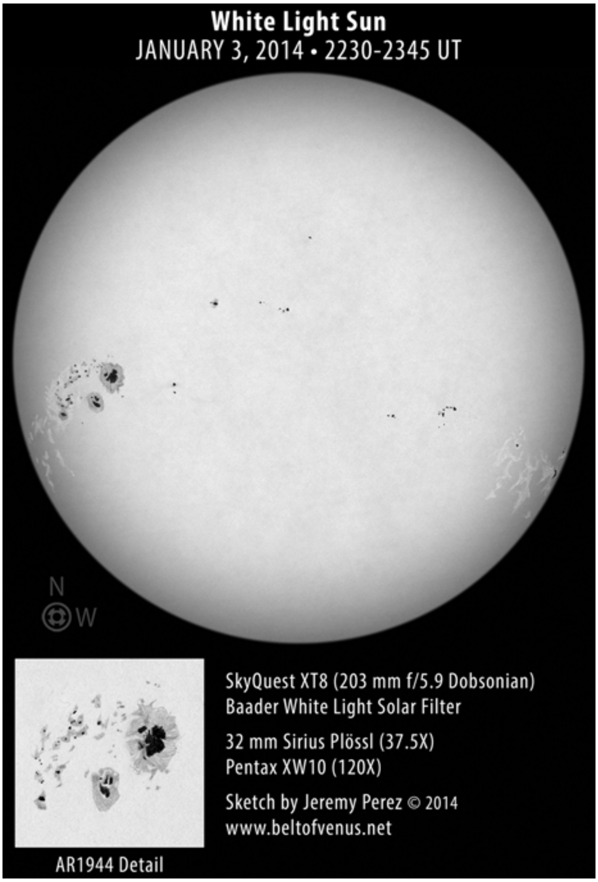

Fig. 3.9 The Sun in white light—January 3, 2014, 22:30–23:45 UT. SkyQuest XT8 203 mm f/5.9 on a Dobsonian mount, Baader white light solar filter, 32 mm Sirius Plössl at 37.5× and a 10 mm Pentax XW at 120×. Graphite on white paper and processed with photo-editing software. (Courtesy of Jeremy Perez, Arizona, USA)

Fig. 3.10 The Sun in white light—November 15, 2013, 17:00 UT. Lunt LS152, Nagler 5 mm, 180×. Graphite pencils and white paper were used at the eyepiece. A photo of the sketch was processed in Photoshop and layered over an actual image of the Sun to produce its granulated texture. Color was digitally added to portray the color produced by the white light solar filter. (Courtesy of André Vaillancourt, Québec, Canada)

3.1.3 Ink (By Erika Rix)

Ink drawings are reminiscent of the techniques used centuries ago by astronomers. They are resistant to aging and provide deep tones for dramatic effect. But the thought of using an open bottle of ink near observing equipment may dissuade you. These days, artist pens are available that have India ink stored in the pen's shaft. They come in various colors with a range of nib options that include size, brush, and chisel (Fig. 3.11).

Several techniques are commonly used for pen and ink drawings, including stippling, ink washes, hatching, and random lines. Preliminary drawings can even be made at the eyepiece with graphite and then later drawn over with ink. The following technique provides a simple introduction, using only a single pen at the eyepiece.

Fig. 3.11 Faber-Castell PITT artist pens can be used in lieu of quill and ink at the eyepiece. (By Erika Rix)

Suggested Materials

- White paper, minimum of 8″ × 8″
- Black artist pen, superfine nib
- 6-in. circular protractor

Step 1

Lay the protractor onto the paper, and then trace a light circle around it with the pen to create the Sun's disk. The larger the drawing circle, the easier it will be to sketch the details of your observation. Six inches in diameter should suffice to represent the solar disk.

Add the most prominent umbra to the sketch circle first by holding the artist pen upright just above the location it should be within the disk. Lower the nib onto the paper. The pen pressure and the length of time that the nib touches the paper will affect the size of the spot.

Tip

Practice creating different sized spots, brush strokes, and tones on a scrap sheet of paper before rendering them on your observation sketch.

Once the boldest spots are in place within the sketch, use lighter pen pressure with a faster release off of the paper to render the smaller umbrae and pores (Fig. 3.12).

Step 2

Again with light pressure, outline the areas of penumbrae with the artist pen as seen in Fig. 3.13. Shading within the penumbral areas can be added by lightly brushing the pen within the circled areas. If desired, you could use a pencil for this step or simply omit the shading.

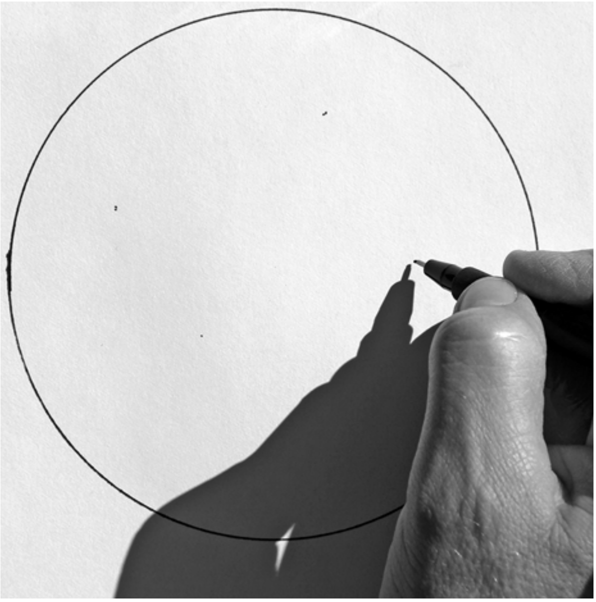

Fig. 3.12

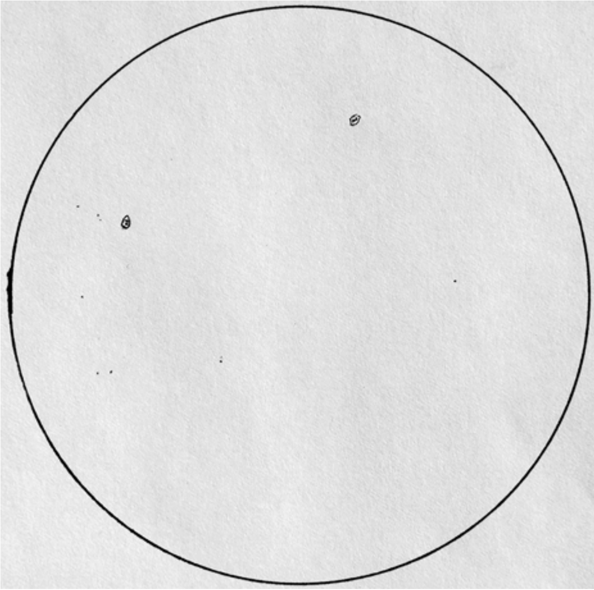

Fig. 3.13

Step 3

Indicate the faculae regions, and then finish the sketch by including notes and orientation. The arrow outside of the sketch area points toward the direction of drift in Fig. 3.14.

As a media comparison, Fig. 3.15 is a graphite sketch of the same observation.

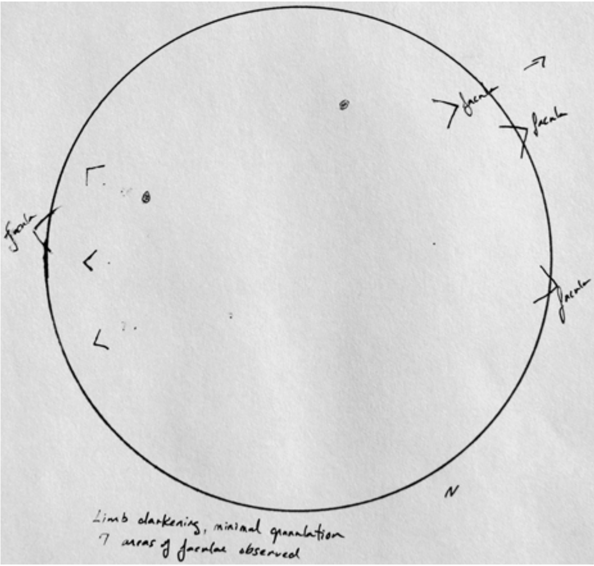

Fig. 3.14 Active regions 2185 through 2191—October 15, 2014, 1450 UT. Celestron Omni XLT 102 mm f/9.8 refractor, LXD75, homemade Sun Funnel followed by a Thousand Oaks glass white light filter, Baader Planetarium Hyperion 8-24 mm Mark III set at 16 mm, 63×. 76°F (24.4 °C), light winds, 24 % humidity, Wilson IV, 5/6 transparency. WH Smith white cartridge paper (135 gsm), Faber-Castell black S artist pen. (By Erika Rix)

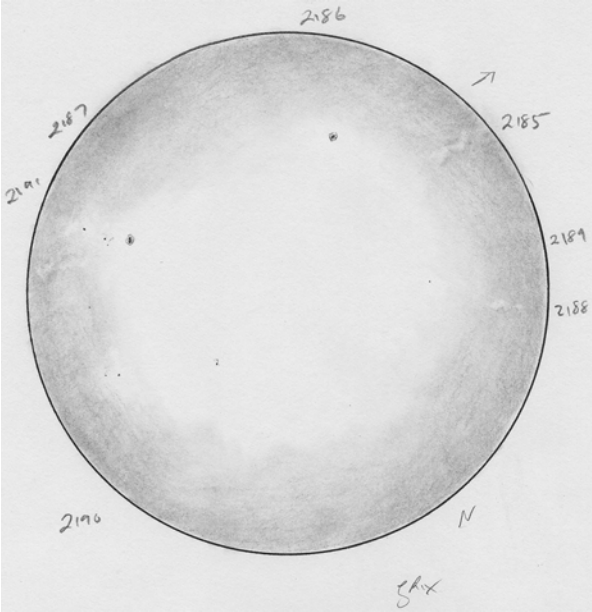

Fig. 3.15 Active regions 2185 through 2191—October 15, 2014, 1503 UT. Drawn as a media comparison 13 min after the ink drawing in Fig. 3.14. WH Smith white cartridge paper (135 gsm), #2 graphite pencil, 0.5 mm mechanical pencil, blending stump. (By Erika Rix)

3.1.4 Mixed Media (By Erika Rix)

Each type of medium has its own forte. For example, charcoal and pastels produce rich, textured markings that blend easily, and artist pens create deep tones with high contrast. Oil-based pencils work well over pastels and can be sharpened to fine points for detailed work or smudged to cover larger areas. On occasion, experiment with new materials. You might discover that some combinations work better than others for the type of object you wish to sketch.

Suggested Materials

- White paper, minimum of 8″ × 8″
- Black artist pen, superfine nib
- Black charcoal or pastel stick
- Black oil-based color pencil (with or without wood casing) or #2 graphite pencil

Fig. 3.16

- Assortment of blending stumps and a chamois
- 6-in. circular protractor
- Vinyl eraser pencil, shaped with a craft knife

Step 1

Lay the protractor onto the paper, and then trace a light circle around it with the pencil. Next, place the stick of charcoal onto its side with the edge of one end just inside the circle line. Using medium pressure, create a swath of charcoal completely around the inner edge of the disk (Fig. 3.16).

Step 2

Blend the charcoal with a chamois. Start with wide strokes along the edge of the disk, followed by light circular motions while moving toward the center. This technique produces a soft, light gray background with limb darkening, as often seen through a white light filter (Fig. 3.17).

Fig. 3.17

Step 3

Shape the eraser with a craft knife so that it has a flat edge. Then, use its edge to remove stray charcoal outside of the disk circle (Fig. 3.18).

> *Tip*
>
> To prevent smearing, use a bulb blower rather than your fingertips to remove any debris left by the eraser. Also, resist the urge to blow the debris away with your breath. You may end up with a ruined sketch from spittle!

Step 4

Holding the artist pen upright, draw the largest umbral portions of the sunspots first. These initial markings are the most important because the positions of the remaining spots will be referenced to them. The remainder of umbrae is added next. If you feel uneasy using ink, plot the spots lightly with a pencil before going over them with pen (Fig. 3.19).

Fig. 3.18

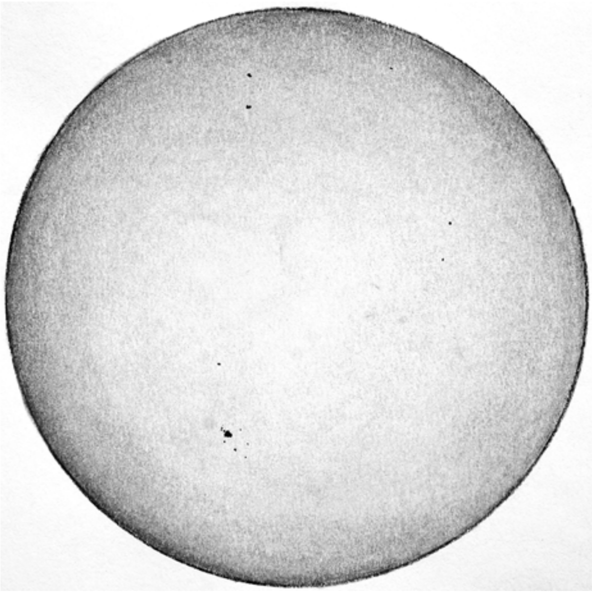

Fig. 3.19

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 3.20

Step 5

Begin adding penumbrae with a sharpened oil-based pencil. Increase magnification as the seeing permits to capture the finest lighter areas that are otherwise difficult to spot. The active region in Fig. 3.20 is more complex, producing a beautiful pattern of pores and penumbrae around the darker umbrae.

Step 6

Use the shaped eraser to draw faculae. This technique involves using firm pressure of the eraser point to remove charcoal from the paper (Fig. 3.21) Gum erasers in wood casings, similar to pencils, are available and can be sharpened to a stiff point. The caveat is that they sometimes leave pink streaks, whereas vinyl erasers erase cleanly to expose the white paper beneath.

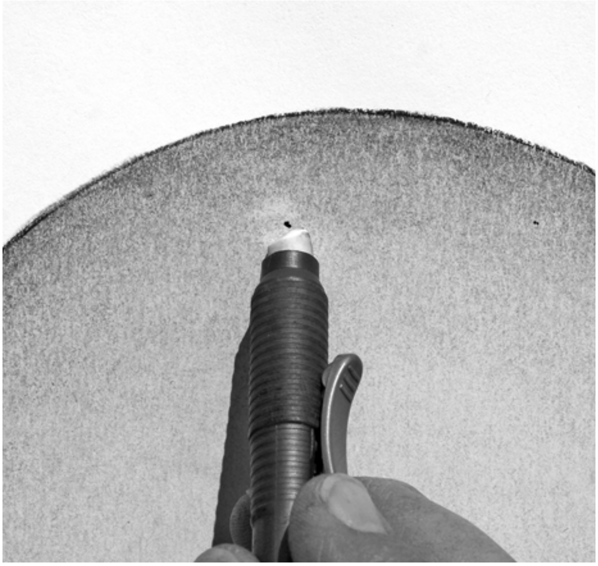

Fig. 3.21

Tip

Faculae are usually more evident within the darkened limb; however, when conditions are optimal, they may be detected near active regions further in. Increase magnification to dim the view. Gently tap the telescope. The slight motion could help you detect areas of contrast. Once spotted, you can look closer to see if they are indeed faculae.

Step 7

Define the boundaries of the faculae by softly adding shading around them with the oil-based pencil. Note that in Fig. 3.22, the pencil is encased in wood. It is a different brand with slightly less oil composition than the pencil shown in Fig. 3.20. Less oil means that it is harder, and therefore creates lighter markings.

Step 8

If needed, use a small blending stump to smoothen the shaded areas so that they blend into the darkened surroundings (Fig. 3.23).

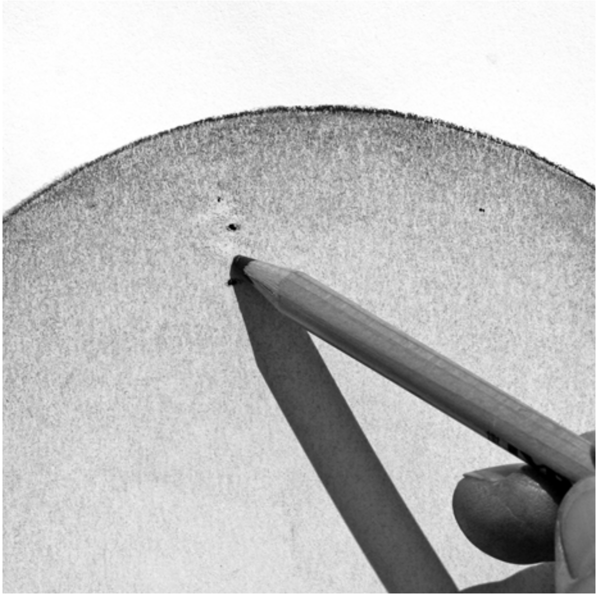

Fig. 3.22

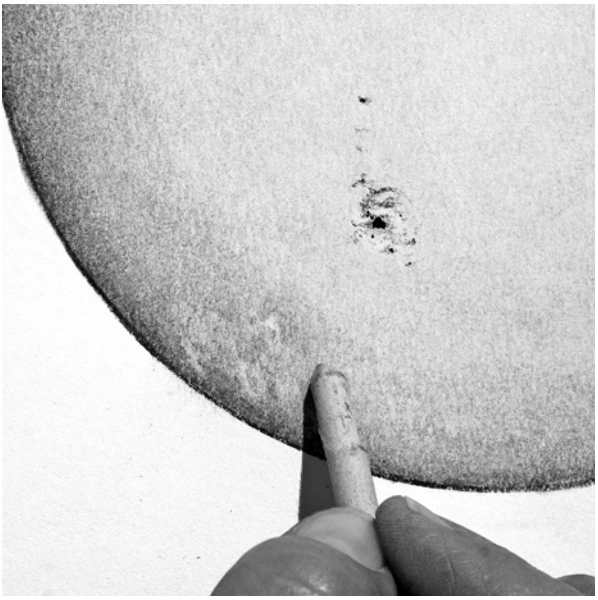

Fig. 3.23

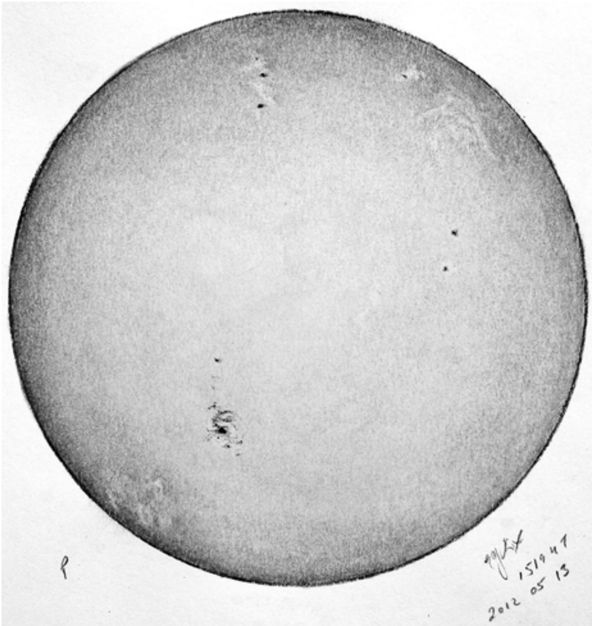

Fig. 3.24 NOAA 11476, 11477, 11478, 11479—May 13, 2012, 1330–1530 UT. Celestron Omni XLT 102 mm f/9.8 refractor, LXD75, Thousand Oaks glass white light filter, Baader Planetarium Hyperion 8-24 mm Mark III, 125×. 70°F (21.1 °C), winds NNW 7 mph, clear to scattered clouds, 88 % humidity, Wilson IV, 5/6 transparency. WH Smith white cartridge paper (135 gsm), Faber-Castell black S artist pen, charcoal, black oil-based pencils. (By Erika Rix)

Step 9

To complete the sketch, scan the Sun once more through the eyepiece to add details that were missed previously. Be sure to include notes pertinent to your observation (Fig. 3.24).

3.1.5 Cybersketching (Technique of Peter Grego)

Personal Digital Assistants (PDA), tablet PCs, and smartphones are capable of running sophisticated drawing software that allow an observer to create sketches using a stylus or touch screen. Along with being an excellent way to record detailed features, cyber or digital sketching has the advantage of convenience, freeing the sketcher from the difficulties associated with handling and applying a medium, not to mention the clean up required afterwards.

Suggested Materials

- Personal Data Assistant (PDA), tablet PC, or smartphone
- Compatible sketch or drawing program
- Stylus

Step 1

Select the circle tool and drag to the size desired.

Step 2

Select the circle again, and then apply a gray gradient fill to represent the photosphere and the solar limb darkening. Save this template for future use.

Step 3

Adjust the zoom so that the circle fits entirely on the screen. This will allow accurate placement of the sunspots relative to one another and to the solar disk.

Step 4

Select a small brush or tip and chose a shade of gray slightly darker in tone than the photosphere. Then mark the positions of the main sunspots that are visible.

Step 5

Using the small tip, select a shade of gray slightly lighter in tone from the photosphere, and then use it to mark the location of the brighter faculae.

Step 6

After the sunspot positions have been recorded, zoom in on the individual spots. Selecting the shades that correspond to those features, use a small tip to add to the details such as the umbra and penumbra or any umbral bridges that may be visible. Zoom out to show the whole disk.

Step 7

Add the cardinal points and orientation marks to the sketch. And finally, jot down the details of the observation, including the date, time and the instrument to supplement the drawing (Fig. 3.25).

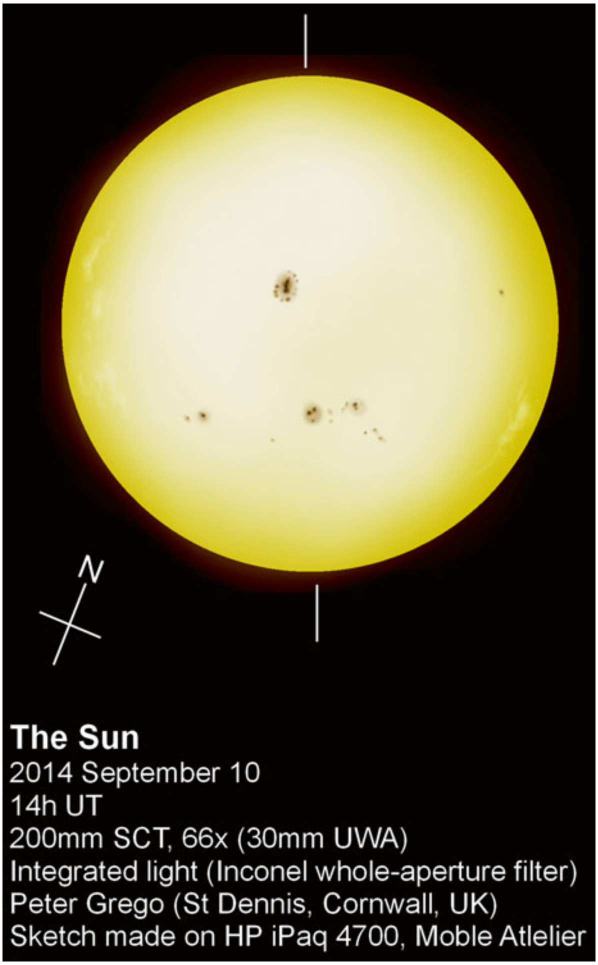

Fig. 3.25 Cybersketch of the Sun in white light—September 10, 2014, 14:00 UT. 200 mm SCT, 30 mm UWA, 66×, Inconel full-aperture filter. HP iPaq 4700. (Courtesy of Peter Grego, Cornwall, England)

Warning! ALWAYS use a suitable filter when directly observing the Sun

3.1.6 Digital (Technique of Juanchin Perez)

This next digital technique includes two applications, a photo editor and a photo-composition, to produce a smartphone sketch. A photograph of a circle drawn on white paper is used as the base template.

Suggested Materials

- Smartphone
- *Paint FX* photo effects editor app
- *Juxtaposer* photocomposition app
- Stylus
- White paper circle for use as a photographed template

Step 1

Tape a white paper plate or circle on a dark surface and photograph it with the smartphone. The phone's camera should be set to take a slightly overexposed photo. Save this image; it will be used as the solar disk template for future sketches.

Step 2

Open *Paint FX* and select the color black for the sunspot umbrae. Using the stylus, indicate the approximate positions of the sunspot groups with small black marks. Zoom into each area so that they can be drawn to their correct observed shapes. Resize by pinching and moving them around the sketch using *Juxtaposer*, and finally drop them into place to match their locations on the solar disk.

Step 3

Use *Paint FX* to select a lighter tone of gray and a brush to draw the penumbrae. Again, adjust the zoom by pinching until the sunspot is large enough to add the details.

Step 4

Select a lighter tone of gray and apply it to the limb area.

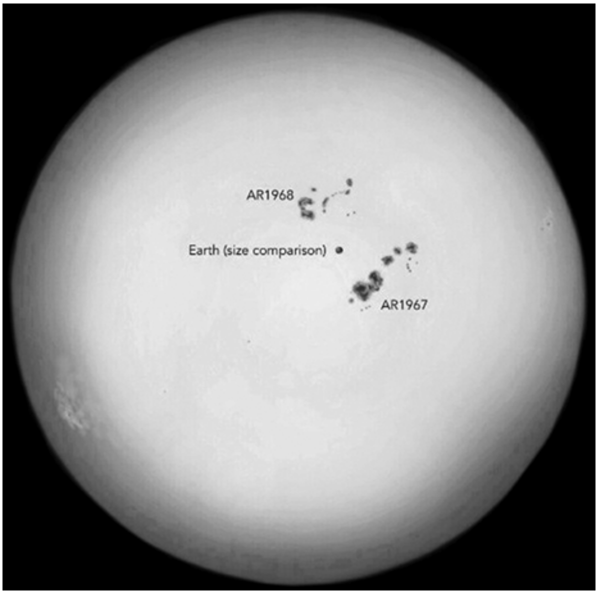

Fig. 3.26 Digital drawing of the Sun—February 4, 2014. 80 mm APO refractor, white light solar filter, 5 mm eyepiece. Digital drawing using an iPhone, Paint FX, and Juxtaposer. (Courtesy of Juanchin Perez, Arizona, USA)

Step 5

Use the *Paint FX* defocus or un-sharpening tool to soften the appearance of the interior edge of the limb. Save the changes to complete the sketch (Fig. 3.26).

3.1.7 Daily Sunspot Tracking (By Erika Rix)

As mentioned in Chap. 2—*Sketching for Science*, tracking daily sunspot movements permits us to witness the morphological changes that occur over an extended period of time. The series of sketches produced from our observations can then be compared in sequence or even brought to life through animation (see Chap. 10—*Animations, Tracking Active Regions by Erika Rix*).

Purpose

Any full disk technique and media may be used, but if sunspots are the focus for this exercise, you may want to forgo adding limb darkening and background shading. The sketches should be clean and concise for daily comparisons. This is especially important if you choose to animate the sketches.

Warning! ALWAYS use a suitable filter when directly observing the Sun

Consistency

Use the same materials and disk circumference for each sketch. Although it may not always be possible, try to observe at the same time each day for evenly spaced progression.

White Light Filter, Projection, or Both

More details can be observed using a white light filter and an eyepiece. But if you find it easier to plot prominent umbrae using a projection observing method, take advantage of that option. You can switch back to the filter and eyepiece combination to add the remainders of the sketch after the initial reference spots are in place. Remember, though, that the projected solar orientation may not match that of an eyepiece view.

For the majority of the sketches in Figs. 3.27, 3.28, and 3.29, a homemade Sun Funnel was incorporated during the first part of the observation (see Chap. 4—*Solar Projection*, Sect. 4.2 *Sun Funnel*). Because the funnel is placed in the eyepiece holder, rotating the sketch was all that was necessary to match the orientation of the two views. The projected view size was very close to the disk circumference on my sketch, making it much easier when compared to an eyepiece view, to gauge correct positions and sizes of the sunspots.

Plotting Sunspots

Compare your sketches to each other daily. The sunspots should progress forward with each drawing. To help maintain accurate placements, the previous day's sketch could be placed underneath the paper for the current observation. Match up the disk circles and orientation. In a similar vein, a solar grid template could be used underneath your sketch to assist for correct sunspot positioning (see Appendix A, Fig. A.8).

Comparing the Results

Make sure to include the dates and UT times of the observations on your sketches. Once they are scanned, the images can be rotated or flipped to match standard orientation—north is up, west is to the right. These final steps will allow comparisons to be made, not only between your own daily recordings, but also with images from other observers and space telescopes.

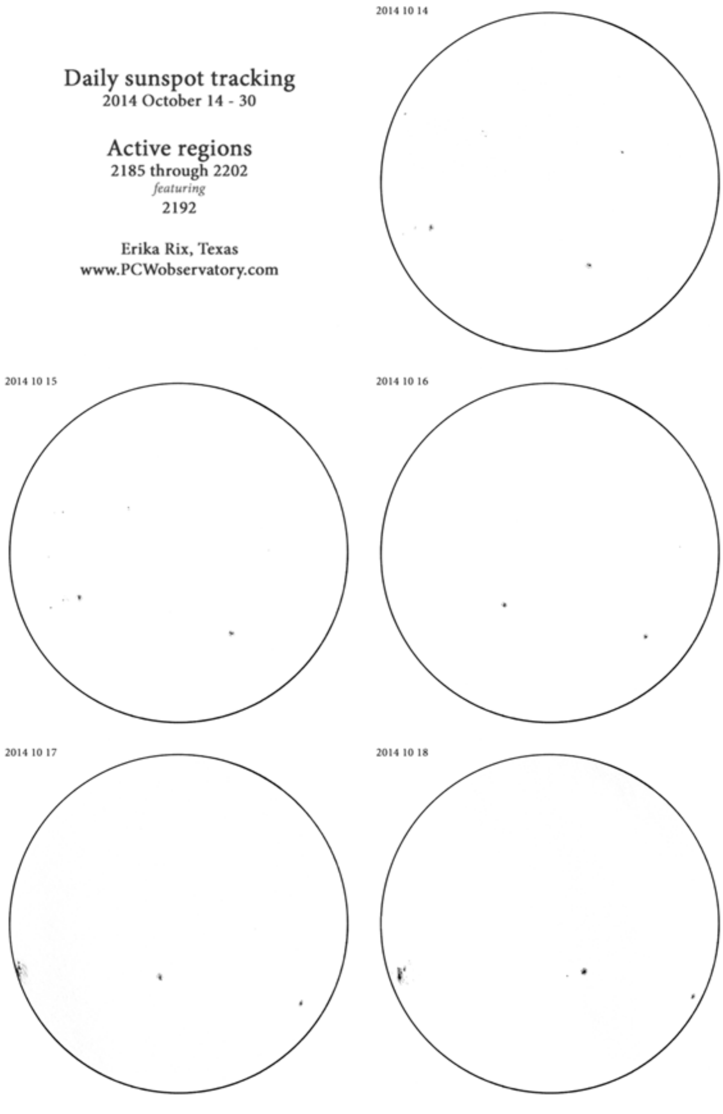

Fig. 3.27 Daily whole disk drawings to track sunspots—October 14–18, 2014. Celestron Omni XLT 102 mm f/9.8 refractor, LXD75, homemade Sun Funnel followed by a Thousand Oaks glass white light filter, Baader Planetarium Hyperion 8-24 mm Mark III set at 16 mm, 63×. WH Smith white cartridge paper (135 gsm), Faber-Castell black S artist pen, 0.5 mm mechanical pencil, blending stump, 6-in. circle template. (By Erika Rix)

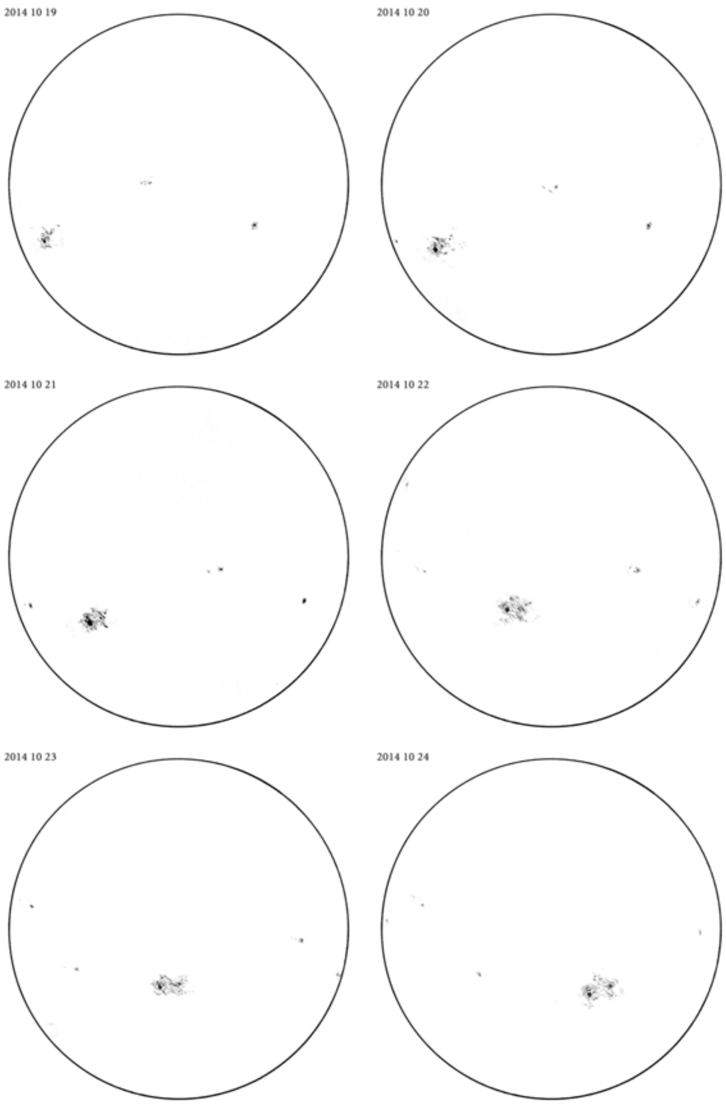

Fig. 3.28 Daily whole disk drawings to track sunspots—October 19–24, 2014. (By Erika Rix)

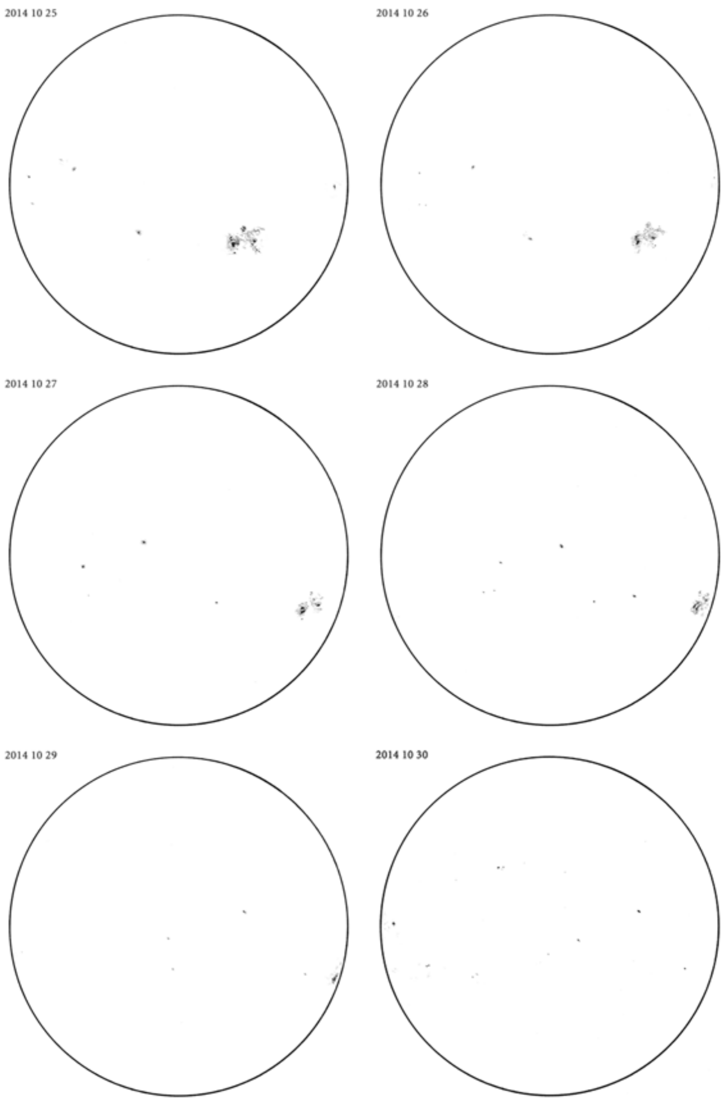

Fig. 3.29 Daily whole disk drawings to track sunspots—October 25–30, 2014. (By Erika Rix)

3.2 Active Regions

The most prominent features of the photosphere are groups of sunspots resulting from strong fluxes of magnetic fields. They are classified by their magnetic polarity. These are called active regions, and they can create some of the most energetic processes in our solar system. Consequently, they are often the preferred sketching targets when using medium to high power through a white light filtered telescope or through eyepiece projection. Simple, easy to learn techniques using graphite, pen and ink, and pastels on white paper are presented in this section (Fig. 3.30).

3.2.1 Graphite (By Sally Russell)

For this example of an interesting and complex sunspot group (Active Region 1575), I chose to use my driven mount so that I would be able to push the magnification as high as the conditions would permit.

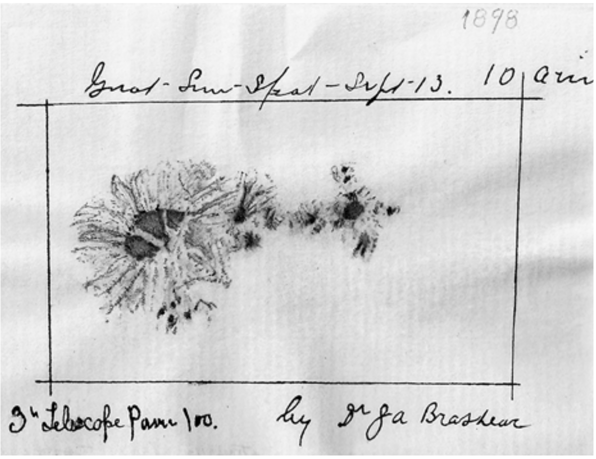

Fig. 3.30 *Great Sunspot* of September 13, 1898. This white light sketch was by John Brashear (1840–1920) with pencil on paper. The frame and inscriptions were in pen and ink. Brashear, born in Brownsville, Pennsylvania, was an astronomer, an instrument designer, and an honorary member of the RASC. It's thought that observation was from *Isle Urania*, the Brashear family island in Georgian Bay, Muskoka, Ontario. (Courtesy of the Royal Astronomical Society of Canada and *Specula astronomica minima*)

Suggested Materials

- White drawing paper (Daler-Rowney heavyweight cartridge paper, 135 lbs, 220 g/m^2, size 5¾″ × 8¼″, UK size A5, was used in this example)
- 2B and 4B graphite pencils
- Plastic eraser

Step 1

To start the sketch, I used a sharpened 2B pencil to lightly draw the rough outlines of the umbra, the dark center of the sunspot, and then put in some dots as anchor points to show the extent of the penumbra, the lighter, surrounding region (Fig. 3.31). During this process, I was checking the layout and extent of the sunspot group by constantly looking back and forth between the eyepiece and the paper. Once I was happy with the overall scale and layout, erasing and re-drawing any lines or dots as necessary, I lightly added in the more detailed outlines for the penumbra (Fig. 3.32).

Fig. 3.31

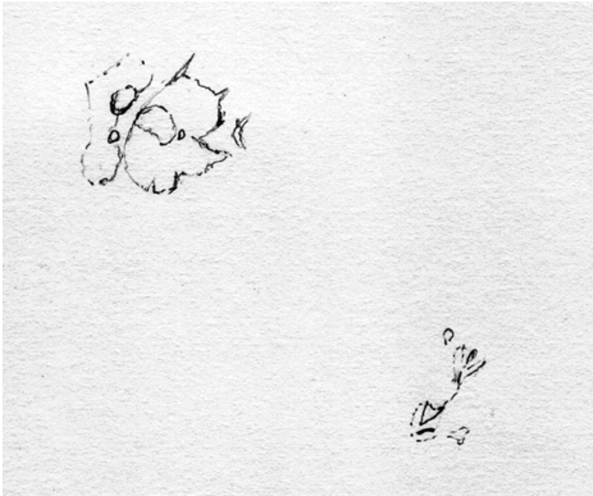

Fig. 3.32

Step 2

With the softer, 4B pencil, which gives a darker tone than a 2B pencil, I carefully shaded in the umbral regions. This helped to marry the eyepiece view with the evolving sketch (Fig. 3.33).

Step 3

Using the 2B pencil again, I started shading in the penumbral regions. I find the most realistic effect is achieved by carrying out the shading in a radial fashion, from the umbra outwards and also inwards from the outer edge of the penumbral region outline (Fig. 3.34). I rotate the page a little between working each section, so that I am always sketching with my hand in the position that I find the most comfortable. This helps to give even results (Fig. 3.35). I added any slight darker markings to the edge of the penumbra as necessary, and kept studying the eyepiece view. Because I drew a very light line to delineate the edge of the penumbral regions, this was easily incorporated as I was doing the radial drawing.

If the seeing deteriorates as the Sun rises higher in the morning sky (this often happens), then you might need to change your eyepiece to give a lower power, which has the effect of sharpening up the (now smaller) image.

Fig. 3.33

Fig. 3.34

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 3.35

Step 4

To finish the sketch, I checked the eyepiece view for any pores and small wisps of penumbra that I might have previously missed, and added these in. I then recorded the finish time for my records, and checked for and noted the cardinal directions.

Figure 3.36 is the finished sketch. The historical sketches shown in Figs. 3.37 and 3.38 provide wonderful examples of sunspots drawings from the 1800s.

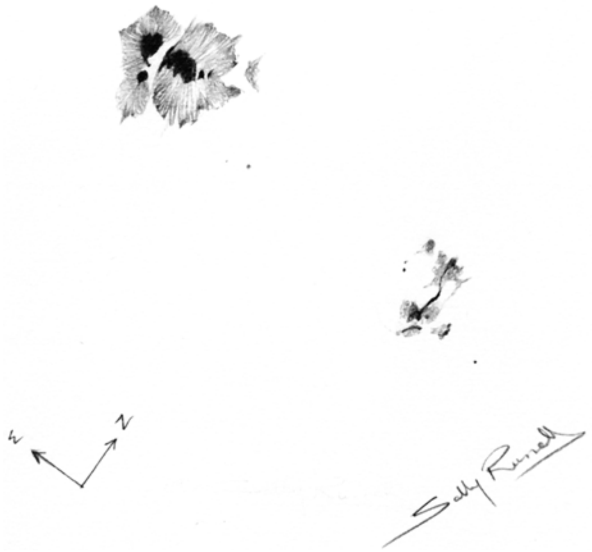

Fig. 3.36 Active region 1575—September 22, 2012, 07:55–09:55 UT. 105 mm f/6 refractor, 120×, Kendrick white light filter. Clear, calm, 55°F (13 °C), Antoniadi III-IV. Graphite on white Daler-Rowney heavyweight cartridge paper. (By Sally Russell)

Fig. 3.37 Sunspot group from February 19, 1891. Allan F. Miller (1851–1947) created this sketch with pencil and watercolor on watercolor paper. The observation was made using a 4-in. Wray refractor on an equatorial mount and a Herschel wedge. Miller was a prominent amateur solar observer of the late nineteenth and early twentieth century. His sketching style was strongly influenced by that of S. P. Langley. (Image courtesy of the Royal Astronomical Society of Canada)

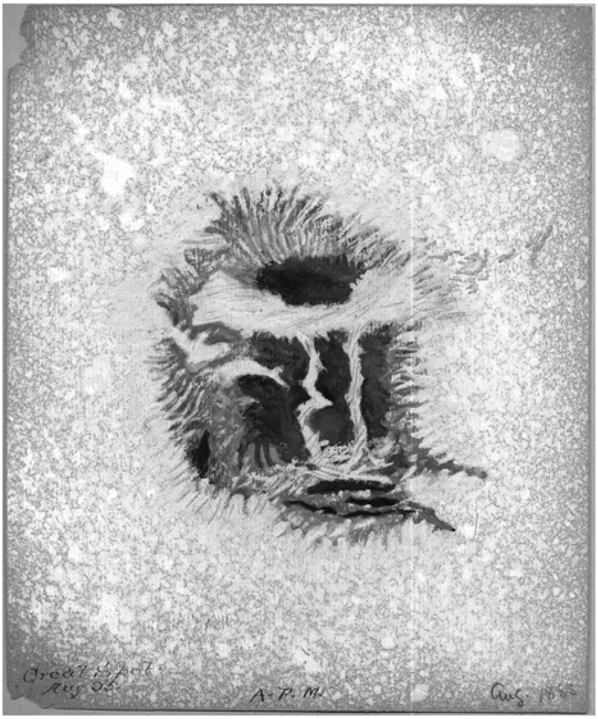

Fig. 3.38 August 23, 1888 sketch by Allan F. Miller (1851–1947). The sketch was created with pencil and watercolor on watercolor paper. A 4-in. Wray refractor on an equatorial mount and Herschel wedge were used during the observation. (Image courtesy of the Royal Astronomical Society of Canada)

3.2.2 Graphite (Technique of Dr. Hannák Judit)

Hannák Judit is the leader of the Sungazing group for the Hungarian Astronomical Association, Magyar Csillagászati Egyesület (www.mcse.hu)

Although the media is similar to that used in the previous tutorial, this technique offers a different approach to sketch active regions. Rather than starting with the darker umbra, the penumbra of the sunspot is outlined first.

Suggested Materials

- Set of HB to 4B graphite pencils
- White acid free sketch paper pad 60 lb (160 g/m^2), 9″ × 12″
- Plastic or rubber eraser

Warning! ALWAYS use a suitable filter when directly observing the Sun

Begin by selecting an interesting sunspot group to sketch. Try to provide plenty of space on the page to give enough room to document all the sunspots in a group, and sufficient space within the groups for the details of the sunspots.

Step 1

Outline the penumbrae with the HB graphite pencil.

Step 2

Next, outline the umbrae with an HB pencil. Umbral bridges are recorded in this step as well, by drawing two lines that represent the shape of their borders as they cross the umbrae.

Step 3

Add the fine filaments to the penumbrae using an H or HB pencil to render their delicate appearance. Do this by drawing closely spaced radial lines as they appear in the eyepiece. They are often seen in subtle swirling or spiraling patterns, so careful observation is needed to fully document these intricate lineations.

Step 4

Fill in the previously outlined umbrae with the 2B to 4B pencils, making note of any umbral bridges that were outlined in *Step 2*. These features could be added later by using an eraser; however, the best results are obtained by carefully filling in around them, and then leaving the white of the paper where the bridges cross the umbrae.

Step 5

Lightly shade the area around the sunspot group by holding the HB pencil at an oblique angle to the paper in order to produce broad strokes. Avoid applying graphite to those regions where the faculae are the brightest.

Step 6

Erase any of the shading applied in *Step 5* with a plastic or rubber eraser to render the details in the faculae. Figure 3.39 is of the finished sketch. Figure 3.40 is another example of a sunspot sketch from the 1800s.

Fig. 3.39 NOAA 11302—September 24, 2011, 12:30–13:20 UT. 200/2470 refractor, Fornax 51, 7 mm planetary, 352×. Graphite on white paper. (Courtesy of Dr. Hannák Judit, Polaris Observatory, Budapest, Hungary)

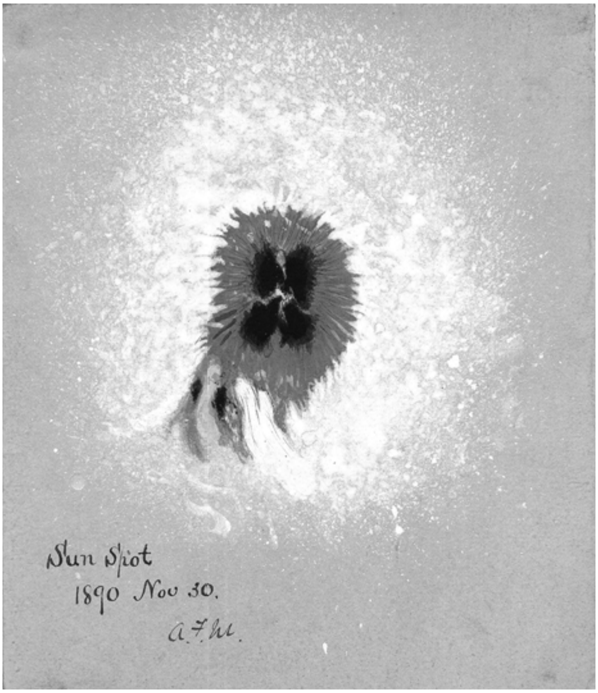

Fig. 3.40 November 30, 1890, sketch by Allan F. Miller (1851–1947). The sketch was created with pencil and watercolor on watercolor paper. A 4-in. Wray refractor on an equatorial mount and Herschel wedge were used during the observation. (Image courtesy of the Royal Astronomical Society of Canada)

Warning! ALWAYS use a suitable filter when directly observing the Sun

3.2.3 Ink (By Richard Handy)

This tutorial differs from the ink technique that was used for the full disk sketch in Fig. 3.14. A simple under-drawing is produced first with graphite before drawing over it with ink. Also, bottled India ink with pen and metal nib are used rather than a felt-tipped artist pen.

Suggested Materials

- Strathmore 400 series medium white drawing paper, 9″ × 12″
- H graphite pencil
- Art gum eraser
- India ink
- Medium-fine nib and pen

Step 1

Create a simple under-drawing by using an H graphite pencil to sketch the outline of the dark umbrae and the lighter-toned penumbrae. Any errors in the position, size, and shape of the sunspot group can easily be corrected with a pencil and art gum eraser before the permanent ink is applied (Fig. 3.41).

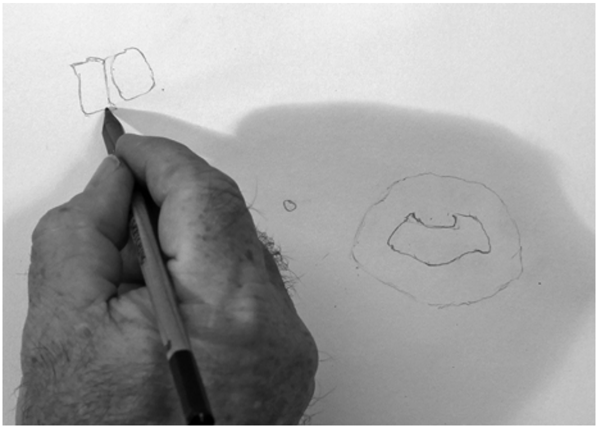

Fig. 3.41

Step 2

Light, but closely spaced dashed strokes are then applied to the interiors of the umbral outlines with a medium fine-tipped nib dipped in India ink (Figs. 3.42 and 3.43)

Fig. 3.42

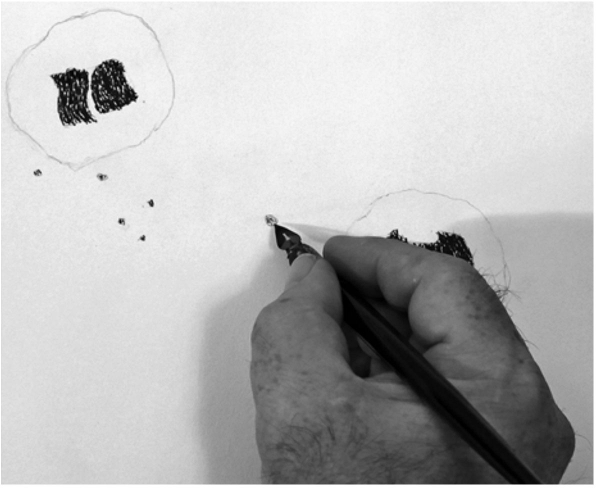

Fig. 3.43

Step 3

Next fill in the outlined areas of penumbrae with wider separated, light dashed strokes drawn approximately radial to the umbrae centers (Fig. 3.44).

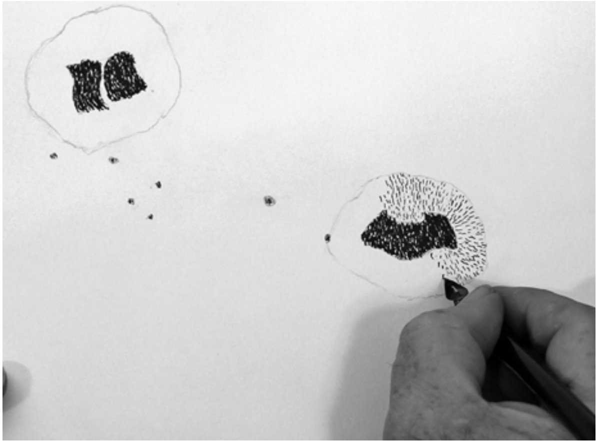

Fig. 3.44

Step 4

Once the ink is dry, the pencil under-drawing is then removed from the sketch with an art gum eraser (Fig. 3.45).

Figure 3.46 is the finished sketch.

Felt-tipped artist pens with India ink (see Fig. 3.11) make exceptional alternatives to the traditional quill pen and bottled ink. They are available separately or in sets with an assortment of nibs and colors.

Figure 3.47 illustrates how a felt-tipped artist pen is used to create the dark umbral areas of sunspots, followed by graphite for the lighter penumbrae.

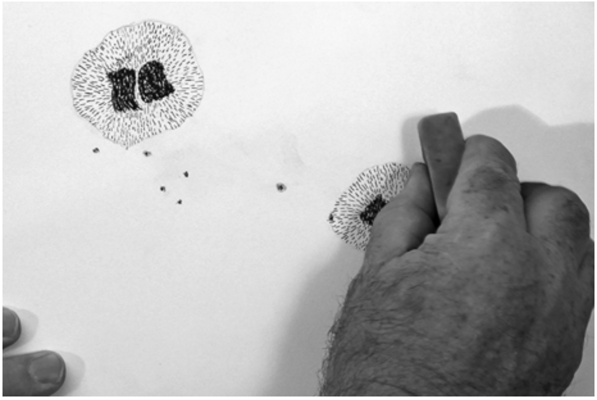

Fig. 3.45

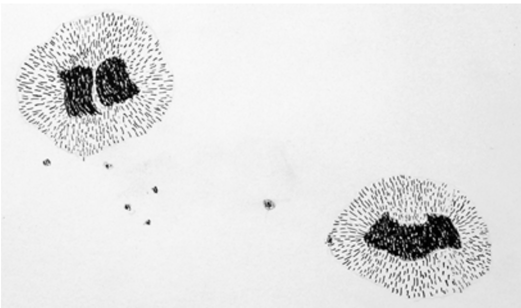

Fig. 3.46 NOAA 11861—October 13, 2013, 21:07–22:00 UT. Alter 815, 203/3048 f/15 Maksotov Cassegrain, 35 mm TeleVue Panoptic, 87×, AstroZap Baader AstroSolar filter film ND 5 visual. Antoniadi III. India ink on white paper. (By Richard Handy)

Warning! ALWAYS use a suitable filter when directly observing the Sun

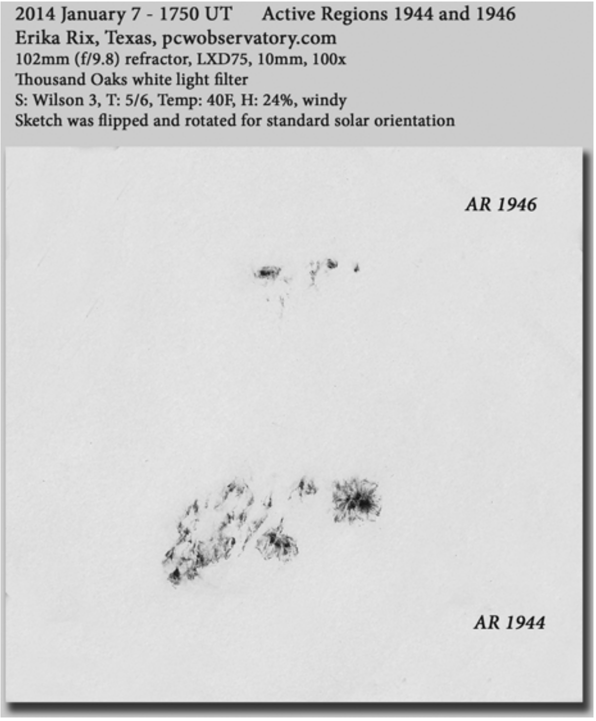

Fig. 3.47 Active regions 1944 and 1946—January 7, 2014, 1750 UT. Superfine black felt-tipped artist pen and graphite on white paper. (By Erika Rix)

3.2.4 Black Pastel on White Paper (By Richard Handy)

Most pastels are available in both stick and pencil form. Although the pencils are useful for precision and tight areas, that shouldn't prevent you from using a pastel stick for similar tasks. The trick is to make your sketch a little larger and incorporate a blending stump or a tortillon for the finer details.

Suggested Materials

- Strathmore 400 series medium white drawing paper, 9″ × 12″
- Black B Conté crayon
- Blending stump
- Art gum eraser

Step 1

When sketching a sunspot group, start by placing the most obvious features on the paper first using a black Conté crayon. These are the darker umbrae of the sunspots. Attention should be placed on the accuracy of their positions and shapes. Carefully placed firm, short strokes of the Conté represent the observed group of umbrae (Fig. 3.48).

Fig. 3.48

Fig. 3.49

Fig. 3.50

Step 2

Next, a blending stump is rubbed against the side of the black Conté crayon stick (Fig. 3.49). This loads the stump with a layer of Conté powder, which, when applied in gentle radial strokes around the umbrae, renders the appearance of the penumbrae (Fig. 3.50).

Fig. 3.51 NOAA 11721 and 11722—April 13, 2013, 16:00–16:30 UT. Alter 815, 203/3048 f/15 Maksotov Cassegrain, 35 mm TeleVue Panoptic, 87×, AstroZap Baader AstroSolar filter film ND 5 visual. Antoniadi III. Conté crayon on white paper. (By Richard Handy)

Step 3

Careful use of the blending stump, and an art gum eraser for correction, allows for a fairly realistic representation of the final form of the sunspot group.

Figure 3.51 is the finished sketch.

The color appearance of the Sun in white light usually varies in hues of white and yellowish orange. For that reason, white or pale orange colored paper is often chosen for those types of solar sketches. However, as seen in Fig. 3.52, even black paper can be used effectively to portray the white light view. Similar to using white pastel on black paper to sketch the highlights of lunar terrain so that the dark shadows automatically appear, so does the black umbra of a sunspot using the same technique (Figs. 3.53, 3.54, 3.55, 3.56, 3.57, and 3.58).

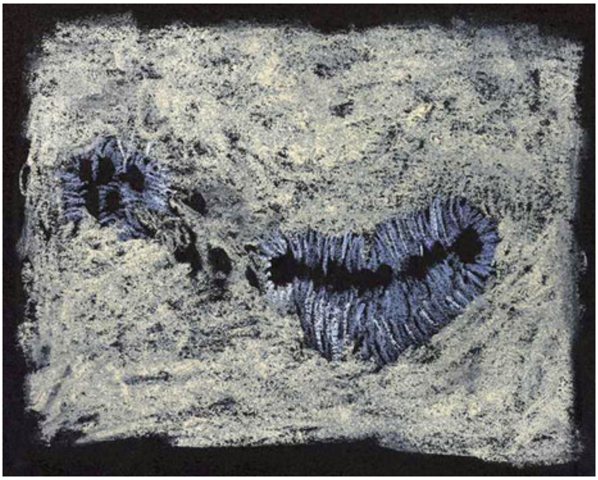

Fig. 3.52 NOAA 11040 in white light—January 14, 2010. Explore Scientific 127 mm ED refractor. Conté crayons and pastels on black Strathmore Artagain paper. (Courtesy of Stephen Ramsden, Georgia, USA)

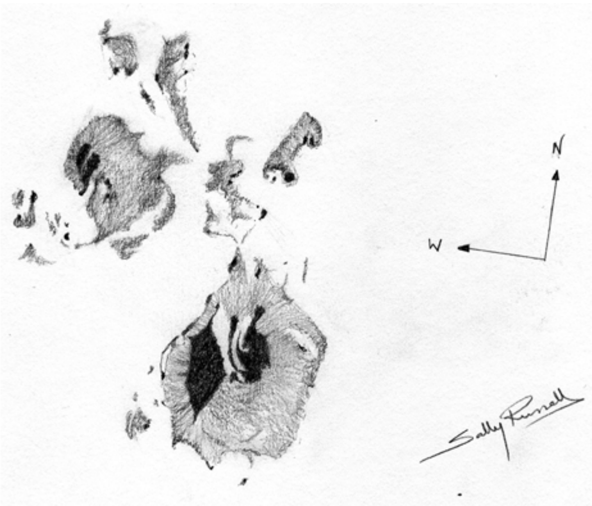

Fig. 3.53 Active region 2192 in white light—October 27, 2014, 08:38–10:00 UT. Graphite on white paper. (By Sally Russell)

Fig. 3.54 Active region 1890—November 8, 2013, 11:12–11:48 UT. 200 mm reflector with 1200 mm focal length on a Dobsonian mount, full aperture white light filter, 14 mm TeleVue Radian, 85×. Science Week 2013. Soft pencil on white paper. (Courtesy of Deirdre Kelleghan, Wicklow, Ireland)

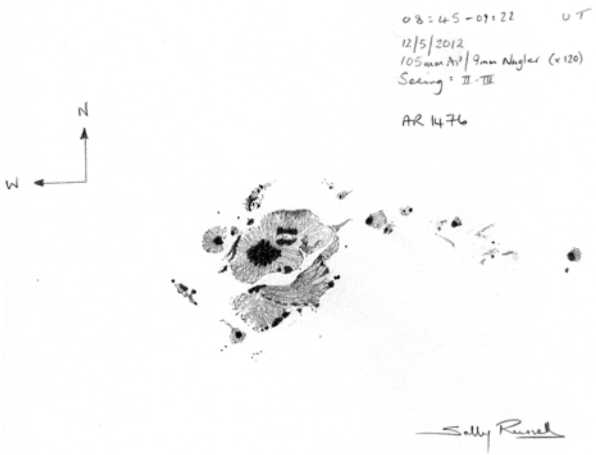

Fig. 3.55 Active region 1476 in white light—May 12, 2012, 08:45–9:22 UT. Graphite on white paper. (By Sally Russell)

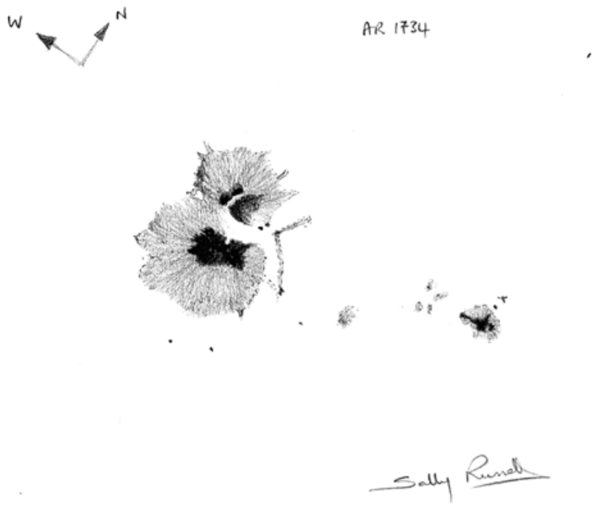

Fig. 3.56 Active region 1734 in white light—May 6, 2013, 08:39–10:10 UT. Graphite on white paper. (By Sally Russell)

Fig. 3.57 Active region 1785 in white light over two days—July 6, 2013, 14:53–15:37 UT and July 8, 2013, 18:13–18:37 UT. Graphite on white paper. (By Sally Russell)

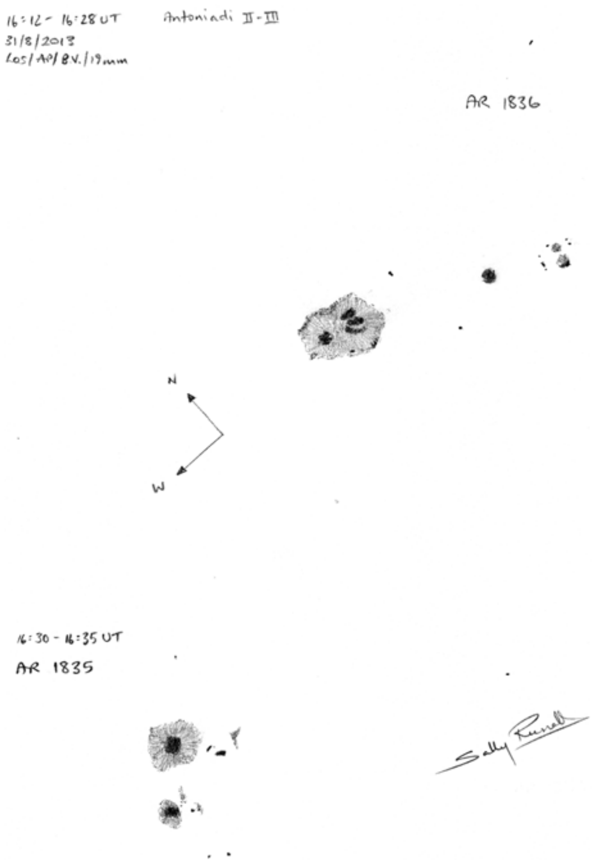

Fig. 3.58 Active regions 1835 and 1836 in white light—August 31, 2013, 16:12–16:35 UT. Graphite on white paper. (By Sally Russell)

3.2.5 Faculae: Black Pastel (By Richard Handy)

Seen most easily in white light near the solar limb, faculae are bright patches of the photosphere commonly observed near, or between, sunspot groups. They represent deeper, and therefore hotter, regions of the giant solar granulation or convection cells that, due to our perspective, appear as bright spots or patches. Faculae are associated with plages in the chromosphere.

The blending ability of pastels helps to create the soft appearance of limb darkening. Additionally, they are capable of accepting several layers so that new markings can be created over existing ones. This comes in handy when adding the lighter patches of faculae near the end of the sketch.

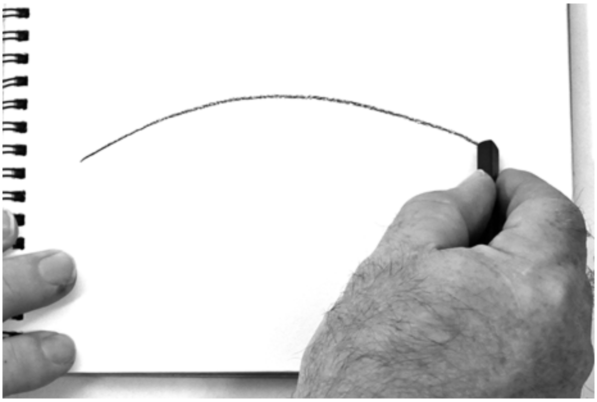

Fig. 3.59

Suggested Materials

- Strathmore 400 series medium white drawing paper, 9″ × 12″
- Conté crayons, Black 2 and White
- Art gum eraser

Step 1

The corner of a black Conté crayon stick is used to draw a segment of the solar limb's curvature in the area of a couple of active regions (Fig. 3.59).

Step 2

A blending stump is loaded with black Conté crayon by rubbing the flat side of the stick with the tip of the stump (Fig. 3.60).

Step 3

After the blending stump is gently applied to the interior edges of the curve, several layers can be added to build up a gradation, darker towards the limb and lighter towards the inner sector of the curve. Several loadings of the stump with the Conté crayon are required to represent the observed limb darkening (Fig. 3.61).

Fig. 3.60

Fig. 3.61

Step 4

The shapes and relative positions of the major sunspot umbrae in the active regions are sketched in carefully with the black Conté stick (Fig. 3.62).

Step 5

Load up the blending stump a little more heavily on the tip, and apply immediately around the umbrae to render the observed penumbrae (Fig. 3.63). The sketch is nearly finished at this point (Fig. 3.64).

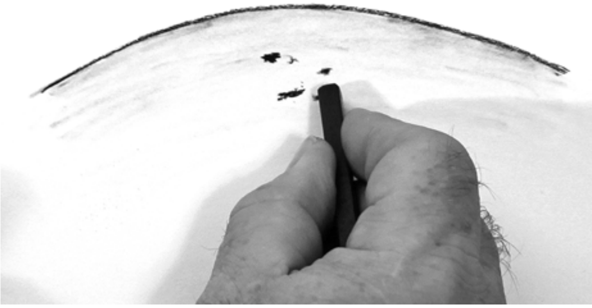

Fig. 3.62

Fig. 3.63

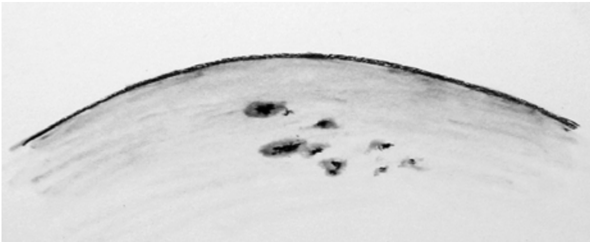

Fig. 3.64

Warning! ALWAYS use a suitable filter when directly observing the Sun

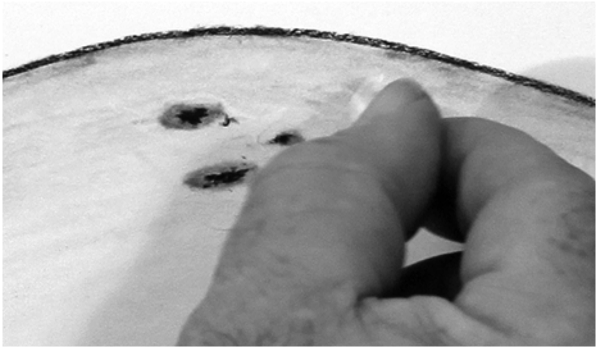

Fig. 3.65

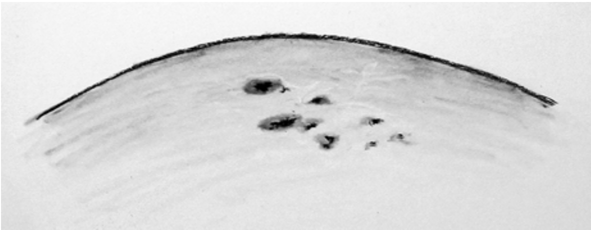

Fig. 3.66 NOAA 11861 and 11870—October 17, 2013, 18:00–18:30 UT. Alter 815, 203/3048 f/15 Maksotov Cassegrain, 35 mm TeleVue Panoptic, 87×, AstroZap Baader AstroSolar filter film ND 5 visual. Antoniadi III. Conté crayon on white paper. (By Richard Handy)

Step 6

Finally, a stick of white Conté crayon is used to sketch the appearance of bright faculae in the areas of the photosphere around the active regions (Fig. 3.65).

Figure 3.66 is the completed sketch.

3.2.6 Faculae: Charcoal and Ink (By Erika Rix)

Another method commonly used to draw faculae is to outline those sections so that they are left bare while the darker areas around them are filled in (see Chap. 6—*Calcium K Filters, Graphite Pencil and Chalk Pastel on White Paper by Sally Russell*). But as an alternative, you could do just the opposite. A darkened background is created first. Then, using a sharpened eraser, the faculae are drawn by removing the background markings to expose the underlying white paper.

Suggested Materials

- White drawing paper or card stock, at least 5″ × 7″
- Charcoal, flat stick
- Charcoal pencil, light
- Black artist pen, fine tip
- Blending stump
- White vinyl eraser, sharpened to a point

Step 1

Draw the arc of the solar limb with a charcoal pencil while using an upside down dinner plate (or something similar in size) as a template. The larger the sketch, the easier it is to add details when drawing with an eraser.

Next, create the darkened background that represents the photosphere. Although the eyepiece view is typically white or yellow, depending on the type of white light filter being used, an exaggerated darker background is created to increase the contrast for the addition of faculae. Use the flat side of the charcoal stick to fill in the solar limb. Medium pressure and circular motion should be used so that no sharp lines are created (Fig. 3.67).

Step 2

Working inward by starting at the limb's edge, use a circular motion and harder pressure with your fingertips or a chamois to blend the background. Then, add another layer of charcoal to create limb darkening. As seen in Fig. 3.68, I tend to switch to linear strokes for added control during this phase of the drawing. Again, avoid using too much pressure or the corner of the charcoal stick. Doing so could result in sharp lines that are difficult to remove.

Step 3

Blend smooth using increased pressure near the limb's edge, and then softening the pressure as you work inward. The transition should be unnoticeable (Fig. 3.69).

Step 4

Sharpen the tip of your eraser with a craft knife so that it is pointed, yet still firm enough to draw with. I use a white vinyl (plastic) eraser pencil encased in a plastic tube as shown in Fig. 3.70. Some are encased in wood, and the white variety works exceptionally well. Although the pink pearl eraser pencil is sturdy, it sometimes leaves a pink streak rather than a clean erasure.

Fig. 3.67

Fig. 3.68

Fig. 3.69

Fig. 3.70

Begin drawing the facula structures with the eraser. The harder the pressure used, the brighter the faculae will be.

Step 5

Umbrae are added next with an artist pen. Using ink creates greater contrast within the sunspots and their surroundings. And in instances where more erasure is required, it can be completed over the markings without smudging or removing them (Fig. 3.71).

Step 6

Penumbrae and the edges of faculae are defined with the use of a light charcoal pencil (Fig. 3.72). Smoothen the transition between the new charcoal additions that define the faculae and the surrounding photospheric background.

Closely scan the region once more to include any features previously missed. Seeing was poor during my observing session. By using a zoom eyepiece, the magnification could be adjusted as needed to sharpen the details. Figure 3.73 shows the completed sketch.

For more examples using a similar technique, see Chap. 3—*Whole Disk, Mixed Media (by Erika Rix)* and Chap. 6—*Sketching from an Electronic Eyepiece and Screen View, Graphite (by Sally Russell).*

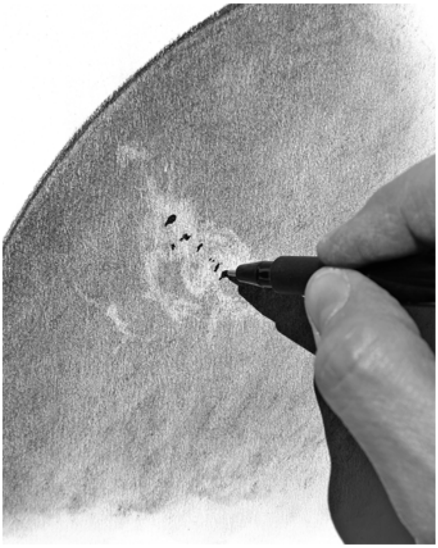

Fig. 3.71

Fig. 3.72

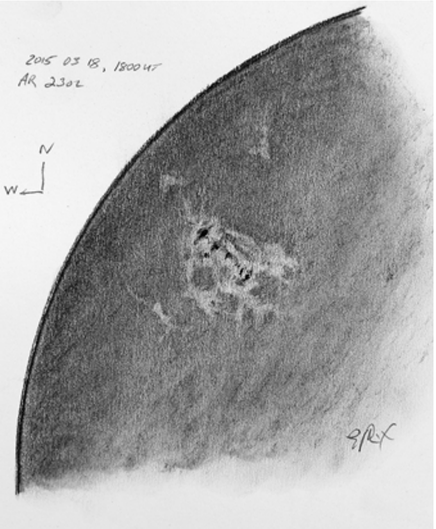

Fig. 3.73 Active region 2302—March 18, 2015, 1800 UT. Celestron Omni XLT 102 mm f/9.8 refractor, Thousand Oaks glass white light filter, Baader Planetarium Hyperion 8-24 mm Mark III, 125-42×, LXD75. Wilson I-II, transparency 5/6, lightly scattered clouds with a slight breeze, 81°F (27 °C), 36 % humidity. White card stock, charcoal stick, light charcoal pencil, Faber-Castell PITT artist pen F, sharpened vinyl eraser pencil. (By Erika Rix)

Chapter 4

Solar Projection

Solar projection permits safe solar viewing for anyone who has a telescope and a modest eyepiece. An added advantage is that it allows a number of observers to simultaneously sketch the Sun in white light. Freehand drawing and sunspot tracings can be done over the course of several days to document the evolution and positions of active regions. This chapter provides techniques best suited for these types of projection methods.

The eyepiece you choose for solar projection should not have cross wires, plastic, or cemented components, which could melt and cause damage from the intense heat of the sunlight. If the lenses are cemented, stop down the aperture of the telescope to 60–100 mm with an aperture mask.

As for telescope types, a refractor with less than 100 mm aperture and a straight through optical train works best. The use of a Newtonian reflector or catadioptric telescope runs the risk of damaging its secondary mirror holder, internal stops, and shade tubes. If you do use a reflector or a larger refractor, stop down its aperture to 60–100 mm with an aperture mask.

If in doubt on whether or not your telescope is suitable for projection techniques, check with the manufacturer first. You may also want to confirm that your telescope warranty is not invalidated if used for solar projection.

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical
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Warning!

Always supervise the use of projection equipment and never leave the telescope unattended. Never look through an unfiltered telescope, and either cover or remove all finderscopes that haven't been fitted with a solar filter.

Observe in short stints and do not leave the telescope pointed at the Sun for long durations. This could cause damage to the optics or other components of your telescope.

4.1 Sunspotter: The Safer Solar Telescope

A safe and convenient way to observe the Sun is with a self-contained solar projection unit called a Sunspotter, by Learning Technologies, Inc. (Fig. 4.1). It is a wooden, folded-path Keplerian telescope that uses a series of mirrors and a 62 mm objective lens to project a 3¼-in. (83 mm) image of the Sun onto a white viewing platform.

4.1.1 Sunspotter Basics (By Kim Hay)

The Sunspotter has two main sections—the triangle containing the projection components, and the cradle that it rests on. Sunlight enters through an objective lens and

Fig. 4.1 Sunspotter: The Safer Solar Telescope, by Learning Technologies, Inc. (By Kim Hay)

Sunspotter specifications

Objective lens	2-element achromat, 700 mm FL, fully coated
Objective aperture	61.7 mm diameter, stopped down to 57 mm
Mirrors	50 mm × 50 mm × 10 mm, two @ 25 mm × 25 mm × 5 mm, <1/4 wave
Field lens	4-element, 12.5 mm FL Plössl, fully coated, 10 mm aperture
Magnification	56×
Dimensions	16″ (H) × 15″ (L) × 6″ (W)
Weight	6.6 lbs

Fig. 4.2 Kim Hay is seen aligning the Sunspotter with the Sun's path. (By Kim Hay)

bounces off a series of mirrors before making its path through the field lens and projecting the Sun's image onto a viewing screen.

To align the unit, the cradle is moved side to side, and the triangle is tilted up and down until the shadow of the gnomon at the front of the telescope disappears (Fig. 4.2). Small adjustments are made until the light from two small pinholes on either side of the objective lens falls upon two white aiming dots on either side of

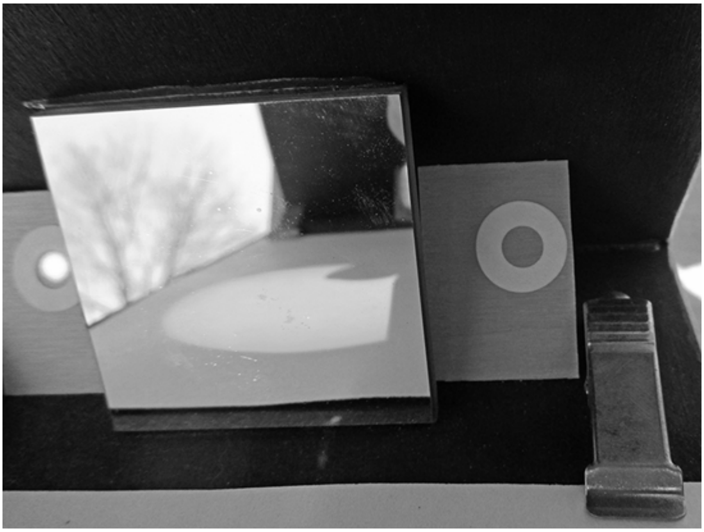

Fig. 4.3 To achieve alignment, sunlight should be visible within both white circles. (By Kim Hay)

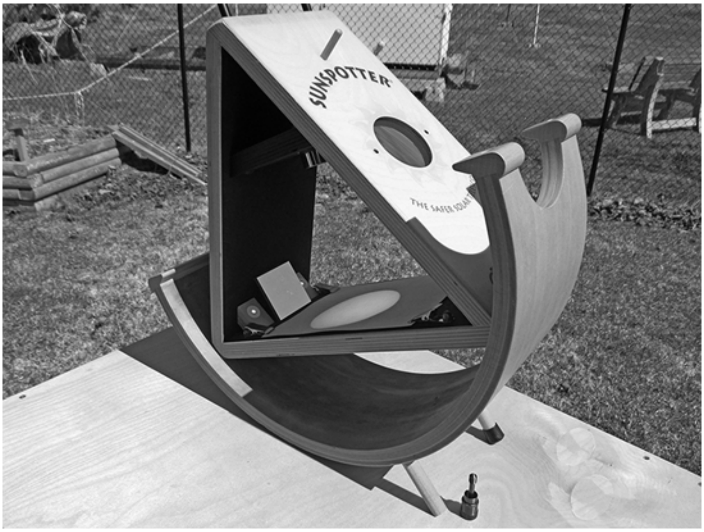

Fig. 4.4 Both white circles near the viewing platform are lit with sunlight, and the solar image is now visible. (By Kim Hay)

the unit's first mirror (Fig. 4.3). Once alignment is achieved, the solar image can be seen on the viewing screen (Fig. 4.4). For your convenience, full instructions are provided directly on the back panel of the unit (Fig. 4.5).

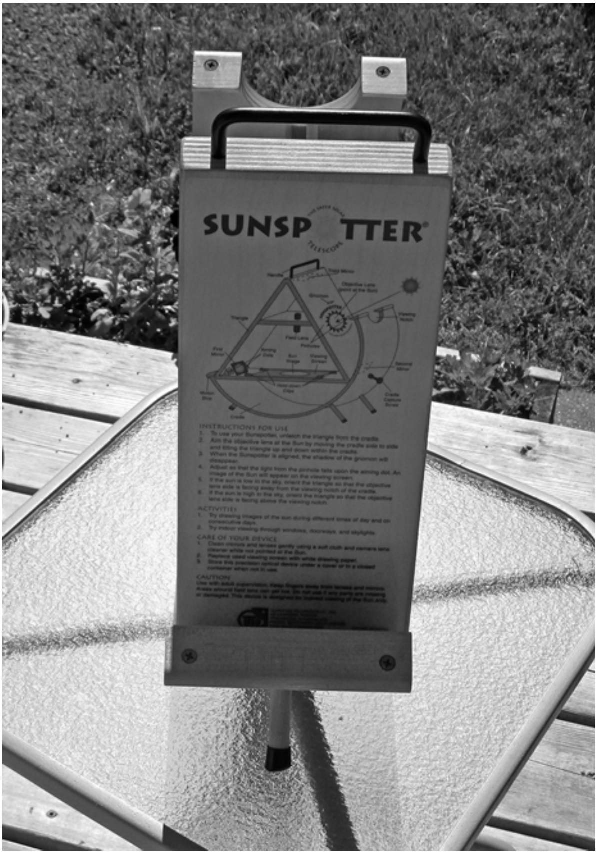

Fig. 4.5 The instructions are printed on the back panel of the Sunspotter. (By Kim Hay)

Tip

White sheets of paper, cut down to size, can be attached with metal clips to the viewing screen to improve the views. For sketching purposes, a 3 ¼-in. circular template, with or without grid references, can be drawn onto the paper.

Atmospheric conditions affect the sharpness of the projected image. So even though the unit can be used indoors through a window, it works best on sunny, transparent days. Contrasted details are difficult to see if clouds or haze are present. Figure 4.6 shows the Sun's image as projected onto the viewing platform.

Warning! ALWAYS use a suitable filter when directly observing the Sun

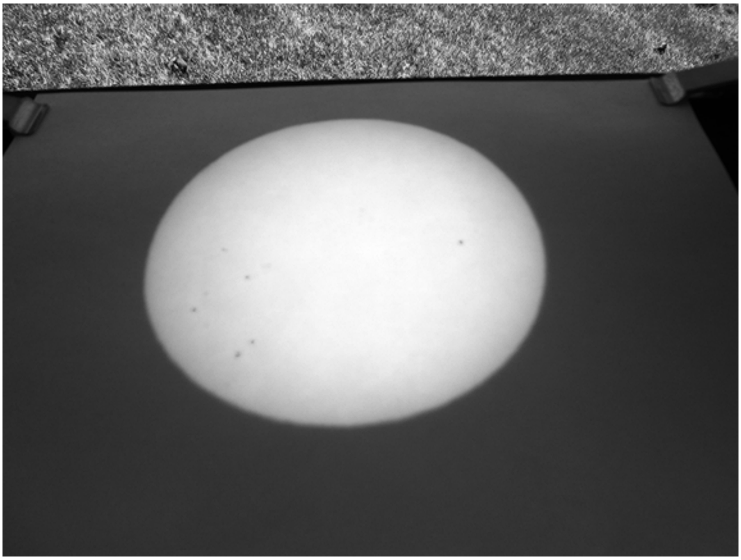

Fig. 4.6 Projected solar image displayed on the viewing platform. (By Kim Hay)

The triangle section doesn't leave much room for tracing sunspots of the projected image directly onto the paper. Also, the image drifts across the viewing screen fairly quickly due to Earth's rotation. To sketch on paper that is attached directly to the platform, constant adjustments to the unit's alignment would be required so that the sunspots are matched up each time new markings are added. You may find it easier to sketch the Sun on a separate sheet of paper off to the side of the telescope. That way you'll only need to bump the telescope every minute or two during the process. A solar grid or other type of template could be used underneath the sketch for reference. Likewise, you could sketch that day's activity directly onto the template (see Chap. 2—*Sketching for Science*).

To complete the sketch, record the equipment used, date, time in UT, and the observing conditions. The direction that the image drifts from the viewing screen is the western limb of the Sun. The sketch can then be scanned, processed, and labeled using image editing software on your computer.

Many thanks to the Department of Physics, Engineering Physics & Astronomy, Queen's University, for the use of their Sunspotter telescope during the preparation of this section.

4.1.2 *Sketching for Children (By Erika Rix)*

Many of us can recall a moment from our youth so special that it sparked a lifelong passion. We have the opportunity and the means to introduce the wonders of astronomy to children and young adults. And what better way to teach them than with hands-on observing and astronomical sketching? The following section demonstrates how the Sunspotter can be used during this worthwhile endeavor.

Suggested Materials

- White paper, minimum of 8″ × 8″, attached to a drawing board
- Ruler or protractor to draw straight lines
- Child-safe protractor compass to create circle templates
- Pencil, whichever type the child would enjoy using
- Eraser, any variety

Step 1

Set up a fun workspace for your budding astronomer. The table and chairs should be at heights suitable for their size, and the Sunspotter and sketching supplies within reach. Make sure your child is wearing suitable clothing for the weather conditions and protective sunscreen.

Step 2

Prepare a sheet of paper to be used on the Sunspotter's viewing platform. To do this, create a 3 ¼-in. circle template in the center of the paper, and then draw cross hairs on it. This breaks up the solar disk image and provides a drawing reference for the child. Alternatively, you could create a drawing grid similar to the Solar Grid template (Fig. A.8) found in Appendix A.

Place the paper on the viewing platform, and then align the telescope so that the Sun's image is projected within the circle template. Once the image is centered, the paper can be trimmed down with scissors and secured with the metal clips that are provided on the platform (Fig. 4.7).

At this point, the child could actually trace the sunspots onto the projected solar image. But keep in mind that it is beneficial for him or her to use the projected image only as a reference while creating the actual sketch on a separate sheet of paper. Doing so improves hand/eye coordination and trains the child how to observe. The following steps explain the sketching process.

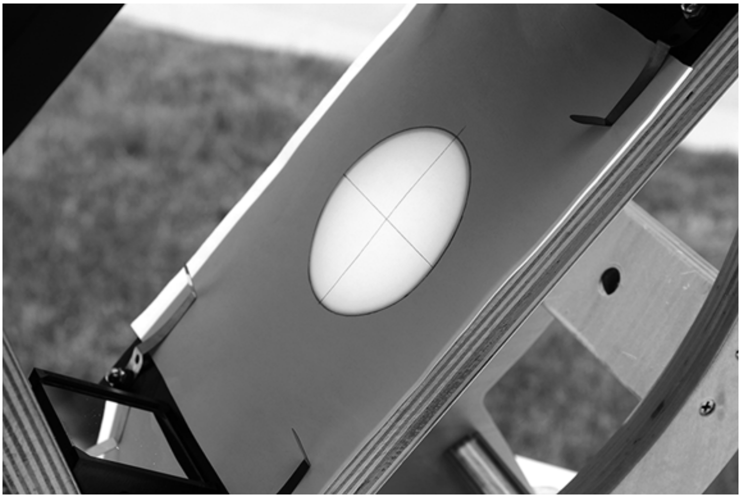

Fig. 4.7 Drawing reference for the projected solar image. (By Erika Rix)

Step 3

From this step forward, the child should complete all steps with minimal intervention from you other than guidance. Your role should be that of support and encouragement as you explain how to do each step and its purpose.

An outline of the Sun is drawn onto the paper. Let the child decide its size, but try to encourage one large enough that there is room to draw, yet small enough to not be overwhelming. Three inches to five inches in diameter is optimal.

Select the hole setting for the desired circle size, and then have the child place the pencil's tip into it. While the circle is being drawn, you may need to help hold the compass in place (Fig. 4.8).

Step 4

The straight edge of a protractor is used to create cross hairs on the sketching paper to match those of the viewing platform. The idea is to have identical grid references for both the drawing circle and the projected solar image. Again, you may need to support the protractor during this process so that it remains firmly in place (Fig. 4.9).

Fig. 4.8 A child-safe protractor compass is used to create a circle template on the sketching paper. (By Erika Rix)

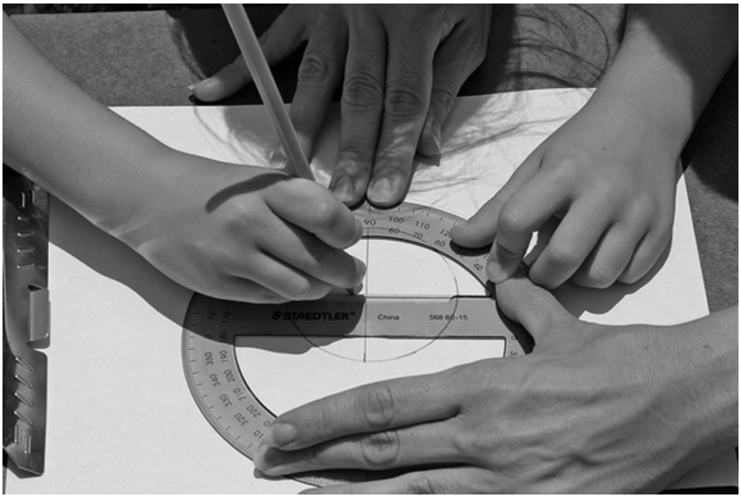

Fig. 4.9 Use a straight edge to draw crosshairs with the circle template. (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

Step 5

Align the Sunspotter so that the solar image is projected within the circular grid on the viewing platform. The image will slowly drift out of view, so frequent adjustments will be necessary during the course of the sketch.

Kids love fun facts about the Sun (see Chap. 2—*Sketching for Science,* Sect. 2.1 *Solar Facts*). Take a few moments to point out the sunspots. Explain briefly what they are as well as how we can track their movements and evolving shapes. He or she may notice that the spots have darker and lighter areas within them. That is a great opportunity to explain the difference between an umbra and a penumbra.

Have your child locate the largest sunspot on the viewing platform and ask where it should be drawn within the sketch circle. The drawing grids on both sheets of paper should be used to cross-reference their positions (Fig. 4.10).

Step 6

The pencil should be held fairly upright for precise markings. The darker umbra is recorded first, and then lighter pencil pressure is used to create the penumbra if observed. Any remaining sunspots are drawn in similar fashion.

If a mistake is made, it's generally easier to put a light cross through it and then continue with the sketch. However, keep the eraser handy should your child prefer that option instead. You can't blame a kid for wanting a perfect sketch! (Fig. 4.11).

Fig. 4.10 Tara Krzywonski explains how to plot sunspots to her daughter, Emily. (By Erika Rix)

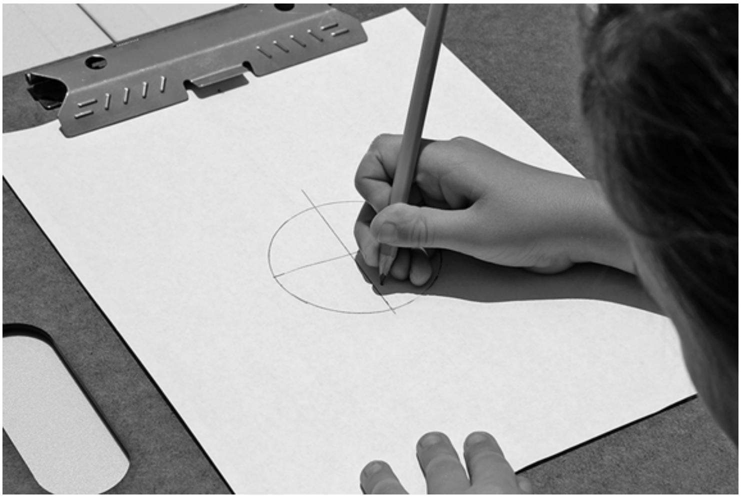

Fig. 4.11 Crosshairs are used for accurate sunspot placements. (By Erika Rix)

The young astronomer featured in this section now teaches other children how to sketch the Sun. For more information, see Chap. 11—*Ideas for Outreach*.

4.2 Sun Funnel

Do you have spare, inexpensive eyepieces lying around? If so, you'll want to check out the easy-to-follow instructions to build your own Sun Funnel—*Build a Sun Funnel for Group Viewing of Sunspots & the Transit of Venus.* http://galileoscope.org/wp-content/uploads/2012/02/Build_a_Sun_Funnel1.pdf

A Sun Funnel is a rear-screen solar-projection device that fits into the telescope's eyepiece barrel. This avoids the risk of someone accidentally looking through the eyepiece of an unfiltered telescope. It's easy to build using simple, low cost materials. And because it allows a group of people to safely observe the Sun at the same time, it's perfect for outreach and special celestial events (Figs. 4.12 and 4.13).

4.2.1 Active Regions (By Erika Rix)

Plotting the initial two or three sunspots onto your blank circle template is the most important, and also the most difficult, step of the sketching process. Since they are to be used as references while plotting the remaining sunspots, it's imperative that each mark is created with accuracy.

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 4.12 Sun Funnel attached to a 102 mm f/9.8 refractor on a driven mount. (By Erika Rix)

The large viewing area of the Sun Funnel's projection screen makes that step easier. For starters, the drawing board with your sketch paper attached to it can be held next to the projected image for side-by-side comparisons. Secondly, the projected image is nearer in size to the circle template when compared to the view through an eyepiece, so little thought is needed to adjust the size of the sketched object (Fig. 4.14).

If seeing and transparency permit, the entire sketch can be made with the use of a Sun Funnel. Otherwise, you can switch to a solar filter and eyepiece combination to add the remainder of the sketch details after the initial reference spots are in place. Eyepiece views are usually clearer and allow for higher magnifications. Be sure to attach the solar filter to your telescope before removing the Sun Funnel.

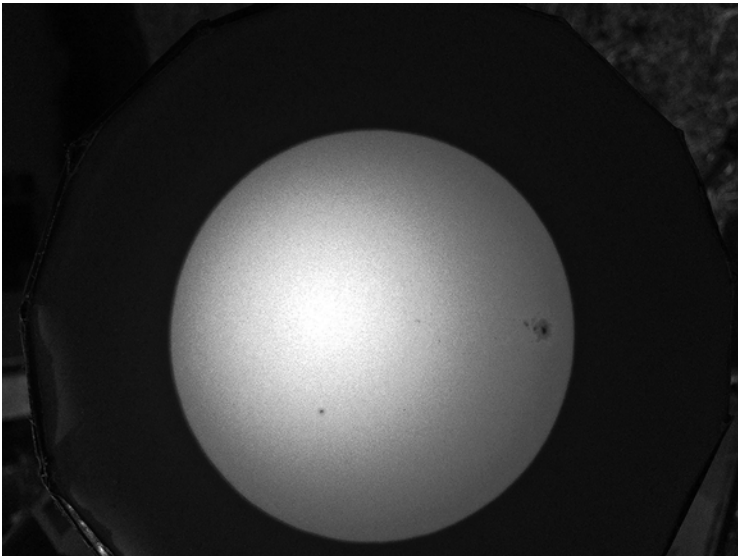

Fig. 4.13 Projected solar image on October 19, 2014 while using a Sun Funnel. (By Erika Rix)

Fig. 4.14 Hold the sketch close to the Sun Funnel to easily cross-reference between the two views. (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

Suggested Materials

- White paper, minimum of 8″ × 8″, attached to a drawing board
- Black artist pen, superfine nib (can substitute with a 2B or 4B graphite pencil)
- #2 (HB) graphite pencil or a 0.5 mm mechanical pencil, for greater precision
- Small blending stump
- 6-in. circular protractor

Step 1

Using the pen and protractor, create a circle temple on the paper to represent the Sun's disk. The larger the drawing circle, the easier it will be to sketch the details of your observation. Six inches in diameter should suffice. Then refer to See Chap. 1—*Introduction to Solar Observing and Sketching*, Sect. 1.2 *Essential Tips*, *Finding the Sun* to align your telescope. Remember to cover or remove the finderscope. Rather than using an eyepiece, insert the Sun Funnel into the eyepiece barrel.

Add the most prominent umbra to the sketch circle first by holding the artist pen upright just above the location it should be within the disk. Lower the nib onto the paper. The pen pressure and the length of time that the nib touches the paper affect the size of the spot (Fig. 4.15). Imagine cross hairs or a clock face on both the projected solar image and your circle template. It will provide grid references between the two for accuracy.

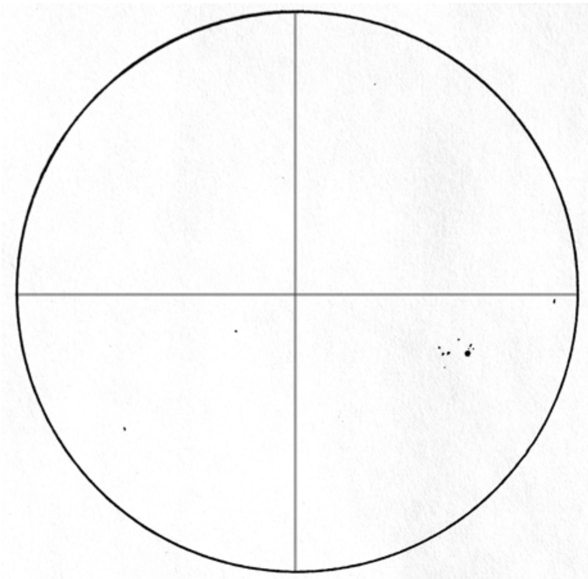

Fig. 4.15 Imagining crosshairs on both the projected solar image and your circle template provides grid references when plotting sunspots. (By Erika Rix)

Tip

For improved views, fit a sun shield over the optical tube at the front of your telescope so that the projection screen is shaded. See Chap. 1—*Introduction to Solar Observing and Sketching*, Sect. 1.1 *Basic Equipment*, *Sun Shields.*

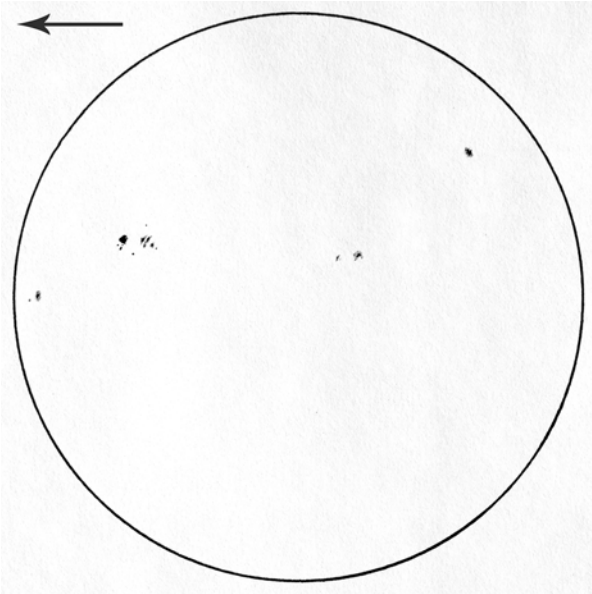

Fig. 4.16 Switching from the Sun Funnel view to the eyepiece and solar filter view might result in differing solar view orientations. Adjust your sketch orientation accordingly. (By Erika Rix)

Step 2

Outline penumbrae very lightly with the #2 graphite pencil, and then decide if you will proceed with the Sun Funnel or switch to the solar filter/eyepiece combination. If you swap them out, it may be necessary to rotate the sketch to match the eyepiece orientation. Depending on the Sun's activity the day of your observation, there may be too few sunspots to easily do this. Marking the direction of drift just outside of the sketch area enables a positive match.

Delicately and with precision, begin adding the detailed areas of the penumbrae with the #2 graphite pencil. Look closely for previously missed umbrae or pores, and add them next with the artist pen (Fig. 4.16).

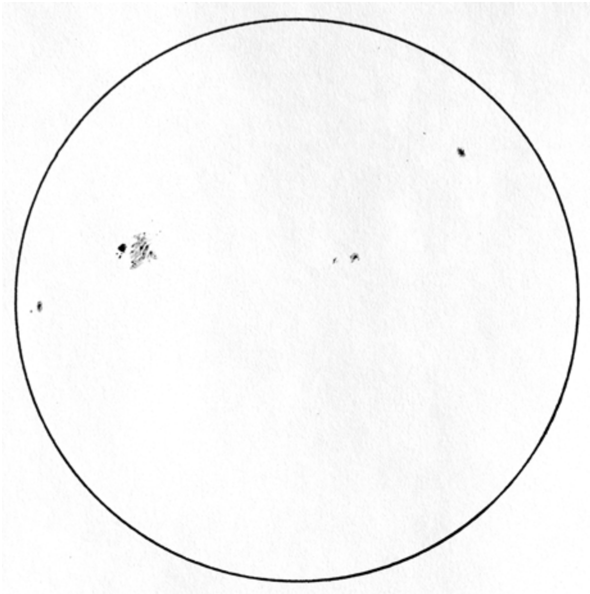

Fig. 4.17 Heightened details of complex regions can be observed by switching to an eyepiece view with the use of a proper solar filter to the front end of the telescope. (By Erika Rix)

Step 3

The large active region shown in Fig. 4.17 was so complex that instead of outlining the area, I held off tackling it until I switched to the eyepiece/filter view. It permitted higher magnification for a more precise sketch. I used a 0.5 mm mechanical pencil to complete that region.

Step 4

The tip of a small, clean blending stump can be used to carefully smudge areas where needed. Be aware, though, that you may have to touch up any sunspots that were softened in the process. If you notice faint bands of contrast around the active regions, they can be rendered lightly with the tip of a blending stump that still has graphite on it. Include notes pertaining to your observation to finish the sketch (Fig. 4.18).

This method of using both projected and eyepiece views provides detailed results for daily solar records. See Figs. 3.27 through 3.29 in Chap. 3—*White Light Filters*, Sect. 3.1 *Whole Disk*, *Daily Sunspot Tracking (by Erika Rix)* for a 17-day sketch sequence using this technique.

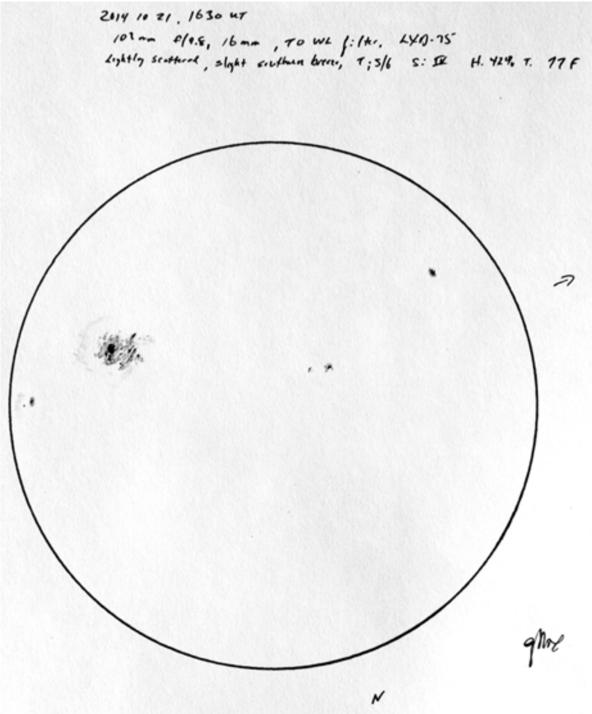

Fig. 4.18 Active regions 2187, 2191–2194 in white light—October 21, 2014, 1630 UT. Celestron Omni XLT 102 mm f/9.8 refractor, LXD75, homemade Sun Funnel followed by a Thousand Oaks glass white light filter, Baader Planetarium Hyperion 8–24 mm Mark III set at 16 mm, 63×. Wilson IV, transparency 5/6, lightly scattered clouds with a slight breeze, 77°F (25°C), 42 % humidity. WH Smith white cartridge paper (135 gsm), Faber-Castell black S artist pen, 0.5 mm mechanical pencil, blending stump, 6-in. circle template. (By Erika Rix)

4.2.2 Adding Additional Solar Features (By Erika Rix)

When tracking active regions, the less complex the sketch, the better. This especially holds true if there is a chance that the sketches will be used for an animation. Resist the urge to add background shading and limb darkening so that the daily comparisons are clean and easy to interpret.

On the other hand, including those extra features results in a more thorough record of the day's activity. This leaves two choices, assuming you would like to retain a clean version preferred for daily tracking. The first option is to create a second sketch; the other is to save a scanned version of the original sketch before adding the remaining solar features. This section explains how to continue with the sketch.

Suggested Materials

- That day's active region sketch
- Black pencil—graphite, charcoal, or color pencil
- Blending stump
- Eraser—vinyl eraser sharpened to a point or a gum eraser pencil

Step 1

Background shading and limb darkening are typically added at the beginning of a sketch. But because you'll be using a sketch that was already completed for daily tracking, limb darkening is added afterward.

Hold the black pencil at a very shallow angle against the paper just inside the disk's edge. Then with light pressure against the paper, make controlled back and forth pencil motions while leaving little trace of the stroke lines. Grasping the pencil further back from its point will help you achieve better results. To prevent the previously drawn sunspots from being smeared, be careful not to rest your fingers or the palm of your hand over them for support (Fig. 4.19).

The sketch used for Fig. 4.19 *was from a different observation day than that used for Fig.* 4.18.

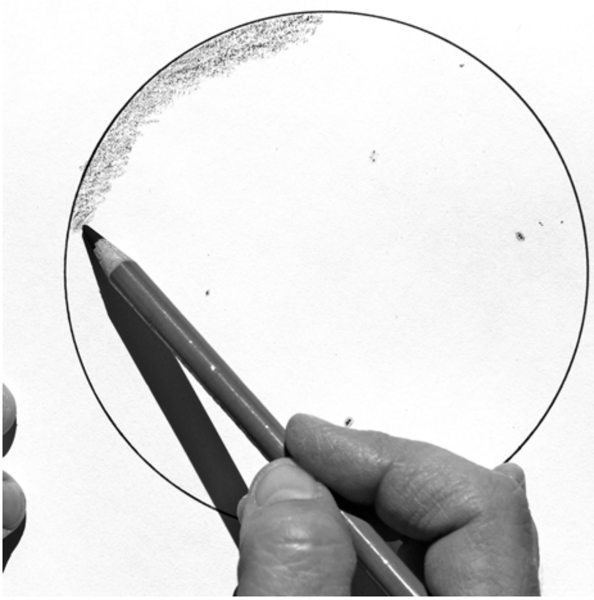

Fig. 4.19

Step 2

Grasp the blending stump closer to its tip. Starting just inside the disk outline, smooth the pencil markings using firm, small circular motions. The shading will gradually lighten as you continue blending toward the center of the disk. Work around areas of faculae so that they are left white (notice the white patch left near the top right limb of Fig. 4.20). Likewise, care is taken around sunspots so that they aren't smudged in the process.

Step 3

A sharpened eraser pencil can be used to render faculae by removing the gray background. The brightness of those areas is determined by the amount of eraser pressure used (Fig. 4.21).

Fig. 4.20

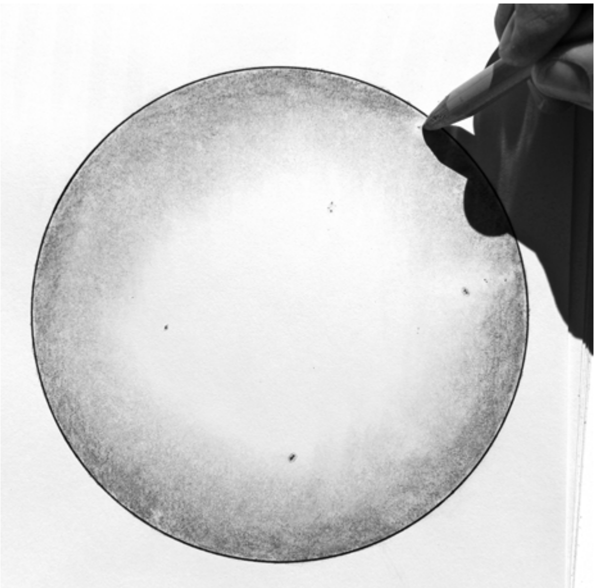

Fig. 4.21

Tip

Before using the eraser on your sketch, experiment with it on a scrap piece of paper to determine how cleanly it removes the type of medium being used. The eraser might leave a film, or as with some gum erasers, a pink hue that is difficult to remove.

Step 4

If needed, use the black pencil to lightly add more contrast around the patches of faculae. Blend the new markings with a blending stump. Add relevant observing details and orientation, rotating the sketch to represent either the Sun Funnel view or that of the eyepiece (Fig. 4.22).

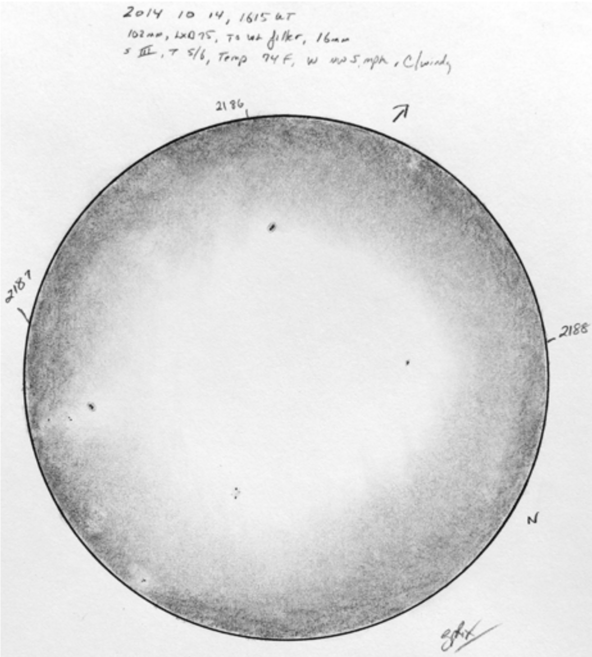

Fig. 4.22 Active regions 2185-2189 in white light—October 14, 2014, 1615 UT. Celestron Omni XLT 102 mm f/9.8 refractor, LXD75, homemade Sun Funnel followed by a Thousand Oaks glass white light filter, Baader Planetarium Hyperion 8–24 mm Mark III set at 16 mm, 63×. Wilson III, transparency 5/6, clear with westerly winds 5mph, 74°F (23°C). WH Smith white cartridge paper (135 gsm), Faber-Castell black S artist pen, 0.5 mm mechanical pencil, blending stump, 6-in. circle template. (By Erika Rix)

4.3 Eyepiece Projection

There are two advantages of using eyepiece projection over a Sun Funnel. First of all, no special equipment is needed. Secondly, and more importantly, is that sunspots can be traced *directly onto* the paper used for the projection. That translates to accuracy in the size, shapes, and positions of the sunspots (Fig. 4.23).

Some observers prefer to attach the projection board (for all practical purposes, this will be your drawing board) to their telescope by means of mounting brackets. The solar image remains within the circle template during the course of the sketch as long as the Sun is in alignment with the telescope (Fig. 4.24).

Others forgo the mounting brackets and manually move their drawing boards as needed. With each pass of the projected image that drifts across your paper, only a few additions can be added before the drawing board has to be nudged again. Contrary to using a mounting bracket, this requires more effort. With either method, a driven mount eliminates the added task of tracking the Sun.

Warning! ALWAYS use a suitable filter when directly observing the Sun

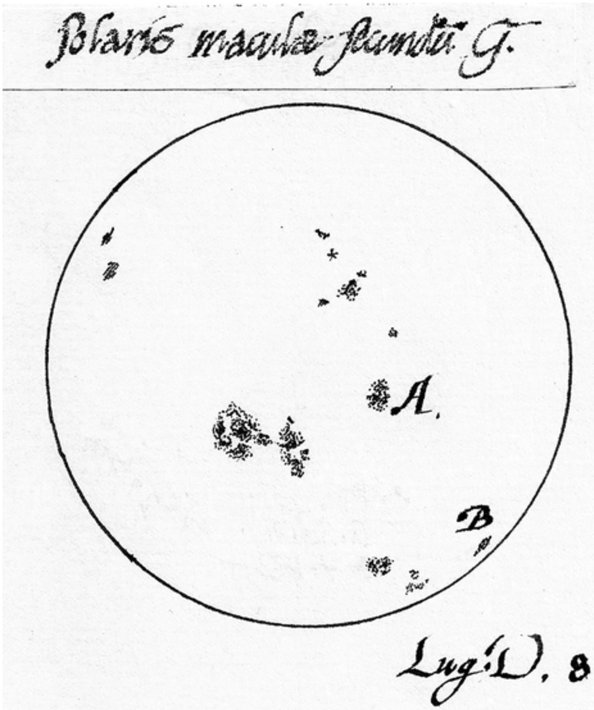

Fig. 4.23 July 8, 1612, projected solar disk sketch by Galileo Galilei (1564–1642) using pen and ink on paper. Early seventeenth century telescopes were capable of good resolution. Galileo and his colleagues did not observe the Sun directly through the eyepiece, but used the method of projecting the image onto a flat surface perpendicular to the optical axis. The typical medium for surviving solar sketches from the seventeenth to eighteenth centuries is pen and ink. It is possible that some eyepiece sketches were done in correctible media, such as pencil or charcoal, and then redrawn in pen and ink for formal notebooks containing second-generation observational records, thus possibly making the survival of the first-generation observational drawings less imperative. (Image courtesy of *Specula astronomica minima*, image after Galileo)

4.3.1 Basic Sketch Technique (By Erika Rix)

This next technique explains how to complete a projected sketch of the Sun without mounting brackets. Since your drawing board won't be mounted to a telescope, find a suitable stand, easel, or wall to support it during the observation.

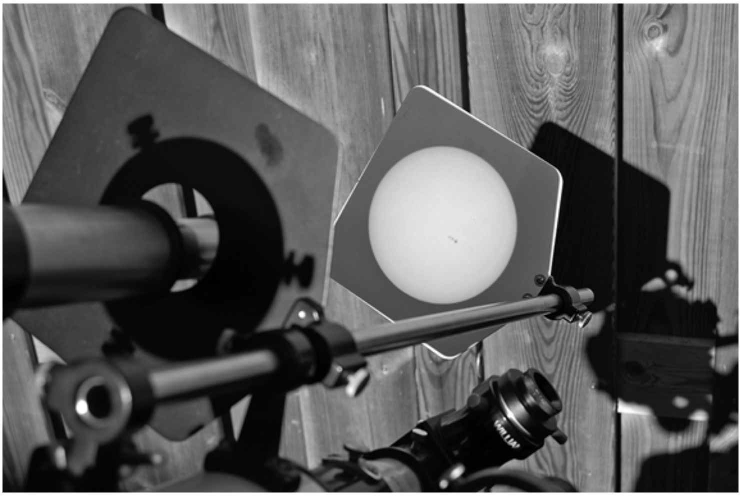

Fig. 4.24 Mounting brackets can be used to attach the projection screen to the telescope. (Courtesy of Roel Weijenberg, Deventer, Netherlands)

Suggested Materials

- White paper, minimum of 8″ × 8″, attached to a drawing board
- #2 (HB) graphite pencil or a 0.5 mm mechanical pencil, for greater precision
- 6-in. circular protractor or compass
- Large box or cloth to shade the paper for higher contrast

Step 1

Using the pen and protractor, create a circle temple on the paper to represent the Sun's disk. Three inches to six inches in diameter is a good size for this type of projection sketching.

Step 2

Refer to Chap. 1—*Introduction to Solar Observing and Sketching*, Sect. 1.2 *Essential Tips*, *Finding the Sun* to align your telescope. Remember to cover or remove the finderscope. Hold your drawing board behind the telescope. Once the solar image is projected onto your paper, alignment is achieved.

Tip

Some dust covers have removable centers. If so, it can be used to reduce the aperture of your telescope rather than making an aperture mask (Fig. 4.25).

Fig. 4.25 When the center of a dust cover is removed, it can serve as an aperture mask. (By Erika Rix)

Adjust the distance between the drawing board and the eyepiece until the Sun fits within the circle template on the paper, and then adjust the focus. If the image looks elliptical, you will need to square up the drawing board with the eyepiece until the image is circular again. Move the stand into position to support your drawing board. If a wall is to be used, you may have to move the telescope mount.

Place the box or cloth around the drawing board so that the projected image is shaded from direct sunlight. This increases contrast. Figure 4.26 shows the complete set up with the solar image projected onto the sketch paper.

Step 3

Refit the Sun's image within the circle template and then swiftly draw the umbral portions of the sunspots with the pencil. Matching the sketch to the projected image of the Sun during each pass becomes easier as more spots are added (Fig. 4.27).

Fig. 4.26 Solar eyepiece projection using a 102 mm f/9.8 refractor with a 12 mm eyepiece and a tracking mount. The telescope's aperture was stopped down to 51 mm, 12 mm eyepiece. (By Erika Rix)

Step 4

Again, refit the projected image within the circle template. This time, use the pencil to trace the penumbrae. After this pass, darken the umbrae if needed. You can hold the pencil at a very shallow angle, and with little pressure on the paper, to lightly fill in the penumbral areas.

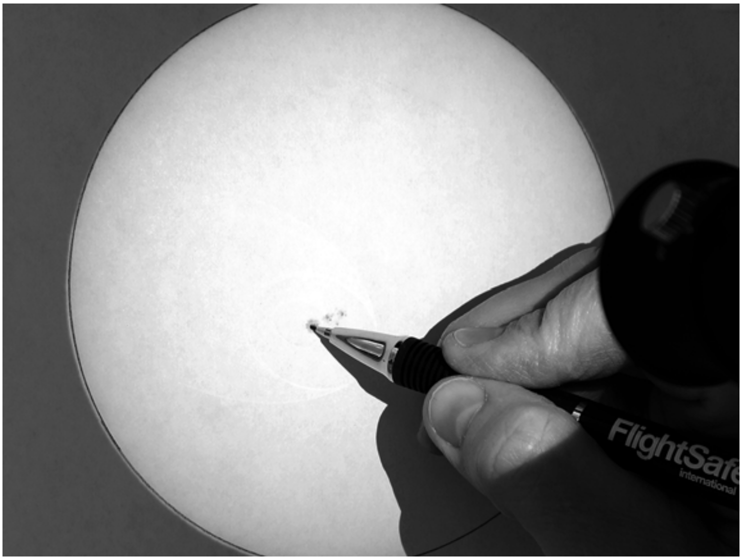

Fig. 4.27 One of the benefits of solar projection is the ability to either mark or trace the positions of the sunspots directly onto the projection paper. This is especially useful if the sole purpose is to record daily solar activity rather than a free-hand rendering. (By Erika Rix)

Step 5

Repeat *Step 3* and *Step 4* until no further details are seen. Scan the entire view once more to capture missed sunspots. Finally, observation notes and orientation are included (Fig. 4.28). Attach the telescope's dust cap immediately after the sketch is completed.

4.3.2 Adding Additional Solar Features (By Erika Rix)

Any sketch produced from eyepiece projection can be finished off directly at the eyepiece with a proper solar filter fitted to the front end of the telescope. The caveat, however, is that the eyepiece projected view (unlike the Sun Funnel) has a mirrored orientation from that of an eyepiece view. Different diagonal or straight through optical path combinations could correct for this. Otherwise, you will need high levels of concentration to mentally mirror the image as you sketch. As an example, when using an ETX70-AT to observe the Sun, west would normally be 90° clockwise from south. Through eyepiece projection, west was 90° counterclockwise from south as seen with the sketch in Fig. 4.29.

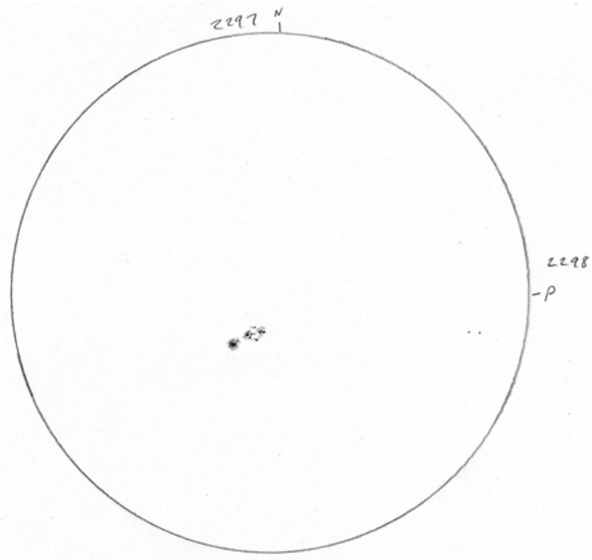

Fig. 4.28 Active regions 2297 and 2298—March 12, 2015, 19:00 UT. Eyepiece projection technique using a Celestron Omni XLT 102 mm f/9.8 refractor stopped down to 51 mm, LXD75, 12 mm eyepiece. Lightly scattered clouds with a slight breeze, 73°F (23°C), 52 % humidity. White printer paper, 0.5 mm mechanical pencil, and 4½-in. circle template. (By Erika Rix)

The sole purpose of this exercise is to include limb darkening, granulation, and faculae to the original projection sketch. Simply follow the technique described in Sect. 4.2 *Sun Funnel – Adding Additional Solar Features (by Erika Rix)*.

Projection sketching techniques shouldn't be limited to full disk drawings, as portrayed in this stunning December 1873 sunspot drawing by Samuel Pierpont Langley (1834–1906) (Fig. 4.30). The sketch was created by projecting the solar image though a 13-in. refractor onto paper (divided into squares) and attached to a projection screen.

After the positions of the larger features were drawn, the projection screen was removed. The sketch was then completed at the eyepiece using a solar filtration device.

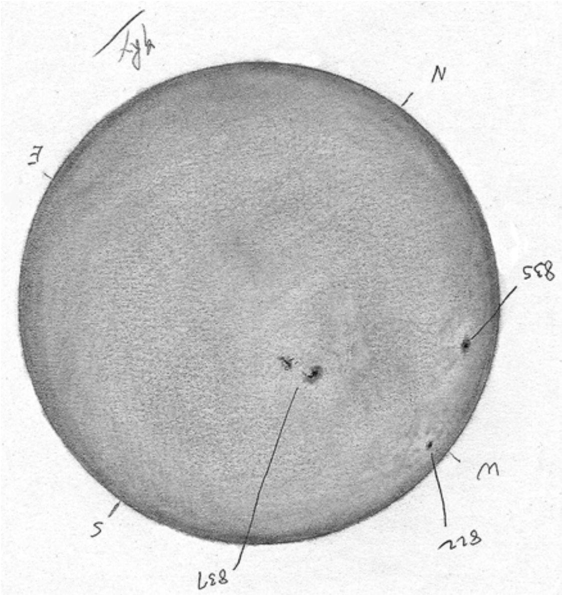

Fig. 4.29 Combination of projection and eyepiece sketch—December 20, 2005, 1930 UT. ETX-70AT refractor. 12 mm Kelner for projection used for sunspot positioning before adding a glass white light solar filter and changing to a 12 mm Kelner, 3× Barlow at 87.5× for a finished eyepiece sketch. Transparency 3/6, 12°F (−11°C), 13 mph winds WSW, partly cloudy. (By Erika Rix)

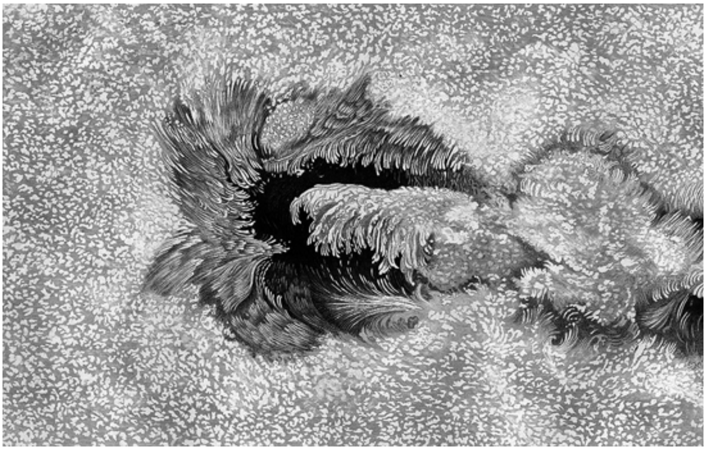

Fig. 4.30 December 1873 sunspot drawing by Samuel Pierpont Langley (1834–1906). Langley was an American astronomer and physicist, inventor of the bolometer, and the third Secretary of the Smithsonian Institution in 1887. He was also the founder of the Smithsonian Astrophysical Observatory and an honorary RASC member. A 13-in. refractor belonging to the Allegheny Observatory was used during the projection portion of the observation. (Image courtesy of *Specula astronomica minima*)

Chapter 5

Hydrogen-Alpha Filters

The chromosphere is a relatively thin layer of the solar atmosphere, nearly 2000–3000 km thick, which lies just above the photosphere and extends into the lower regions of the corona. Due to the temperature rise and lower gas density in the chromosphere, spectral lines are emitted. Hydrogen-alpha (H-alpha or Hα) is the dominant emission line in the chromosphere and can be viewed as a reddish color when isolated using specialized narrowband filters tuned to the 656.3 nm wavelength.

What an exciting set of features these H-alpha filters reveal! Prominences, huge arching loops of magnetically suspended plasma, can be seen floating above the limb extending from emerging fluxes deep in the lower layers of the Sun's interior. Dark filaments, prominences silhouetted against the solar disk, snake across the chromosphere. Bright patches of plage are found in areas of high magnetic fields. Spicules are long thin spikes of hot gas that extend into the corona before cooling and dropping to the lower levels of the chromosphere. Occasionally eruptions of particles produce flares that can be observed as brightened light. Sunspots from the photosphere can easily be seen through the chromosphere's thin atmosphere.

There are multitudes of techniques and colors that can be employed to represent these intriguing features. This chapter presents a diverse set of tutorials designed to help you capture them during your observing sessions.

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical Astronomy Series 178, DOI 10.1007/978-1-4939-2901-6_5

Tip

Keep extraneous light to a minimum for improved image contrast through the eyepiece. The use of a solar cloth over your head when observing in Hydrogen-alpha and Calcium K allows you to see finer detail. With a little practice, the drawing board can be placed under the cloth as well during the sketching process.

5.1 Active Regions and Flares

Active regions are large complex areas in the solar atmosphere that develop when strong magnetic fields emerge from inside the Sun. These localized regions also produce violent flares and powerful coronal mass ejections. Active regions can persist for days to months, all the while evolving and changing before finally decaying. We can closely observe and document these changes through sketching.

5.1.1 Active Region: Mixed Media on Black Paper (By Erika Rix)

Similar to flocking material for nighttime use, black paper prevents light reflection and glare. Using this type of paper for solar sketching allows your vision to remain adapted to the darker view through the eyepiece in H-alpha.

Suggested Materials

- Black acid-free paper, 60 lb (160 g/m^2), 5″ × 7″ or larger
- Pastel or charcoal pencils, white and black
- Artist pen, black, B (brush) or F (0.5 mm) tip
- Hard pastel stick, white
- Bulb blower

Step 1

Attach the paper to a drawing board. Holding the white pastel stick on its side, use medium pressure with broad circular strokes to create the background representing the chromosphere (Fig. 5.1). The coating should be light, and the texture mottled.

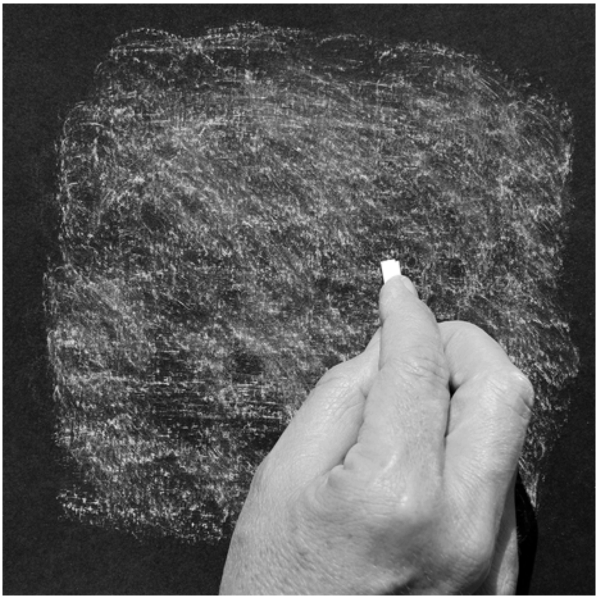

Fig. 5.1

Step 2

Using either your fingertips or tissue (a chamois may remove too much pastel), blend with a circular motion until almost smooth. Slight texture should remain to represent a hint of the chromospheric network, yet it should be smooth enough to prevent the details of the active region from becoming lost within the background (Fig. 5.2). Use the bulb blower to blow the dust residue from the paper, making sure that you are downwind from the telescope optics before doing so.

Step 3

Begin placing umbrae onto the sketch with the black artist pen. The length of time the tip touches the paper affects the broadness of the stroke, so use lighter pressure or a smaller tip size for precision around the edges of the spots (Fig. 5.3). If a mistake is made, cover it with another layer of white pastel. A pencil may be used to lightly outline the areas first.

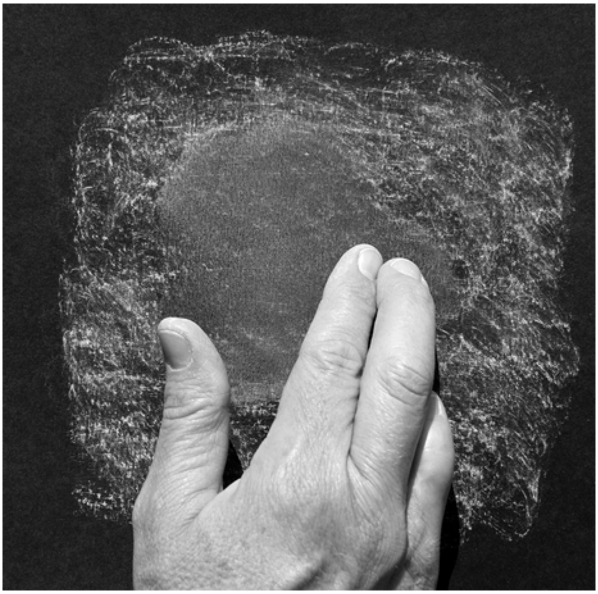

Fig. 5.2

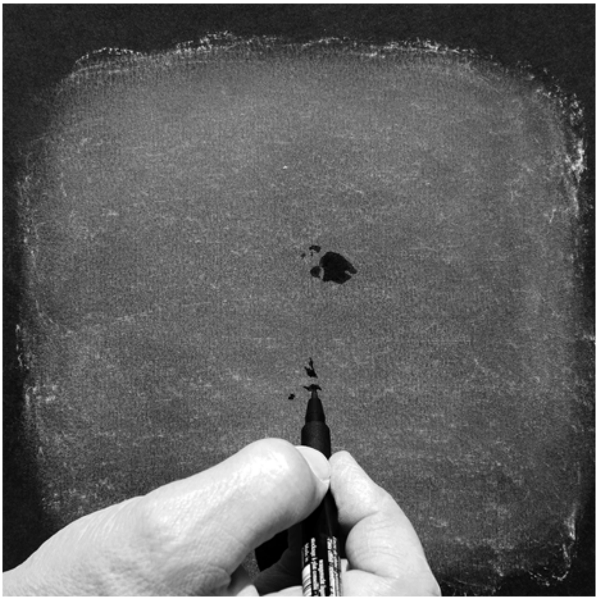

Fig. 5.3

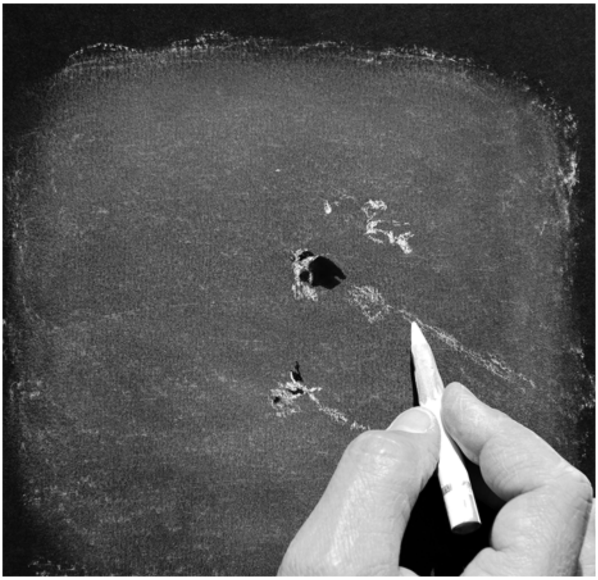

Fig. 5.4

Step 4

Next, use a sharpened white pastel pencil to render distinguishing bright areas within the active region. To the right of the sunspots, as seen in Fig. 5.4, I noticed light streaks resembling long scratches that extended several degrees.

Step 5

The details slowly change during the course of the observation, so work quickly as you start adding the brightest sections of plage with the white pastel pencil. The amount of pencil pressure determines the brightness of the markings. Next, use medium pressure with the black pastel pencil to add filamentary details within the active region (Fig. 5.5)

Step 6

Lighter pressure of the black pastel pencil is used to add contrast around the plage where observed. Note, in Fig. 5.6, how the pencil is held at a shallow angle to create a broad, and fainter marking.

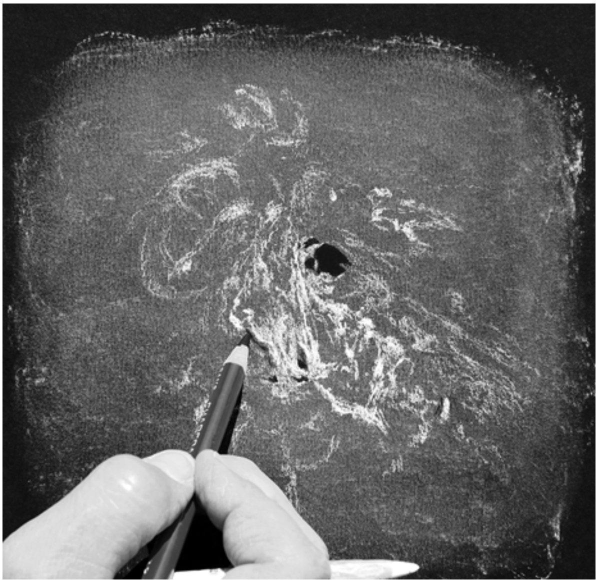

Fig. 5.5

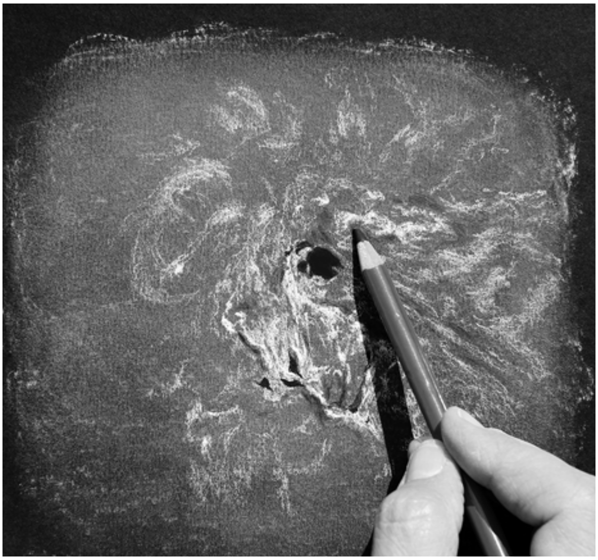

Fig. 5.6

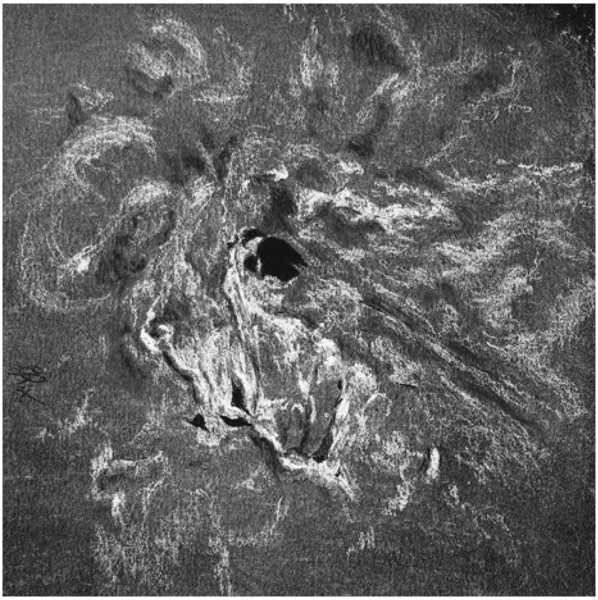

Fig. 5.7 Active region 2192—October 21, 2014, 18:15 UT. The AR was 125,000 km wide and had produced an X1-class flare just a few days prior to the observation. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, 8 mm, 50×. Scattered clouds, Wilson IV, 2–3/6 transparency, 80 °F (27 °C), 36 % humidity, winds light and variable. White Conté crayon and pastel pencil, black General's 6B charcoal pencil, Faber-Castell PITT artist pen B on black Strathmore Artagain paper. *North* is to the *left*; west is down. (By Erika Rix)

Step 7

Continue adding details by alternating between the white and black pastel pencils until the drawing is complete (Fig. 5.7). Strive to complete the sketch within 15–20 min; otherwise, you may end up chasing the details.

The following day, two more sketches were created of AR 2192. Figure 5.8 demonstrates how quickly active regions can change within a short 5-min window.

5.1.2 Solar Flare: Mixed Media on Black Paper (By Erika Rix)

A solar flare occurs when pent up energy from contorted magnetic fields in the Sun's atmosphere is suddenly released with explosive force. It appears as an abrupt brightening, lasting from only a few minutes to an hour.

Warning! ALWAYS use a suitable filter when directly observing the Sun

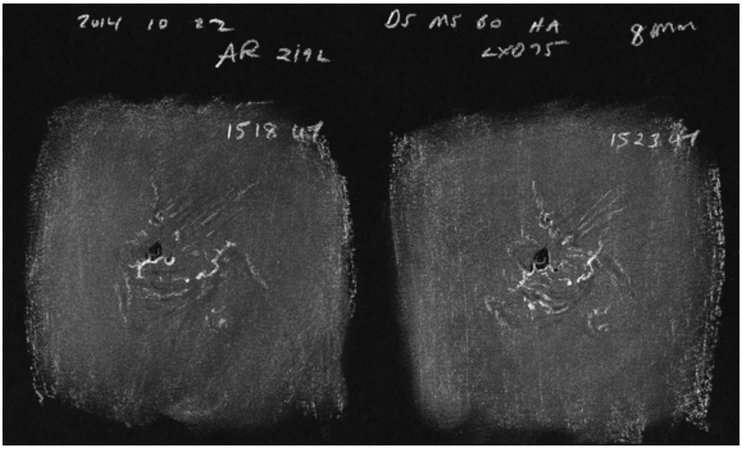

Fig. 5.8 Active region 2192—October 22, 2014, 15:18 UT and 15:23 UT. Two sketches were created side by side to show the changes of the active region within a 5-min period. North is down; west is to the right (By Erika Rix).

The key to recording such an event is speed, drawing the umbrae and flare brightening first, while the remainder of the sketch is completed with no alterations to the prior markings. The technique is very similar to the previous *Active Region—Mixed Media on Black Paper*, with only a few minor changes that are tailored for sketching flares. White pastel and charcoal pencils are specifically chosen for this technique because of the brilliantly bright markings they produce.

Suggested Materials

- Black acid-free paper, 60 lb (160 g/m^2), 5″ × 7″ or larger
- Pastel or charcoal pencils, white and black
- Artist pen, black, B (brush) or F (0.5 mm) tip
- Hard pastel stick, white
- Bulb blower

Swiftly complete Step 1 through Step 3 of *Active Region—Mixed Media on Black Paper*, and then jot down the date and time in UT. This marks when the flare was recorded in your sketch.

Step 4

Next, focus solely on the intensely bright areas of the flare. Use short, detailed strokes with a sharpened white pastel pencil to render them. The bright ribbons will diminish over the course of your drawing, so time is of the essence for this step

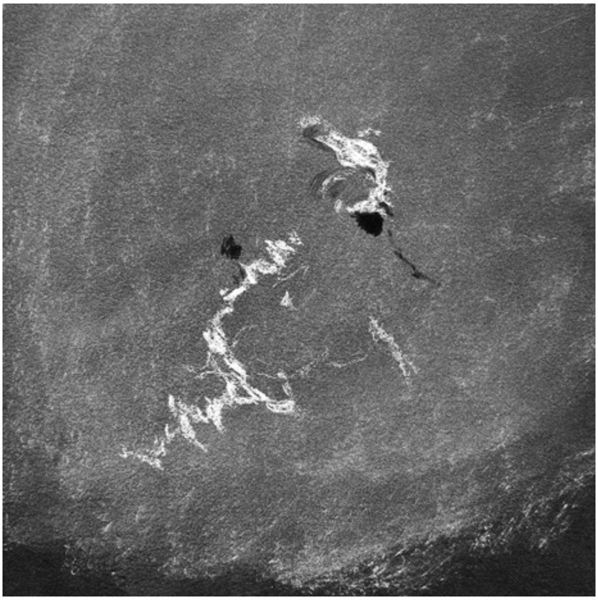

Fig. 5.9

(Fig. 5.9). Once they are completed, resist the temptation to alter them as they change during the remainder of the sketch.

Step 5

The filamentary details are added around the umbrae and flare brightness with the black pastel pencil. Using light pressure with the white pastel pencil, begin adding faint areas of plage within the active region (Fig. 5.10).

Step 6

Continue building the details within the sketch as you work outward from the sunspots and flare. Remember to render the plage fainter than the bright flare region (Fig. 5.11).

Step 7

So that the sunspots and bright ribbons of the flared region stand out, lightly blend the area surrounding them with your fingertips. Avoid over blending; the plage and filamentary structure should still be distinguishable. If needed, use the pastel pencils to touch up any sections that were over blended (Fig. 5.12).

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 5.10

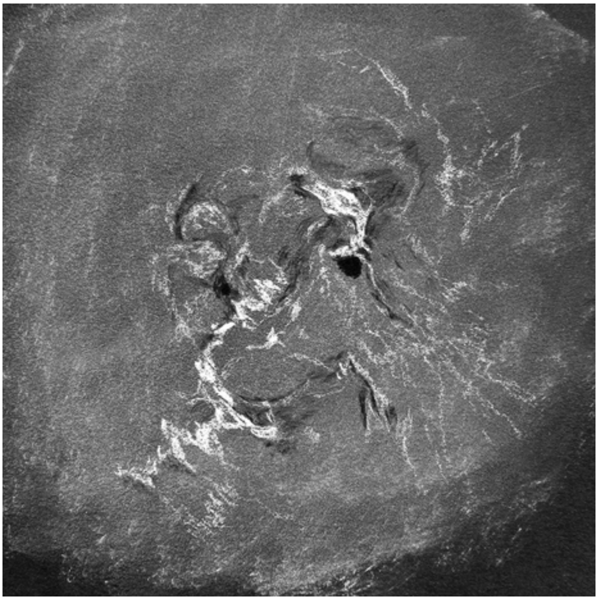

Fig. 5.11

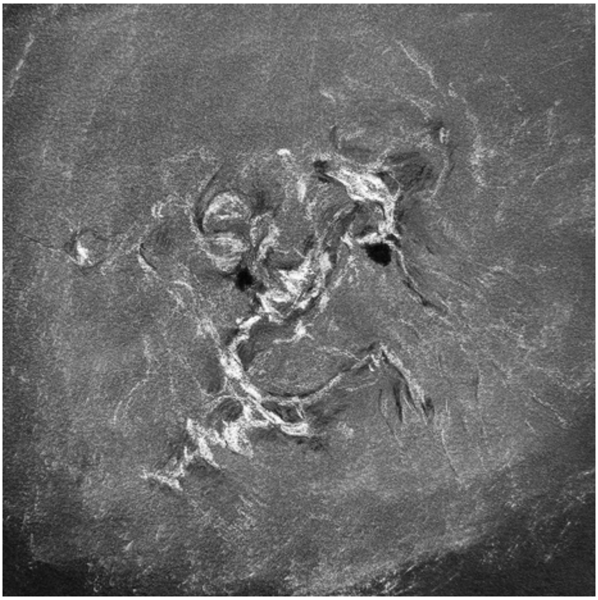

Fig. 5.12 X1 solar flare in active region 2192 at 17:09 UT—October 25, 2014, sketched at 17:30 UT before it diminished. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, 8 mm, 50×. Slight breeze, Wilson III, 5/6 transparency, 86 °F (30 °C), 31 % humidity. White Conté crayon and pastel pencil, black General's 6B charcoal pencil, Faber-Castell PITT artist pen B on black Strathmore Artagain paper. North is up; west is to the *left* (By Erika Rix).

Tip

A short sequence of 2–3 sketches of a flare in progress provides an excellent record of the event. They can also be used to create an animation.

5.1.3 White Charcoal on Black Paper (Technique of Cindy Krach)

Similar materials and technique are used for this next tutorial, but with a slightly different result. This demonstrates the unique styles that personalize each sketch.

Suggested Materials

- Black paper, 60 lb (160 g/m^2), 8″ × 12″
- White charcoal stick
- White and black charcoal pencils

- White watercolor pencil
- Black and white wax pencils
- Sharpened eraser pencil

Step 1

Attach the paper to a heavy duty, oversized clipboard. A sun shield should be slipped onto the optical tube, and a solar cloth should be placed over your head and sketch, if possible, to preserve dark adaptation. Determine and record the cardinal directions as seen through the eyepiece, and then note time, seeing, and transparency off to the side of your sketch.

Step 2

Lay the flat side of the white charcoal stick onto the paper, and with heavy pressure, create a partial circle with a heavy layer of charcoal. The smooth side of the paper will produce an irregular texture to represent the mottled appearance of the solar disk without the need to blend afterward.

Step 3

Add the active regions first. The white and black charcoal pencils are used next to create the patterns of activity within the active regions. A white wax pencil is used for plages; the black one is used to render umbrae. A pointed eraser is used to remove the charcoal from the drawing while creating the filaments during the process.

Step 4

The brightest regions of the prominences are created first with the white charcoal pencil. The fainter portions are drawn with the white watercolor pencil. Some brands of white watercolor pencils produce a bluish hue on black paper. If this occurs, the color levels can be graphically adjusted after the sketch is scanned.

Step 5

Once the sketch is completed, you can polish it up by processing the scanned version through photo editing software (there are freeware versions available on the Internet). Contrast could be added or stray markings removed. The finished sketch in Fig. 5.13 includes a cropped screenshot of the solar graphic from *TiltingSun*

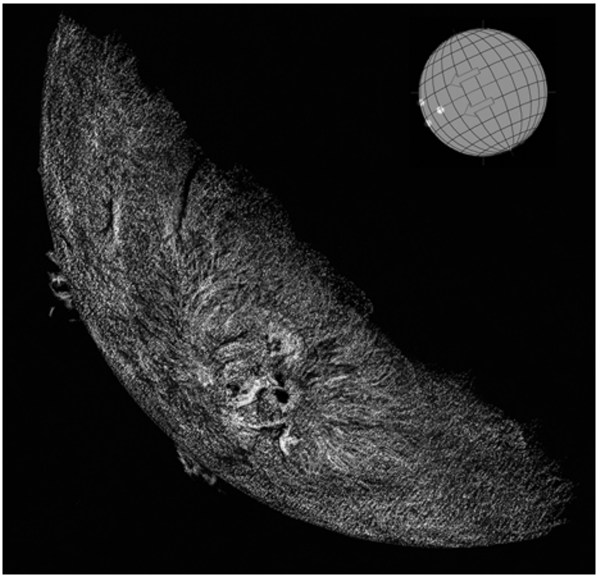

Fig. 5.13 ARs 2192 and 2193—October 26, 2014, 19:00–20:00 UT. Lunt Solar System LS60THa/B1200CPT, 3–6 mm Nagler zoom set at 6 mm, 83×. Wilson IV, transparency 2/4. Black Canson paper 8″ × 12″, white and black charcoal pencils, white Prismacolor watercolor pencil, black and white wax pencils. (Courtesy of Cindy Krach, Hawaii, USA)

(Chap. 1—*Introduction to Solar Observing and Sketching*, Sect. 1.2 *Essential Tips, Determining Disk Orientation*) that is relevant to Krach's observation.

5.1.4 Pastels on Black Paper (By Richard Handy)

When observing the Sun with an H-alpha filtered telescope, the solar view takes on an orange-red hue. The following technique demonstrates how to use color media to portray the Sun's reddish appearance using this bandwidth.

Suggested Materials

- Strathmore Artagain 400 series, coal black drawing paper, 9″ × 12″, 60 lb
- Orange pastel pencil
- Light orange dry pastel stick
- Paper blending stump

Fig. 5.14

Step 1

Begin the sketch by building up the appearance of the chromosphere in the vicinity of the active region. To do this, use firm, gentle strokes with the orange pastel pencil as seen in Fig. 5.14.

Step 2

Apply the orange pastel evenly, except in the areas where the sunspots are located. Work around the sunspots while maintaining their relative shapes and spacing apart from each other. There are two prominent sunspots in the active region featured in Fig. 5.15.

Step 3

A blending stump can be used to smooth the pastel and make fine adjustments to the shapes of the sunspots (Fig. 5.16).

Fig. 5.15

Fig. 5.16

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 5.17

Step 4

The bright plage is drawn with the corner of the light orange pastel stick. Try to follow the flow of its curves (Fig. 5.17).

The final sketch is shown in Fig. 5.18.

5.1.5 *Color Pencils on Black Paper (By Sally Russell)*

Active regions (ARs) with their bright loops and swirls and intertwined active region filaments are great subjects to draw, but it can be a challenge to adequately convey the scale of the target area when it's drawn in isolation. However, if the AR occurs near the limb of the Sun, then including that section of the limb into your drawing can help to show its scale. In this example, there are two active regions in close proximity, AR1493 and AR1499. Between them spans nearly a quarter of the diameter of the Sun's disk.

Suggested Materials

- 8¼″ × 11¾″ sheet of black Canford paper on a clipboard
- Compass (or circular template)

Fig. 5.18 NOAA 11861—October 11, 2013, 21:00–21:45 UT. TeleVue Pronto ED 70 mm f/6.8, 8 mm TeleVue zoom, 60×, Coronado SolarMax 70 mm H-alpha filter. Antoniadi III. Colored Conté crayon and pastel pencil on black paper. (By Richard Handy)

- Watercolor pencils—red, orange, white and black (I used Derwent watercolor pencils in #14 Deep Vermilion, #10 Orange Chrome, #72 Chinese White and #67 Ivory Black)
- Plastic eraser

Step 1

Using a compass fitted with the red watercolor pencil, I drew a suitable arc representing around 60 % of the Sun's limb in the region of interest. Overall, the two ARs made roughly a triangular shape, so with two fingers on my left hand acting as anchor points (one at center disk, and one where I considered the base of the triangle to be halfway towards the limb), I lightly sketched their swirling outlines using the orange pencil (Figs. 5.19 and 5.20). These schematic outlines were easy to erase and re-draw as necessary until I felt I had the area correctly mapped out in relation to the Sun's limb and the correct shapes drawn within the actual ARs.

Step 2

Starting with the red pencil, I began blocking in the surface of the solar disk. By laying the pencil on its side, a broad stroke of color is achieved. The tooth of the paper imparts a slight mottling to the shading, which helps to give the impression

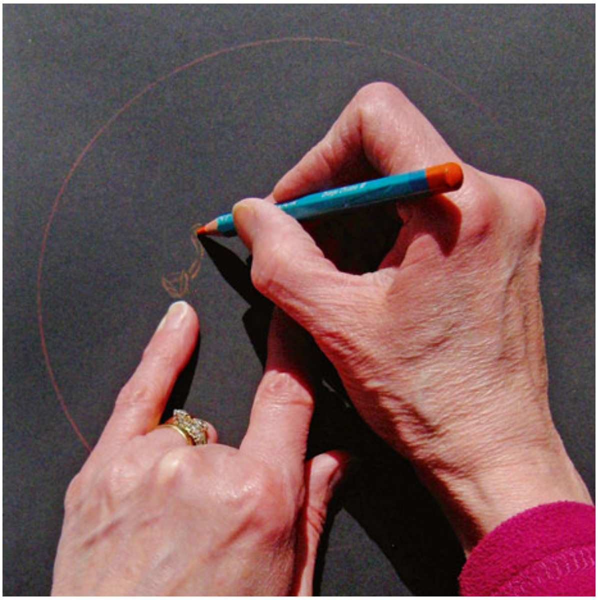

Fig. 5.19

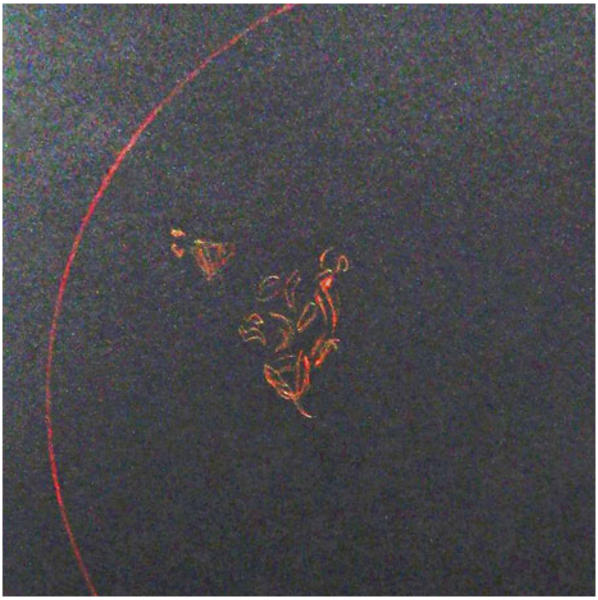

Fig. 5.20

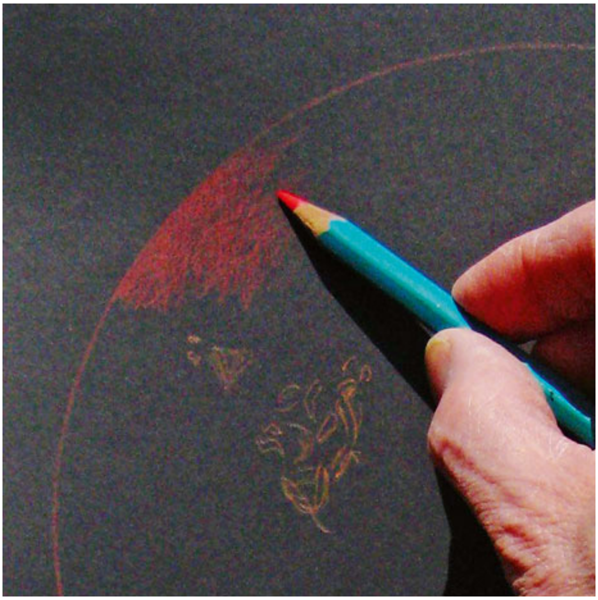

Fig. 5.21

of the H-alpha surface, known as the chromospheric network (Fig. 5.21). I continued with the shading up to and around the previously sketched outline of the ARs, adding a layer of color with the orange pencil and lightly blending with a fingertip until the entire section had been covered (Fig. 5.22).

Step 3

Using the white pencil, I lightly drew over the top of the previously drawn AR outlines, and then went over them again with the orange pencil (Figs. 5.23 and 5.24). The white under-drawing imparts additional brightness to the ARs that would not be achievable with the orange pencil alone.

Step 4

The active region filaments were drawn using the black pencil. It would be difficult to erase any mistakes at this point as erasure would damage the under-drawing, so I was very careful to check the location of the end points for each filament and transfer these anchor points onto my sketch first to help with positioning (Fig. 5.25).

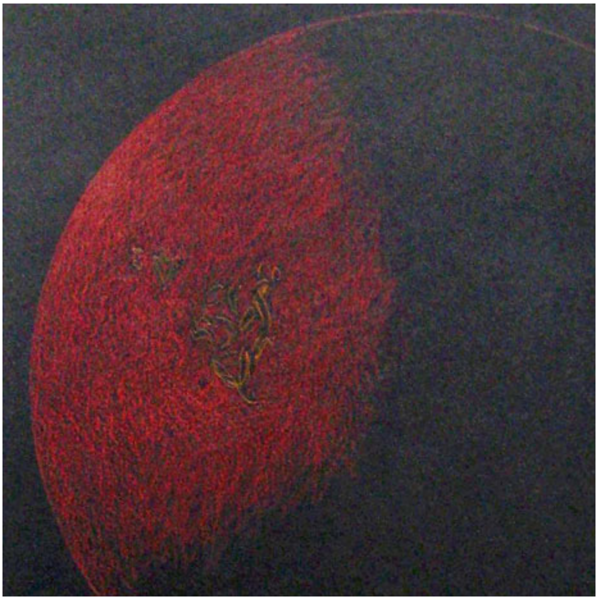

Fig. 5.22

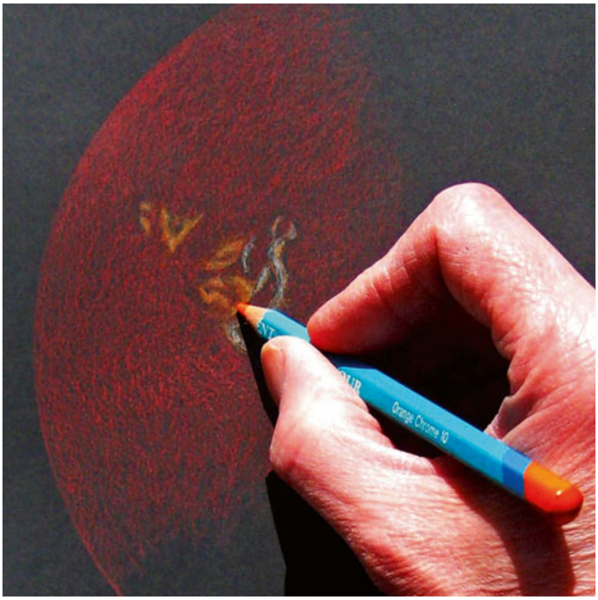

Fig. 5.23

Fig. 5.24

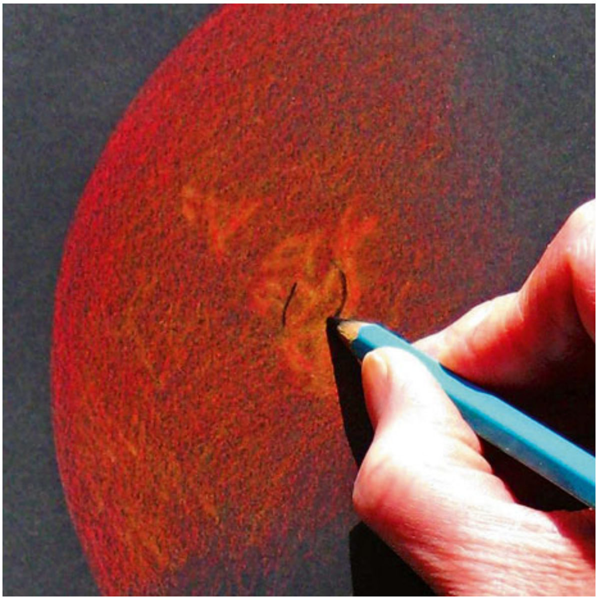

Fig. 5.25

Warning! ALWAYS use a suitable filter when directly observing the Sun

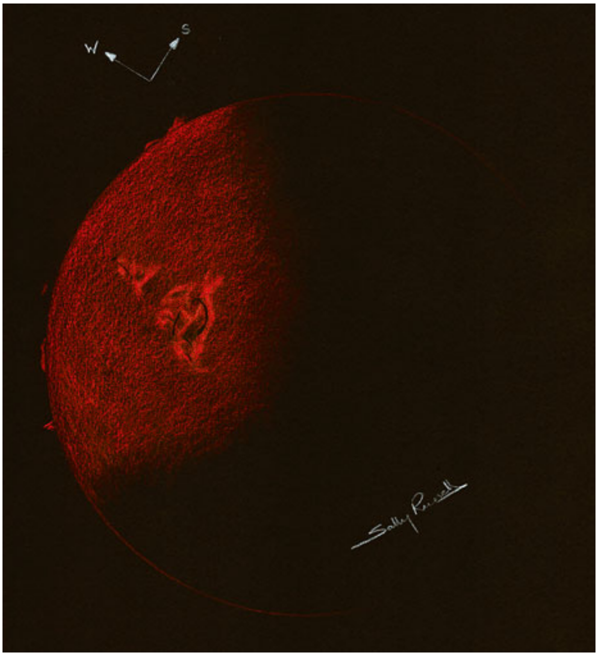

Fig. 5.26 Active regions 1493 and 1499—June 9, 2012, 14:20–15:55 UT. Double-stacked Coronado PST, 8-24 zoom eyepiece, 50-16×, Alt-Az mount. Wind speed 8 mph, gusting to 22 mph, 62.6 °F (17 °C), Antoniadi III-IV. Black Canford paper, Derwent watercolor pencils in #14 Deep Vermilion, #10 Orange Chrome, #72 Chinese White, and #67 Ivory Black. (By Sally Russell)

Step 5

I used the red pencil to draw the small prominences that were visible along the sketched section of the Sun's limb, and then added the cardinal directions.

Figure 5.26 is the finished sketch.

5.1.6 Graphite on White Paper (By Richard Handy)

Graphite pencils really come into their own when it comes to detailed drawings. The mottled appearance of the chromosphere is created with linear dashes, which is similar to stippling. Plages are formed in the process by leaving those areas void of graphite.

Suggested Materials

- Strathmore 400 series medium white drawing paper, 9″ × 12″
- H graphite pencil
- Art gum eraser

Step 1

Use firm, small circular strokes of an H graphite pencil to draw the prominent sunspots of the active regions, paying particular attention to their positions and relative sizes. Accuracy is very important in this step, as the sunspots will provide a reference for the remaining features to be added (Fig. 5.27).

Fig. 5.27

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 5.28

Step 2

Sketch the areas between the sunspots with short, light, linear dashes using the H graphite pencil (Fig. 5.28).

Step 3

Work around plages. By leaving the paper white in those areas, the appearance of bright plage will form automatically. A sharply pointed eraser can be used to remove graphite where needed to better define them (Fig. 5.29).

Fig. 5.29

Step 4

Continue applying small, light strokes of the pencil until the active regions are fully sketched. Include the areas around all of the sunspots and any filaments in that region. Corrections can be easily made with an art gum eraser (Fig. 5.30).

The final sketch can be seen in Fig. 5.31.

5.2 Prominences and Filaments

When magnetic fields extend from the photosphere of the Sun, prominences are formed as ionized particles are lofted high above the solar limb. Often observed as beautiful arcuate shapes that evolve slowly and gracefully during the course of an observation, they also appear as the dark filaments when seen silhouetted against the solar disk (Fig. 5.32).

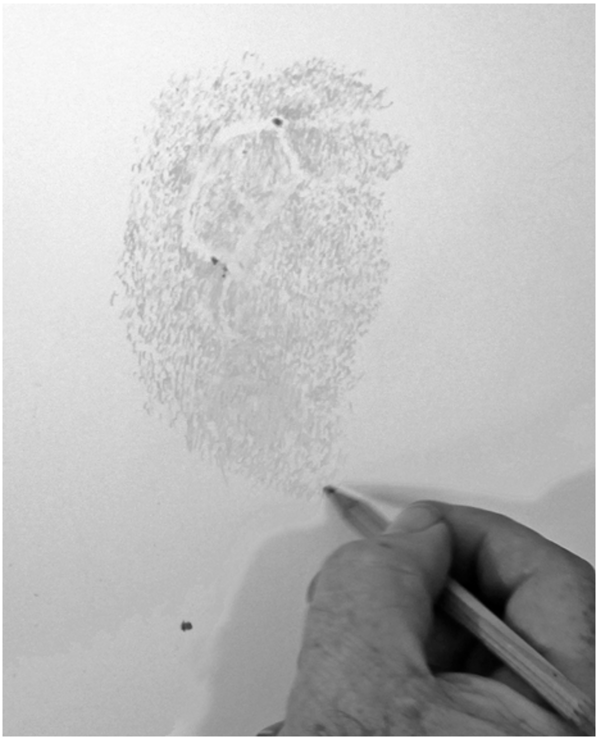

Fig. 5.30

As magnetic fields emerge and decay, the prominences can become transient, sometimes erupting and collapsing, or even breaking away from the limb. Their constant movements reveal the dynamic nature of our star, making them more of a challenge to sketch.

5.2.1 Prominence Classification (By Kim Hay)

In the mid 1800s, astronomers discovered that the light from a prominence came from only a few bright lines of the solar spectrum. They began observing prominences with spectroscopes in full daylight rather than during the brief moments of a solar eclipse. With the advancements in solar filter technology, scientists have gained a better understanding of how solar prominences form and evolve. A classification system was derived to help us study and identify their structures as they extend into the chromosphere and lower regions of the corona.

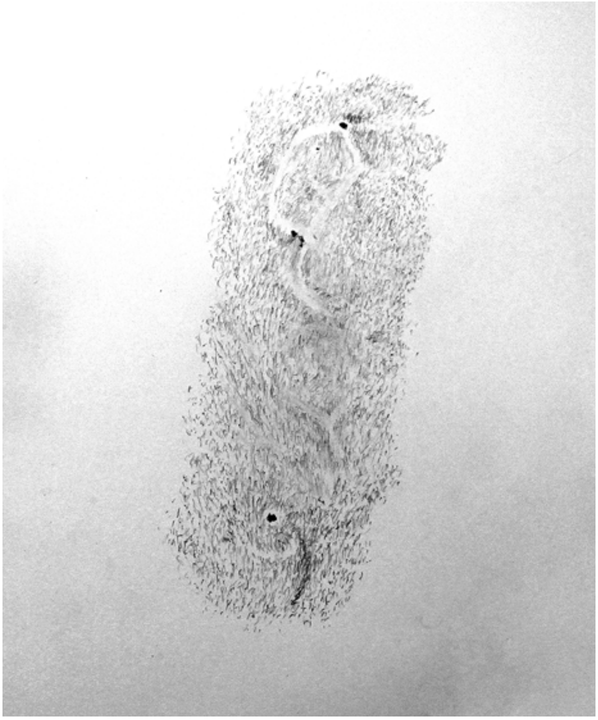

Fig. 5.31 NOAAs 11865 and 11864—October 12, 2013, 21:00–21:55 UT. TeleVue Pronto ED 70 mm f/6.8, 8 mm TeleVue zoom, 60×, Coronado SolarMax 70 mm H-alpha filter. Antoniadi II. H Graphite pencil on white paper. (By Richard Handy)

Italian astronomers, Angelo Secchi (1818–1878) and Lorenzo Respighi (1824–1889), made hundreds of prominence drawings during their visual solar observations and noticed that the structures had a variety of shapes and activity. Secchi derived a classification system that separated the prominences into two categories, long-lived (quiescent) and short-lived (eruptive). After studying spectroheliograms of prominences in the early 1900s, Edwin Pettit, a Mount Wilson astronomer, further divided them into six classes: active, eruptive, spot type, tornadoes, quiescent, and coronal.

The next breakthrough in classification was the Menzel-Evans Scheme of Classification in 1953 when it was determined that the behavior of prominences is determined by the magnetic fields of their origin and in the space where they are observed. It was further refined with the Menzel-Jones classification project in 1958. Donald H. Menzel (1901–1976) and F. Shirley Jones (1913–2000), from the Harvard College Observatory Solar Department, derived the following classification scheme:

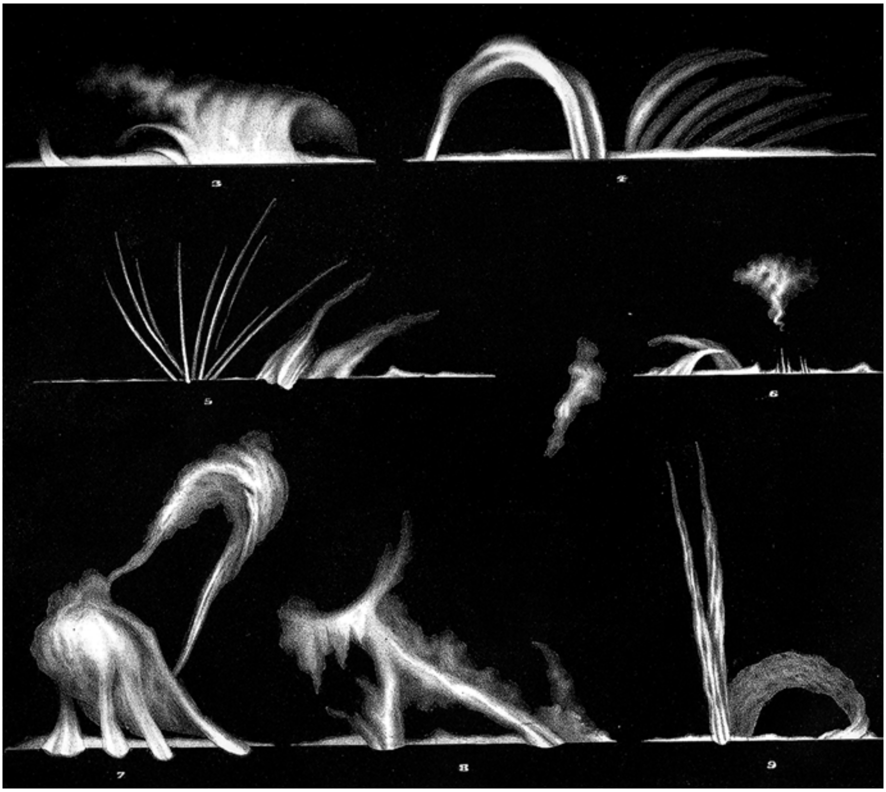

Fig. 5.32 April 5–30, 1872 solar prominences by Étienne-Leôpold Trouvelot (1827–1895). Trouvelot would have used one of the Harvard College Observatory refractors and a spectroscope. The technique involved centering the H-alpha line in the eyepiece, with the slit of the spectroscope trained on the solar limb, and then progressively opening the slit to achieve optimal contrast. The published version is a lithograph. *Astronomical Engravings Illustrating Solar Phenomena* (Cambridge, MA: John Wilson and Son, 1876), p. 5. (Image courtesy of *Specula astronomica minima*)

Class A

Class A includes prominences that originate in coronal space, which contain spot prominences (loops and funnels) and non-spot prominences (coronal rain, tree trunks, trees, hedgerows, suspended clouds, and mounds).

Class B

Class B includes prominences that originate from below the chromosphere, which contain spot prominences (surges and puffs) and non-spot prominences (spicules).

Note: The full article is available from SAO/NASA Astrophysics Data System (ADS), and also in the *Journal of the Royal Astronomical Society of Canada*, Vol. 52, pp. 149–157, bibliographic code 1958JRASC.52.149 J.

Today, a commonly used scheme for categorizing prominences comes from Harold Zirin (1929–2012), a professor of astrophysics at Caltech. He listed two main classes in his book, *Astrophysics of the Sun*, which were further categorized by shape and activity:

Class 1: Quiescent (QRF)

Quiet region filaments (prominences) are wider and last longer, the largest of which may last several rotations: (a) hedgerow, (b) curtain, flame, or fan, (c) arch or platform arch, (d) cap, irregular arch, or fragment, and (e) Disparition Brusque (sudden disappearance)—breaks from the solar limb and usually dissipates within 24 h marking the end of the QRF phase.

Class 2: Active

Active filaments (prominences) are associated with solar flares. They are fast moving and transient: (f) eruptive prominences, (g) surge, (h) spray, (i) post flare loops, and (j) limb flare.

To make identification easier, the image in Fig. 5.33 shows the classes of the prominences and their physical forms.

For more information on prominence classification and how to observe them, visit The Prairie Astronomy Club website to read, *Observing the Sun in H-Alpha.* http://www.prairieastronomyclub.org/resources/solar-observing/observing-the-sun-in-h-alpha/

The best views of prominences occur when the skies are clear with steady seeing. They are in a state of constant flux, and following their progression is quite exciting. Capturing their movements through sketching will certainly give you an appreciation of the dynamics and complexity of our Sun.

5.2.2 Mixed Media on Black Paper (By Erika Rix)

Attempt to draw a section of cloud in the sky on a calm day, and you will understand the challenges faced when sketching a prominence. If not completed quickly, the prominence (and the cloud) will have evolved enough that you could find yourself struggling to keep up. You may even catch yourself erasing and redrawing the changes several times throughout your sketching session. There are a number of tricks we can incorporate that enable us to pull out a prominence's faint structural complexity while also increasing the speed at which we draw it.

Warning! ALWAYS use a suitable filter when directly observing the Sun

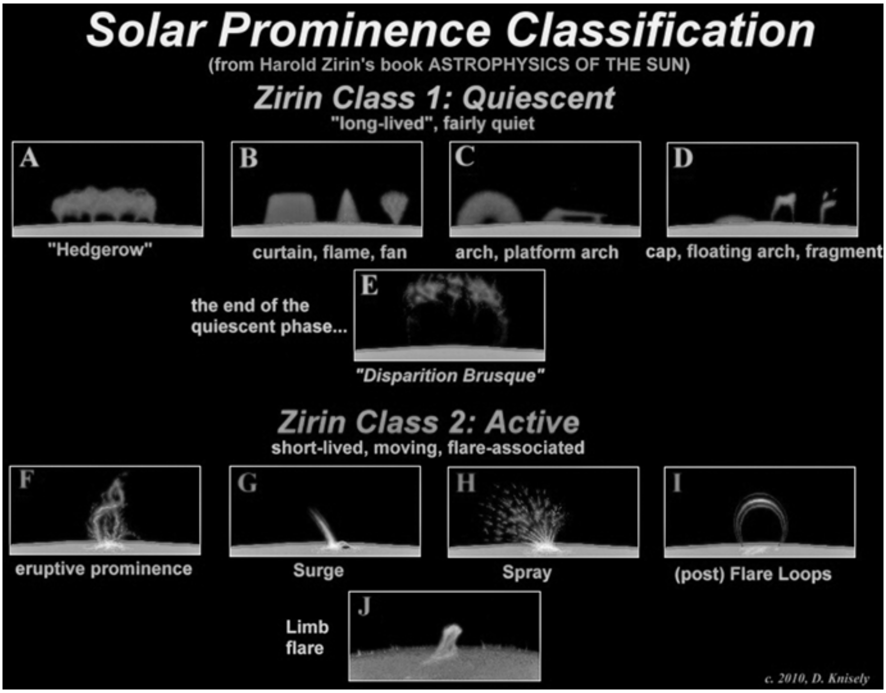

Fig. 5.33 Illustration of Zirin's Solar Prominence Classification. (Courtesy of David Knisely, Nebraska, USA)

As mentioned in Chap. 1—*Introduction to Solar Observing and Sketching,* Sect. 1.1 *Basic Equipment*, solar cloths and sun shields reduce extraneous light to improve the image contrast through the eyepiece view. Along that vein, black sketching paper reduces glare, similar to flocking material. Using any combination of the three helps to preserve the dark adaptation needed to detect the faintest wisps of plasma as you make additions to the sketch.

The task of choosing and blending colors can add several minutes to a sketch, especially if you are not already adept with that medium. The following technique uses white pastels on black paper to produce a detailed prominence sketch in minimal time.

Suggested Materials

- Black acid-free paper, 60 lb (160 g/m^2), 5″ × 7″ or larger
- Pastel pencil, white
- Color pencil, white
- Oil-based pencil, black
- Hard pastel stick, white

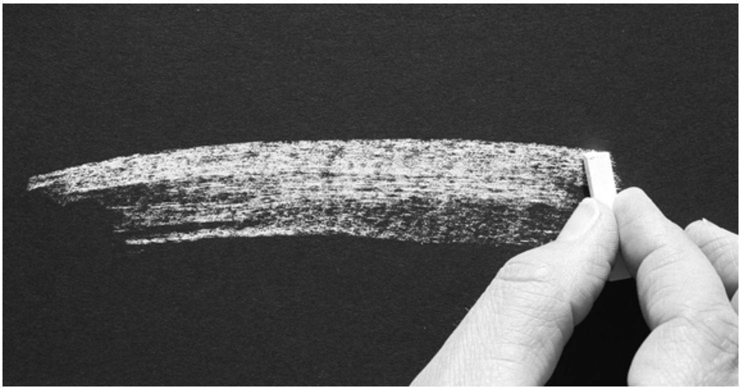

Fig. 5.34

Step 1

Lay the pastel stick on its side. While using medium pressure on the pastel, draw the shallow arc of the limb. The tip of the pastel should remain in contact with the paper so that a continual arc is created with one swipe (Fig. 5.34).

Tip

A steep limb curvature represents a larger wedge of the solar disk, and the prominence would have to be drawn at a much smaller scale. When the arc is created shallower, the prominence can be drawn larger, allowing room for more details to be included within it.

Step 2

Use either a tissue or your fingertip to blend the pastel on the limb. A blending stump may remove too much of the pastel from the smooth grain of the suggested paper.

Next, use a sharpened pastel pencil to draw the brightest strands of the prominences. Great care should be given so that their proportions are accurate as well as their positions from each other (Fig. 5.35).

Step 3

Switch to the white color pencil to add the gauzy wisps of the prominence. A color pencil creates a fainter, sharper mark than a pastel pencil (Fig. 5.36). If you are able, try to sketch under the solar cloth to preserve your dark adaptation.

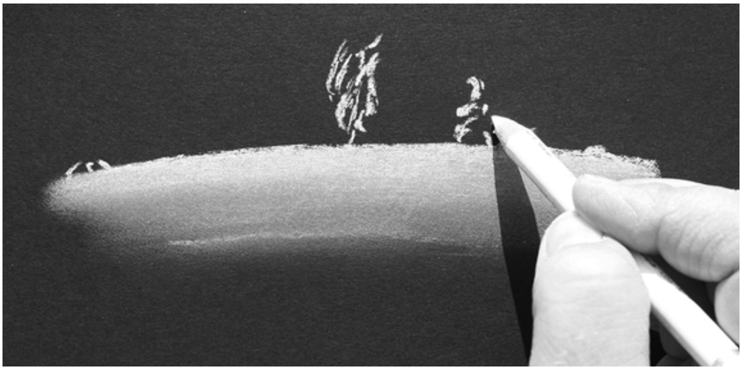

Fig. 5.35

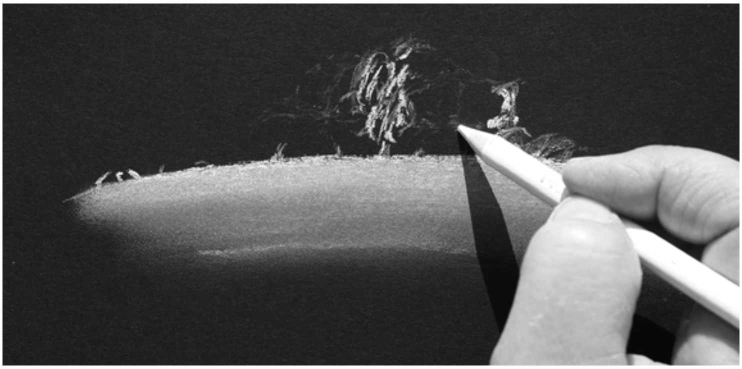

Fig. 5.36

Step 4

The harshness from the pastel markings will soften as you create new markings through them with the color pencil. If additional blending is needed, simply rest your fingertip over the pastel and barely wiggle it. This softens the pastel without diminishing its detail.

Alternate between the color and pastel pencils as you complete the prominence portion of the sketch. Strive to complete the prominence within 5–10 min. If you fall short of that time, there's no need to worry. Your speed will pick up with each sketch (Fig. 5.37).

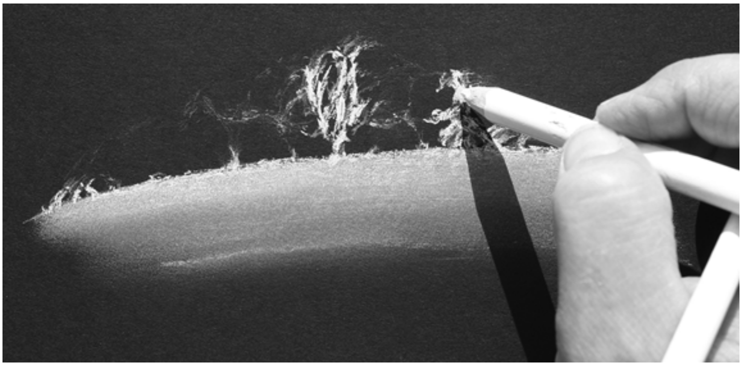

Fig. 5.37

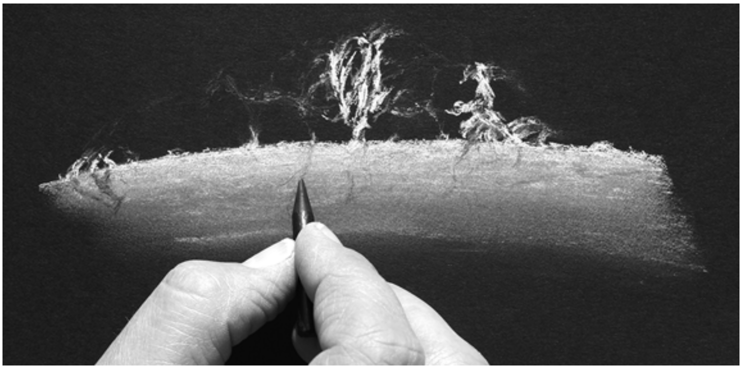

Fig. 5.38

Step 5

Use a sharp black oil-based pencil to draw the tendrils of the prominence as it reaches into the limb (now referred to as a filament). If you notice brightened streaks or patches inside the limb, they can be rendered lightly with short strokes of the pastel pencil (Fig. 5.38).

Figure 5.39 shows the completed sketch.

Additional examples of sketches using similar media and technique can be seen in Figs. 5.40 and 5.41.

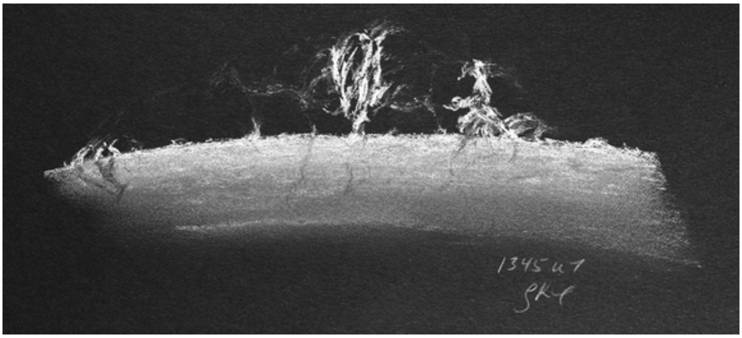

Fig. 5.39 Solar prominence at 70° PA—May 16, 2012, 13:45 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, Baader Planetarium Hyperion 8-24 mm Mark III set at 8 mm, 50×. Clear, calm, Wilson IV, 5/6 transparency, 63 °F (17 °C). White Conté crayon and pastel pencil, black oil pencil, black Strathmore Artagain paper. (By Erika Rix)

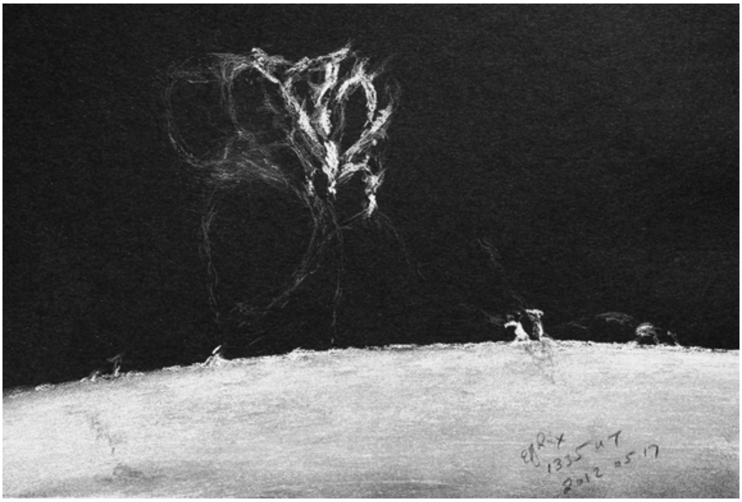

Fig. 5.40 Solar Prominence at 315°PA—May 16, 2012, 14:45 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, Baader Planetarium Hyperion 8-24 mm Mark III set at 8 mm, 50×. Clear, calm, Wilson IV, 5/6 transparency, 73 °F (23 °C). White Conté crayon and pastel pencil, black Strathmore Artagain paper. (By Erika Rix)

Fig. 5.41 Solar Prominence—March 5, 2009, 12:50 UT. SF 70 mm, 19 mm, 85×. Seeing 2/5. White Derwent Graphitint pastel pencil on black Strathmore Artagain paper. (Courtesy of Jeff Young, Ireland)

5.2.3 Erupting Prominence Sequence: White Charcoal on Black Paper (By Erika Rix)

On occasion, our timing is such that we can witness the sudden disappearance (disparition brusque) or emergence of a prominence. As described by Zirin, the former marks the end of the quiescent phase; the latter is associated with high activity.

During an observing session, and indeed while sketching the Sun, I keep a close eye on its overall activity. If I notice an area brightening or rapidly changing, I put aside the sketch I'm currently working on and grab a new sheet of paper to record it. To capture a smooth series of such an event, the sketches should be every few minutes apart depending on its rate of change.

There isn't time to spare waiting for your eyes to become accustomed to the darker view of H-alpha, so it is imperative that a solar cloth and/or a sun shield be used to preserve your dark adaptation. Dark paper is especially useful to prevent glare from hindering your vision. The larger paper size is used so that several small prominence sketches can be drawn on one sheet for comparisons throughout the observation. A zoom eyepiece is also recommended so that the magnification can be quickly adjusted for variable seeing conditions.

Suggested Materials

- Black acid-free paper, 60 lb (160 g/m^2), 9″ × 12″
- Pastel pencil, white
- Color pencil, white

Step 1

Starting at the upper left corner of the paper, draw a very shallow 3-in. to 4-in. arc with the white pastel pencil to represent the limb's edge. Since the prominence extends over a very small fraction of the solar limb, the arc should show only a hint of curvature. You may find it easier to turn your sketchpad (or drawing board) so that your arc matches the orientation of the prominence and arc through the eyepiece view.

Step 2

Quickly and lightly fill the limb in with a few strokes of the pastel, and then blend with your fingertip.

Step 3

Draw the brightest strands of the prominence with the pastel pencil. Be mindful of proportions between those areas and also in reference to their positions from the limb. Work very quickly!

Step 4

Use the white color pencil to fill in the faintest tendrils. Look very closely and adjust the magnification as needed to pull out the details.

Step 5

Record the UT time just outside of the sketch area.

Step 6

Using the previous sketch as a reference, draw the next arc 2–3 in. underneath the first one (or in the top right corner of the paper). If the prominence is especially large, you may need to draw the next arc 3–4 in. down. Repeat Step 1 through Step 5 until the event ends. Match the brightest areas of the new sketch to the previous one so that the proportions remain accurate.

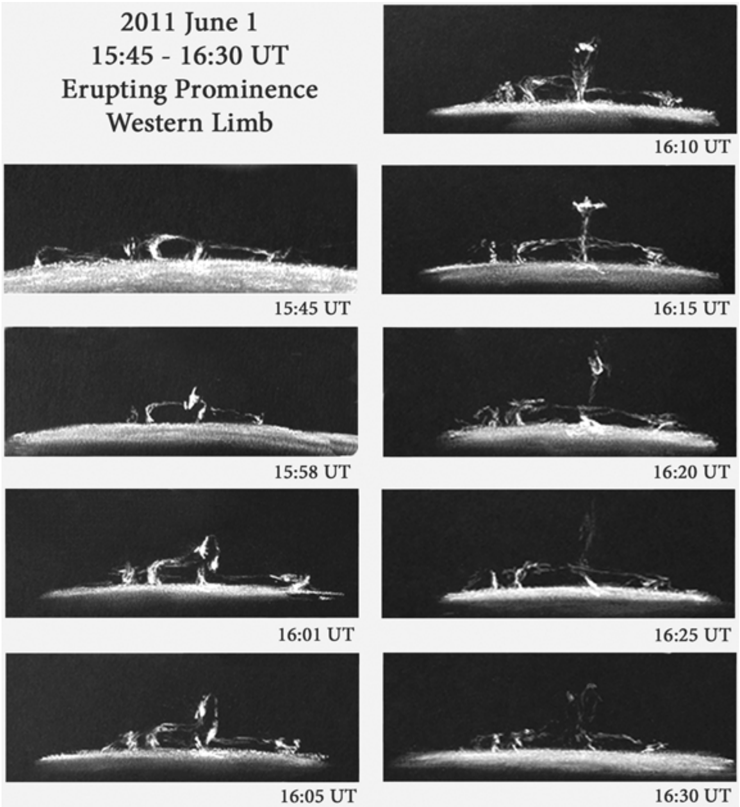

Fig. 5.42 Sketch sequence of an erupting and collapsing prominence—June 1, 2011, 15:45–16:30 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75. 21-7 mm Zhumell zoom eyepiece. Light winds, Wilson IV, 2/6 transparency, 90 °F (32 °C), 42 % humidity. White Conté crayon and pastel pencil, white Prang watercolor pencil, black Strathmore Artagain paper. (By Erika Rix)

Figure 5.42 shows an erupting prominence sequence, rendered 4–5 min apart, with the exception of the second sketch. I used the sequence to create an animation in Adobe Photoshop CS6 that can be viewed at the PCW Memorial Observatory website at https://pcwobservatory.files.wordpress.com/2011/06/201106.gif.

See Chap. 10—Animations *to learn how to create your own animations with sketch sequences.*

The sketch in Fig. 5.43 is of an erupting prominence associated with an active region that had only begun rotating into view on the eastern limb. The active region produced C-class flares the day of my observation.

The same technique was used for this sketch sequence with only a few minor additions. The brightest section indicative of the flare was created with firmer

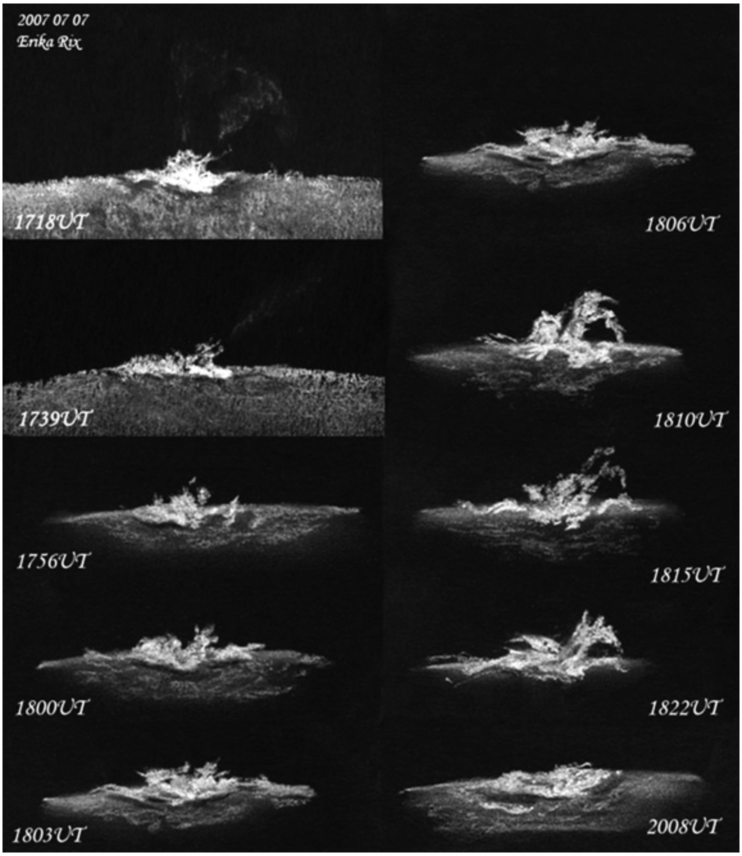

Fig. 5.43 Sketch sequence of an eruption associated with C-class flares from AR 963 that had just begun rotating into view—July 7, 2007, 17:18–20:08 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75. 8 mm TeleVue Plössl eyepiece, 50×. White Conté crayon and pastel pencil, white Prang watercolor pencil, black charcoal pencil, black Strathmore Artagain paper. (By Erika Rix)

pressure of the pastel pencil so that it would stand out drastically from the background markings. A black charcoal pencil was then used to add contrast and depth on the outer edges of the pastel, often seen near those regions. And finally, I pressed my finger against the faintest sprays of prominence in the first two sketches. Without moving it, I gently rocked my wrist to create a soft gauzy effect.

The prominence in Fig. 5.44 underwent drastic changes during the course of an hour. It was very bright and appeared to splash along the limb. It was associated with an active region that produced a coronal mass ejection (CME) the previous day. Note that the sketches were approximately 5–10 min apart, and a charcoal pencil was again used for contrast around the base of the prominence.

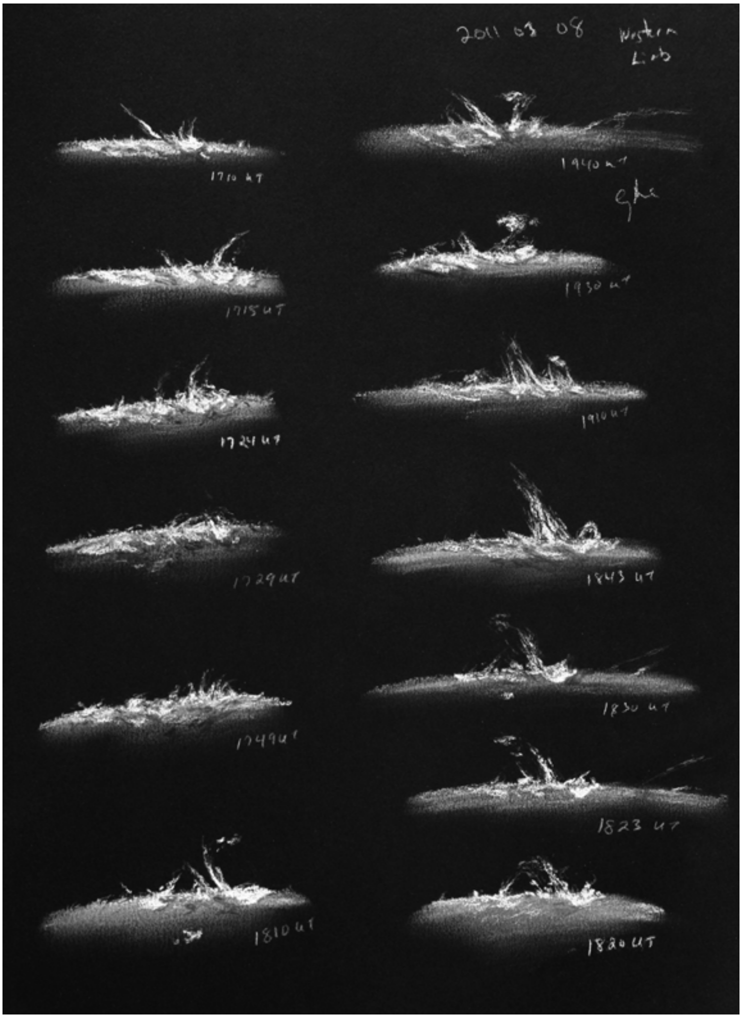

Fig. 5.44 Sketch sequence of a prominence associated with AR1164 that had produced a coronal mass ejection the previous day—March 8, 2011, 17:10–19:40 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75. 21-7 mm Zhumell zoom eyepiece, 50×. Wilson II degrading to IV, 1-2/6 transparency, SE winds at 8 mph, 62 °F (17 °C), 34 % humidity. White Conté pastel pencil, white Prang watercolor pencil, black Derwent charcoal pencil, black Strathmore Artagain paper. (By Erika Rix)

Quiescent prominences can be quite fun for sequences, too. The one shown in Fig. 5.45 particularly caught my eye while working on another section of the Sun. It started off nearly a third of the size in the first sketch of the sequence, and then started to grow!

Warning! ALWAYS use a suitable filter when directly observing the Sun

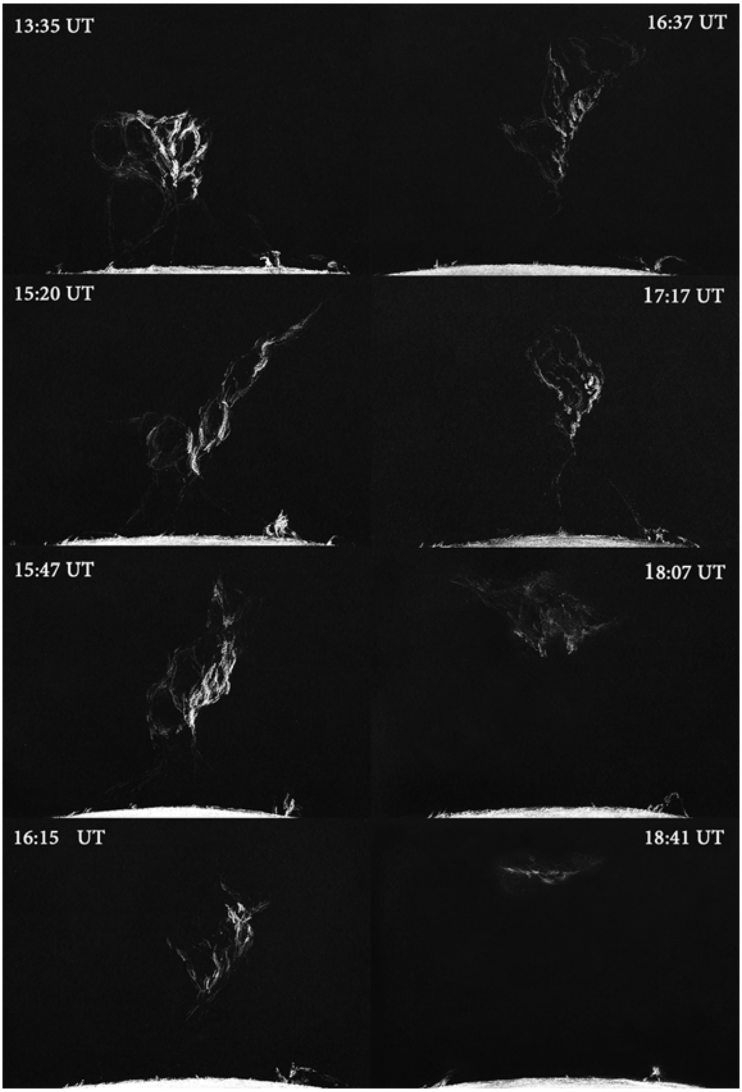

Fig. 5.45 Sketch sequence of a quiescent prominence that expanded and then broke away from the limb—May 18, 2012, 13:35–18:41 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75. White Conté crayon and pastel pencil, black Strathmore Artagain paper. (By Erika Rix)

Using the same technique as with the erupting prominences, the sketches were spread further apart over a 5-h time span. Again, each sketch took only 5–10 min to render. I came back to the telescope several times during the 5-h period to sketch the next drawing in the sequence. It became increasingly difficult to detect the faint

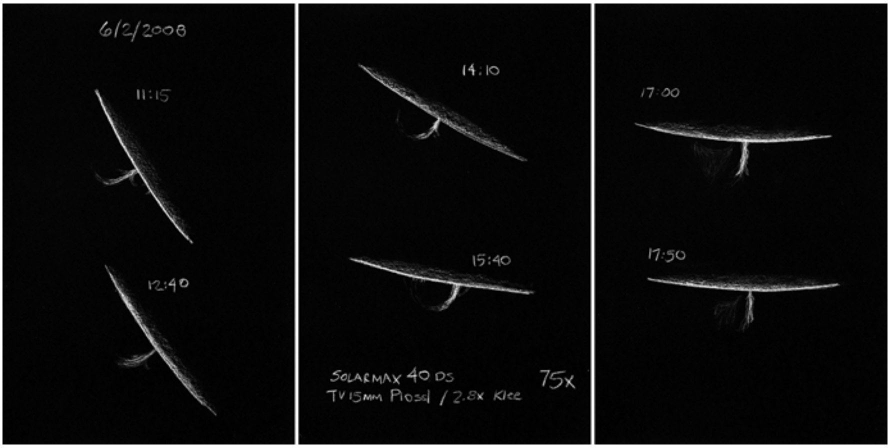

Fig. 5.46 Sketch sequence of evolving quiescent prominence—February 2, 2008, 11:15–17:50 UT. Double-stacked Coronado SolarMax 40, 15 mm TeleVue Plössl, ×2.8 Klee, 75×. Seeing 3/5. White Derwent Graphitint pastel pencil on black Strathmore Artagain paper. (Courtesy of Jeff Young, Ireland)

filaments extending from the plume to the limb, even when sketching underneath a solar cloth. But since the prominence moved so slowly, more time could be spared to soak in the details until finally, the plume separated and floated into space.

Jeff Young offers another example of an interesting slow-moving prominence using white pencil on black paper (Fig. 5.46).

5.2.4 *Flare and Erupting Prominence: Digital Sketching (Technique of Stratos Tsanaktsidis)*

Suggested Materials

- White sketching paper, acid free, 75 lbs, 9″ × 12″
- 2B graphite pencil
- Computer graphics program

This technique begins with the creation of a graphite pencil field sketch, which is later used to produce a final digital sketch. Digital renderings work exceptionally well for sequences because of the ability to work in separate layers. Each layer can be manipulated without affecting the others.

Step 1

At the onset of an erupting prominence, make a quick series of sketches with the graphite pencil and paper. Although they will be rough drawings, strive for accuracy. The size of the prominence should be relative to the scale of the arc segment drawn. Draw the variances between the brightest and faintest ribbons of plasma. Notate flare brightening, if any, along with observed sunspots, filaments and plages along this area of the limb (Fig. 5.47).

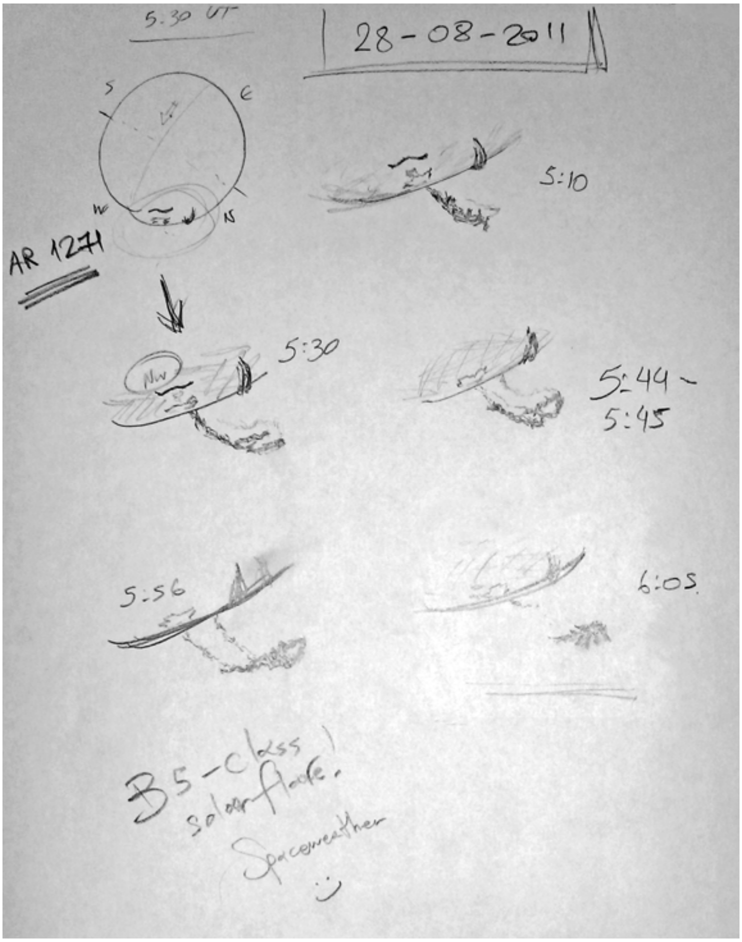

Fig. 5.47 Original sketch series of an erupting prominence during a B5-class solar flare—June 2, 2011, 05:10–06:05 UT. Coronado PST/SolarMax 40, Meade 4000 Super Plössl 9 mm and 7 mm. Graphite on white paper. (Courtesy of Stratos Tsanaktsidis, Thessaloniki, Greece)

Aim to produce a sketch every 5–10 min apart and record the time each sketch was completed. Make sure to include the position angle of the prominence; i.e., north is 0° or 360°, east is 90°, south is 180°, and west is 270°.

Step 2

When the observing session has ended, the field sketches are used as references while recreating them digitally using photo editing software. Adobe Photoshop was used for this tutorial. For the remaining steps, please refer to plates 1 through 8 in Fig. 5.48 when indicated.

Click on *File* and select *New*. Name your document and adjust the width, height, and resolution. A good size to start with is 1200 × 1000 pixels at 300 dpi. Click *OK*. Go to the right upper corner of the screen and click on the upper color box. Select black and click *OK*. Select the *Paint Bucket* tool and then click your curser into the document to create the black background layer.

Step 3

At the top of the screen, click *Layer* and then choose *New*, *Layer*. Select an orange color (Photoshop color: H 25, S 99 %, B 98 %) and then choose a hard round brush size 2500 for the solar limb. Click anywhere on the document to create the orange circle. You can then use the *Move Tool* to position the circle with the document so that only a small section of it is visible for the solar limb.

Step 4

Open a new layer. Choose hard round brush size 25 and select a light red color (Photoshop color: H 7, S 97 %, B 76 %) to sporadically paint spots over the solar disk. Choose an orange/red color (H 19, S 99 %, B 88 %) with a hard brush size of 8 to make similar paint spots. Next, use the *Smudge Tool* with a hard brush size of 43, normal mode, and 38 % strength to make color vortexes and spicules at Sun's limb. Repeat this step once more, and then continue using the *Smudge Tool* to draw out the color from the limb to create spicules (Plate 1).

Add another variety of red color (H 3, S 99 %, B 65 %) using the hard brush size of 8, and then blend again with the *Smudge Tool* hard brush size 17, normal mode, and 12 %. Repeat again using a lighter red color (H 3, S 99 %, B 73 %) (Plate 2).

Once last color is added, light orange (H 25, S 96 %, B 98 %) and then smudged with a hard brush size of 33, normal mode, and 28 % strength. And finally, the *Smudge Tool* is used at hard brush size 11, normal mode, and 35 % strength to create small squiggly lines for completing the chromospheric network (Plate 3).

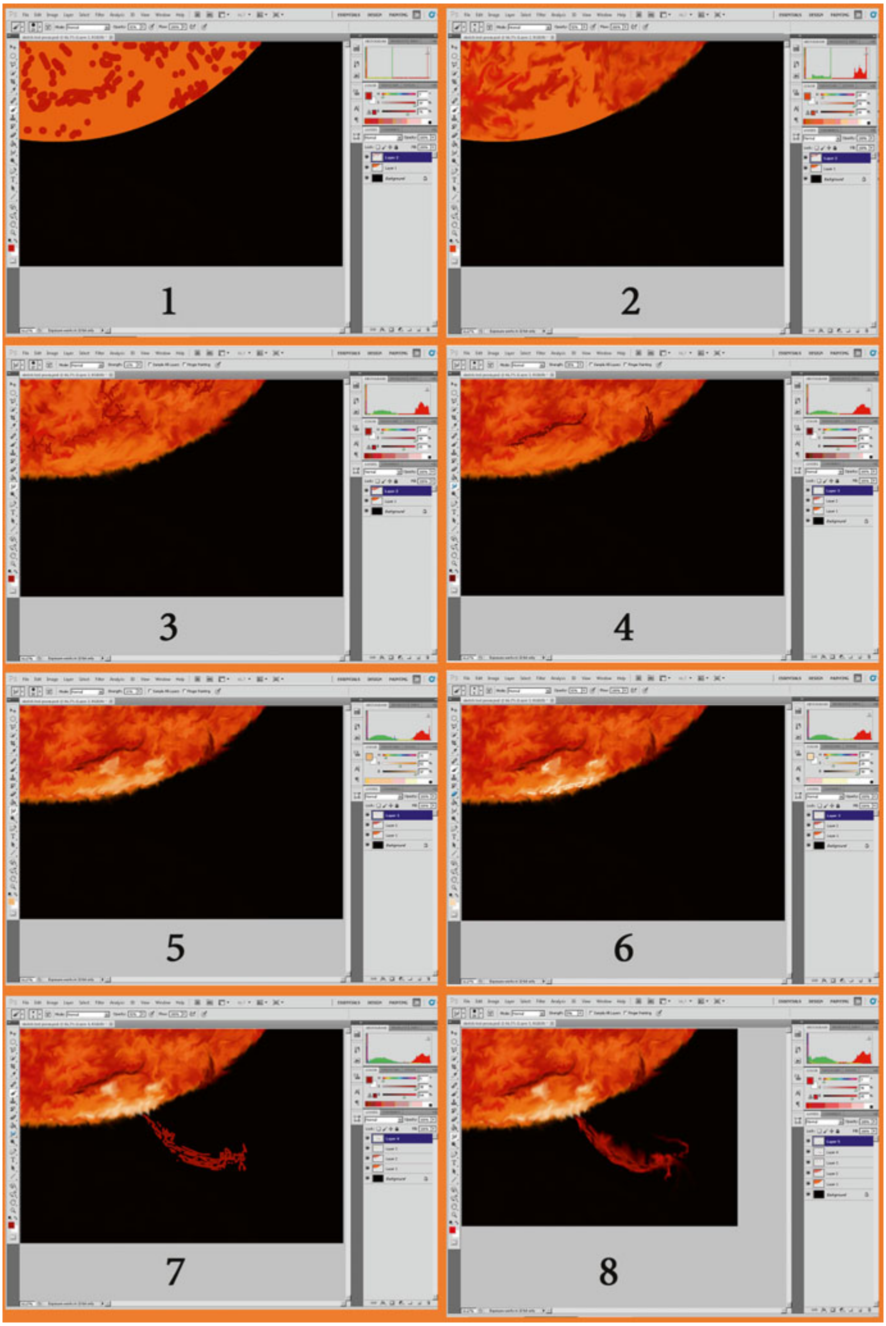

Fig. 5.48 The original field sketch is used as a reference when reproducing the sketch sequence in Adobe Photoshop. (Courtesy of Stratos Tsanaktsidis, Thessaloniki, Greece)

Step 5

Create a new layer. Select a dark brown color (H 5, S 95 %, B 44 %), and using a hard brush size of 8, sketch any filaments in that section of the disk. Smear them using the *Smudge Tool*, size 20 at 27 % to simulate their appearance (Plate 4).

Step 6

Select a bright cream color (H 31, S 52 %, B 97 %), and then add the plage using a hard brush size 8. Smudge with a brush size of 8 in normal mode with an 11 % strength (Plate 5).

Repeat using a brighter off-white color (H 33, S 28 %, B 99 %), and then finish off the active region by smudging with brush size 12, normal mode, and 15 % strength. The solar disk is now complete (Plate 6).

Step 7

Create a new layer. The brightest section of the prominence along the limb is added by selecting a reddish orange color (H 5, S 98 %, B 64 %). Use a brush size 8 to sketch its general shape with small strokes (Plate 7).

Blend and smear the strokes with *Smudge Tool*, size 25 at 15 %, to resemble the prominence. Extend the prominence to render the gauzy, fainter filaments using the *Smudge Tool* size 43 at 5 % strength (Plate 8).

Step 8

Add a new layer to continue building on the prominence without altering its base layer. Select a bright reddish-orange color (H 3, S 96 %, B 79 %) and apply brush strokes, size 4, to add depth and structure as seen through the eyepiece. Again, use the *Smudge Tool* at brush size 39 and 5 % strength to blend and shape the prominence to match that of your sketch.

Step 9

Use the *Crop Tool* to adjust its image field if needed, and then flatten the layers (*Layer, Flatten Image*) before saving the document.

Figure 5.49 shows the compilation of digital sketches that was based on Tsanaktsidis' field drawings.

As a comparison between techniques, the digital drawing of the erupting prominence in Fig. 5.50 was created by redrawing the original sketch in Adobe Photoshop. The purpose was to produce a cleaner version of the sketch where the color and

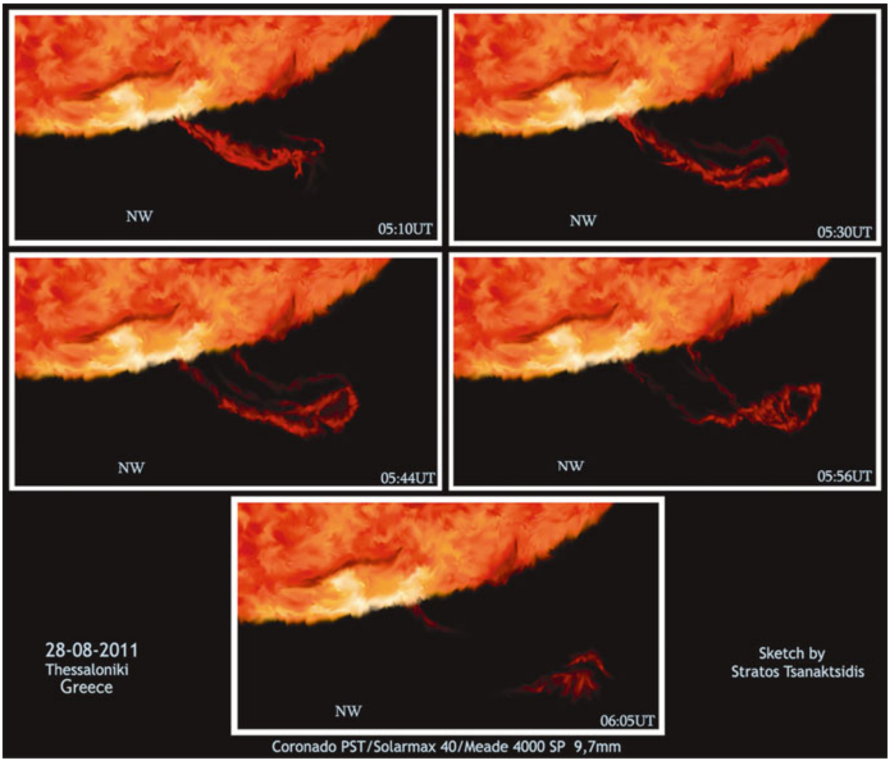

Fig. 5.49 Digital renderings based on a graphite field sketch sequence. (Courtesy of Stratos Tsanaktsidis, Thessaloniki, Greece)

contrast could be easily manipulated. The new drawing was layered over the original so that comparisons and fine adjustments could be made for accuracy. The digital drawing was then layered over an actual image of the Sun to produce the mottled appearance of the chromospheric network.

5.2.5 Digital Coloring (Technique of Les Cowley)

Original black and white sketches can be colorized using photo-editing software. The following examples in Figs. 5.51 and 5.52 were rendered with white pencils on black Canford paper and then processed using Adobe Photoshop.

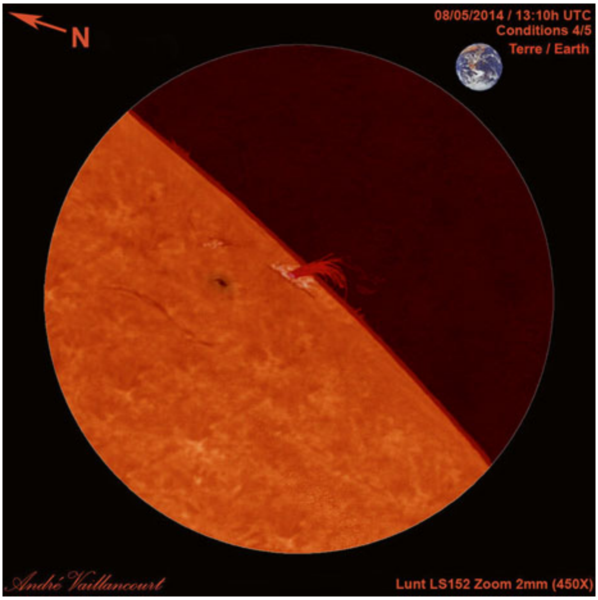

Fig. 5.50 Erupting prominence during an M-class flare from AR 2056—May 8, 2014, 13:10 UT. Lunt Solar Systems LS152 H-alpha, zoom eyepiece set at 2 mm, 450×. Original sketch using color pencils on white paper, then finished digitally by incorporating it with an image of that day's Sun for the mottled texture using Adobe Photoshop. (Courtesy of André Vaillancourt, Québec, Canada)

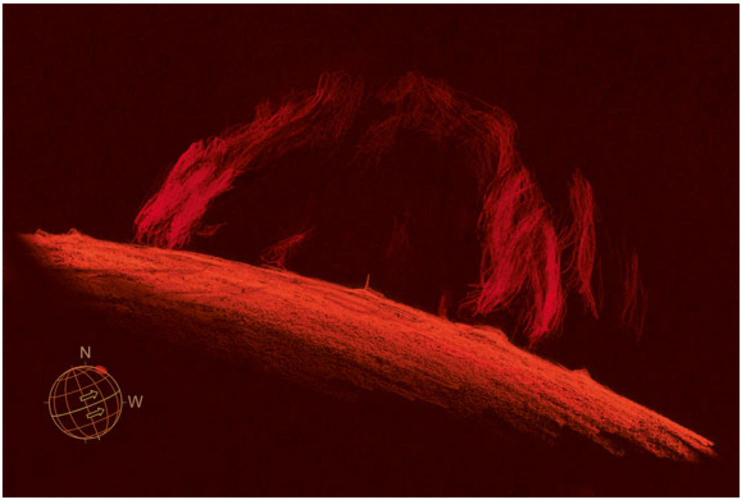

Fig. 5.51 Prominence on NW limb, 330° PA—August 30, 2009, 09:30UT. Coronado SolarMax 60, 50× and 80× magnification. White pencils on black Canford paper, then digitally colorized in Adobe Photoshop. (Courtesy of Les Cowley)

Warning! ALWAYS use a suitable filter when directly observing the Sun

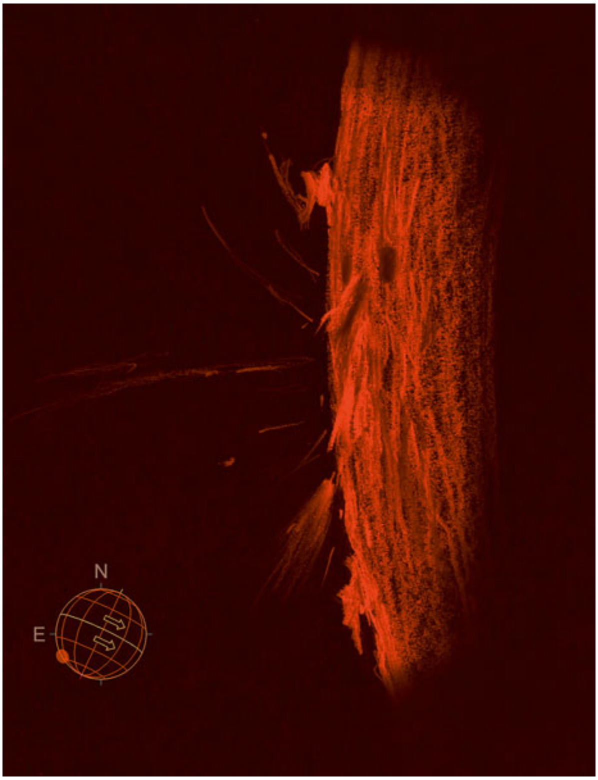

Fig. 5.52 Eruptive prominences on eastern limb 120° PA—March 22, 2011, 10:30 UT. Coronado SolarMax 60, 80× magnification. White pencils on black Canford paper, then digitally colorized in Adobe Photoshop. (Courtesy of Les Cowley)

Step 1

Scan and save your sketch.

Step 2

Open the sketch file in the photo-editing program. Next, click on the following tabs in order—*Image, Adjustments, Levels*.

Step 3

Next, on the tab *Channel,* click on the down arrow to view its options. Reduce the output levels of the blue and green channels.

5.2.6 Color Pastels on Black Paper (By Richard Handy)

We are not limited to computer software when it comes to drawing prominences in color. With a little practice, they can be rendered directly at the eyepiece using several shades of red or orange to depict the subtle hues of the H-alpha view. But for simplicity, which is especially advantageous for the beginner, select only one or two representative colors for the entire sketch.

Suggested Materials

- Strathmore Artagain 400 series, coal black drawing paper, 60 lb (160 g/m^2), 9″ × 12″
- Dry pastel sticks, red and orange
- Art gum eraser
- Blending stump

Step 1

To start the sketch, the red pastel stick is used to draw a shallow arc representing a segment of the Sun's limb (Fig. 5.53).

Step 2

Rub the tip of a clean blending stump against a side of the pastel stick to load it with pigment (Fig. 5.54).

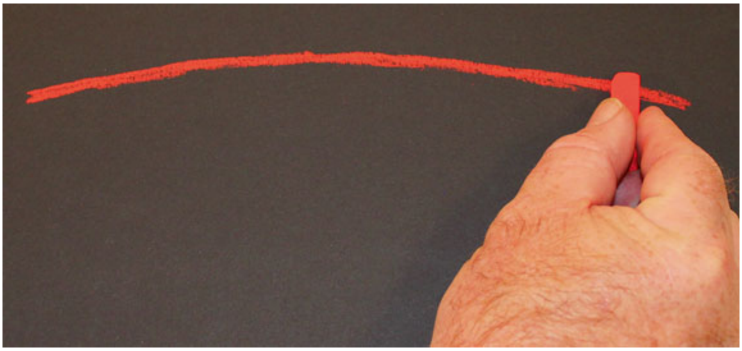

Fig. 5.53

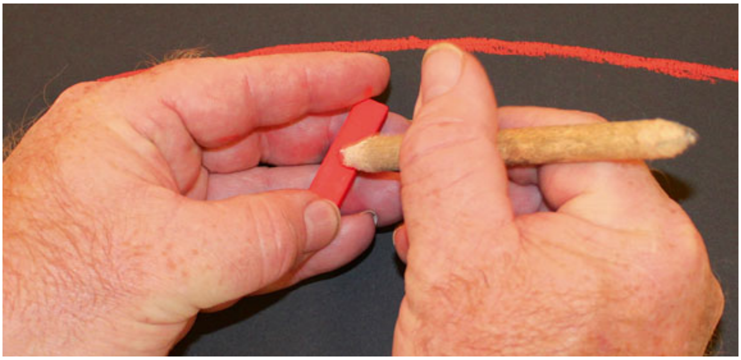

Fig. 5.54

Fig. 5.55

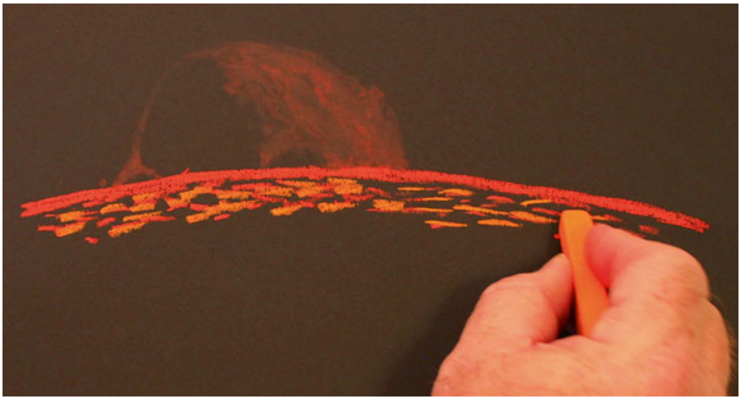

Fig. 5.56

Tip

Clean and sharpen a blending stump by rubbing it against a block of sandpaper. Blending stumps hold pigment and blend more smoothly when they are cleaned regularly.

Step 3

Render the shape of the prominence with the pastel pigment by using light, flowing strokes with the blending stump (Fig. 5.55). Reload the pastel onto the stump as necessary. Keep in mind the size and spacing of each section of prominence relative to the solar limb, otherwise the prominences will appear too large or small in comparison to the eyepiece view.

Step 4

As seen in Fig. 5.56, the chromosphere is represented very simply in the sketch. A layer of short dashes is applied with the red pastel just inside the limb. The same application is done with the orange pastel.

Step 5

Blend and then, using the art gum eraser, remove the pastel dashes to create a gradation of bright to dark inward from the limb arc. Figure 5.57 shows the completed sketch.

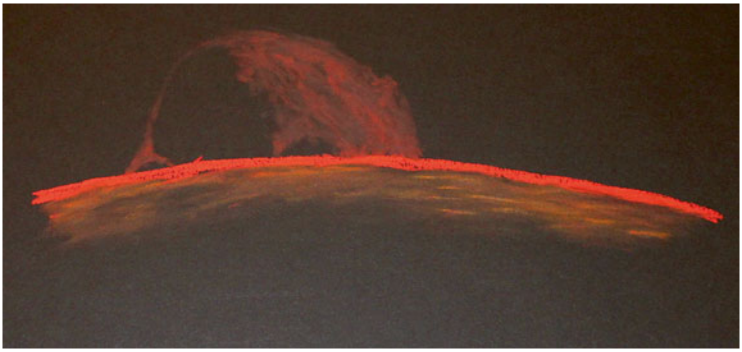

Fig. 5.57 Solar prominence, 190°–200° PA—October 20, 2013, 21:05–21:54 UT. TeleVue Pronto ED 70 mm f /6.8 fitted with a Coronado SolarMax 70 mm H-alpha filter, 8 mm TeleVue zoom, 60×. Antoniadi II. Color pastels on black Strathmore paper. (By Richard Handy)

5.2.7 Color Pencils and Pastel Pencils on Black Paper (By Richard Handy)

Color and pastel pencils produce refined markings when rendering the complex structure of a prominence. The pastel pencil is softer and can be easily manipulated, while the harder color pencil creates fainter, precise lines.

Suggested Materials

- Strathmore Artagain 400 series, coal black drawing paper, 60 lb (160 g/m^2), 9″ × 12″
- Conté pastel pencil, orange
- Prismacolor color pencil, Carmine Red PC 926

Step 1

To start this sketch, an orange Conté pastel pencil is used to draw a shallow arc to represent the Sun's limb.

Step 2

Next while using the Carmine Red pencil, the shapes of the prominences are applied with light strokes. The orange pastel can be used to highlight their brightest areas. Be mindful of the sizes and spacing of the prominences. They should be proportioned accurately to the limb's arc; otherwise they will appear too large or small in comparison to the eyepiece view (Fig. 5.58).

Step 3

Small random scribbles are made with both pencils to render the granular appearance of the chromosphere (Fig. 5.59).

Figure 5.60 displays the finished sketch.

The two previous techniques can be combined to produce a hybrid of the two. The pastel stick produces the blended chromospheric disk and the softer, gauzy appearance of the prominences. The darker pastel pencil is used to draw the limb's arc and the detailed structure of the prominences (Figs. 5.61). Figures 5.62 and 5.63 provide excellent examples of alternative media to use for prominence sketches.

Fig. 5.58

Fig. 5.59

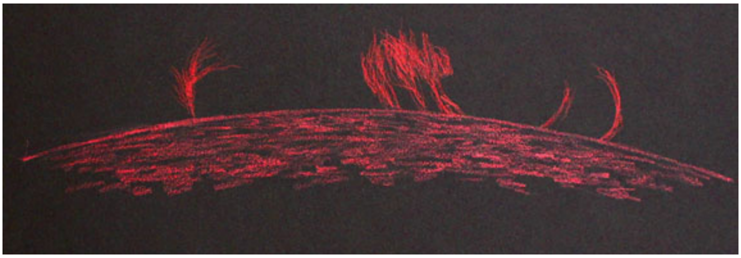

Fig. 5.60 Solar prominences, 30°–50° PA—January 3, 2013, 17:45–18:00 UT. TeleVue Pronto ED 70 mm f /6.8 fitted with a Coronado SolarMax 70 mm H-alpha filter, 8 mm TeleVue zoom, 60×. Antoniadi III. Orange Conté pastel pencil and Carmine Red PC 926 Prismacolor pencil on black Strathmore Artagain paper. (By Richard Handy)

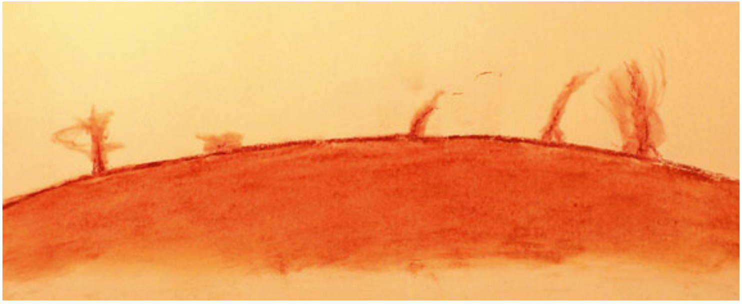

Fig. 5.61 Solar prominence, 80°–90° PA—February 3, 2013, 20:50–21:15 UT. TeleVue Pronto ED 70 mm f /6.8 fitted with a Coronado SolarMax 70 mm H-alpha filter, 8 mm TeleVue zoom, 60×. Antoniadi III. Burnt umber 1355 No. 07 Conté pastel pencil and Conté Sanguine stick on black Strathmore Artagain paper. (By Richard Handy)

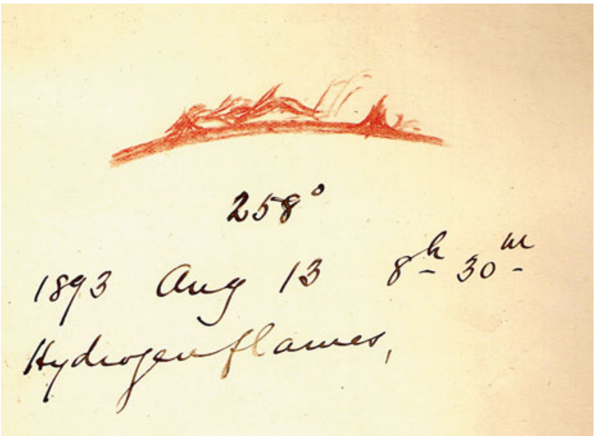

Fig. 5.62 August 13, 1893, prominence drawing by Allan F. Miller (1851–1947) using red pencil on paper. The observation was made using a 4-in. Wray refractor and a Browning spectroscope. (Image courtesy of the Royal Astronomical Society of Canada)

5.2.8 *Charcoal on White Paper (By Erika Rix)*

The faintest wisps of prominence structure are sometimes easier to see in a sketch when set against a light background of white paper. The con, however, is that it also produces a bright glare when used for solar sketching. This can ruin your dark adaptation needed to view the faintest details along the solar limb, often taking a few minutes to regain a keen eye. To minimize this effect, use a sun shield and try sketching underneath a solar cloth that is draped over both you and the eyepiece holder.

Fig. 5.63 Eastern limb prominences—January 12, 2012, 10:50–11:20 UT. Coronado H-alpha PST, 8 mm TeleVue, 50×. Colored pastel on black Conté paper. (Courtesy of Deirdre Kelleghan, Wicklow, Ireland)

Suggested Materials

- Sheet of white paper, 5″ × 7″ minimum
- Charcoal stick, dark black
- Charcoal pencil, medium or light
- White vinyl eraser, sharpened to a wedge or a point

Step 1

Lay the stick of charcoal on its side. Create a wide, shallow arc with a single smooth motion. The wider the arc, the more room there will be to include the finer details of the view. User firmer pressures toward the front end of the charcoal stick so that a continual line is produced to represent the limb's edge (Fig. 5.64). With the charcoal still on its side, use light pressure to fill in the disk.

Fig. 5.64

Step 2

Lightly blend the disk so that a mottled texture remains. Next, the charcoal pencil is used to draw the filament. Concentrate solely on the denser portions, their unique shapes, proportions, and positions. Begin adding the prominences, adjusting the pressure of the pencil as needed for contrast (Fig. 5.65).

Step 3

Use the wedged eraser to outline the brighter contrasted areas around the filament (Fig. 5.66).

Step 4

Less pressure is used with the charcoal pencil to add the slender filamentary ribbons reaching over the limb from the prominence. Adjust the tuning of your H-alpha filter to tighten the bandwidth. You may be able to pull out more detail from the view (Fig. 5.67).

Step 5

The eraser is used to include any remaining plages to finish the sketch, as seen in Fig. 5.68.

Fig. 5.65

Fig. 5.66

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 5.67

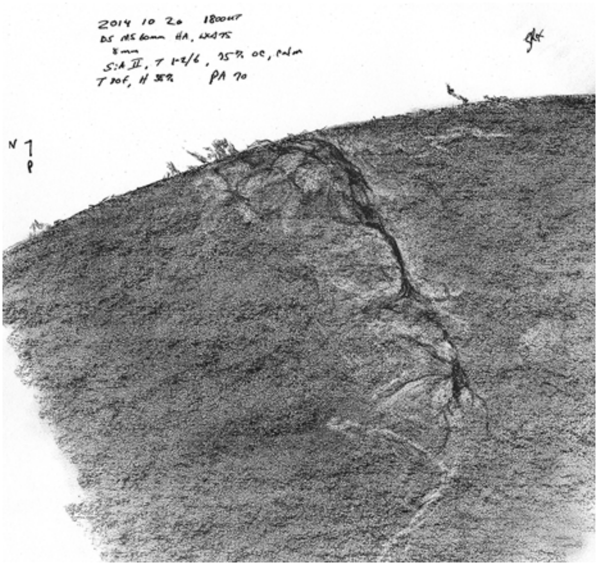

Fig. 5.68 Filament extending over the limb, 70° PA—October 20, 2014, 18:00 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, Baader Planetarium Hyperion 8–24 mm Mark III set at 8 mm, 50×. Wilson II, 1-2/6 transparency, 75 % overcast, calm, 80 °F (27 °C), 38 % humidity. Black charcoal stick, light charcoal pencil, vinyl eraser, and white printer paper. (By Erika Rix)

5.2.9 *Graphite on White Paper (By Richard Handy)*

Graphite shavings are scraped into a container and then used to create soft plumes of prominences. This tutorial explains the technique.

Suggested Materials

- Strathmore Artagain 400 series, medium white drawing paper, 9″ × 12″
- 2B graphite pencil
- Utility or craft knife
- Small container
- Blending stump
- Art gum eraser

Step 1

Draw a shallow arc with the graphite pencil to represent the solar limb. Either use a template as a guide or sketch the arc by hand (Fig. 5.69).

Step 2

The prominence will be drawn using very light coats of graphite powder, which is applied with the blending stump. Using the utility knife, scrape graphite powder from the tip of the pencil into a small container (Fig. 5.70).

Fig. 5.69

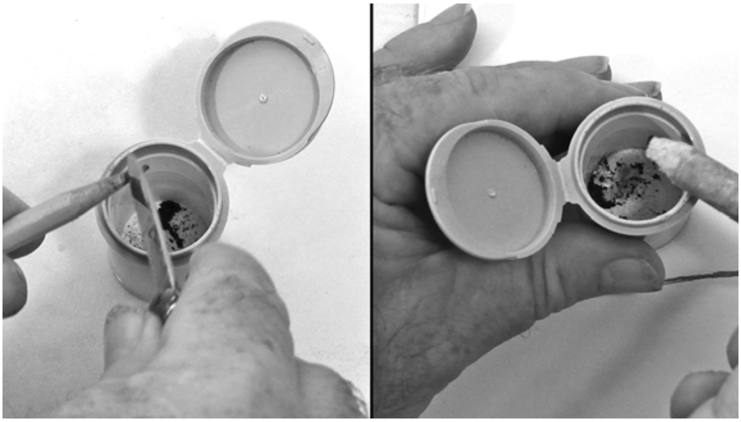

Fig. 5.70

Step 3

Coat the tip of the blending stump with graphite by dipping it into the powder from the vial. Begin sketching the prominence with the blending stump. A light application of graphite produces a realistic diffused appearance. Recoat the blending stump as necessary while you sketch. An art gum eraser can be used to correct any mistakes in the shapes of the prominences (Fig. 5.71).

Step 4

Reload the tip of your blending stump with the powder, and then use rapid strokes to fill in the disk. Build up the darker tones closer to the limb, and then use less graphite and pressure to gradually fade into the white paper as you work inward from the limb (Fig. 5.72).

The completed sketch can be seen in Fig. 5.73.

5.3 Whole Disk

Perhaps one of the most challenging and enjoyable aspects of solar sketching is attempting to capture the entire disk of the Sun in a single drawing. Given the great complexity of the H-alpha view, this can seem a very daunting task. The following selection of easy to follow techniques is provided to assist you in capturing the wide variety of features visible within the chromosphere.

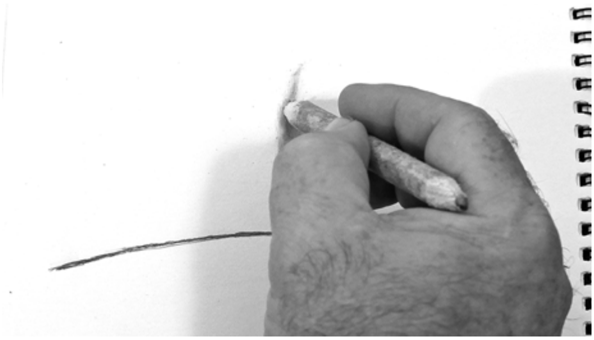

Fig. 5.71

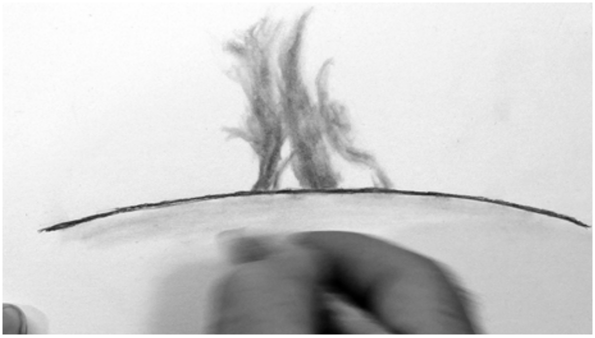

Fig. 5.72

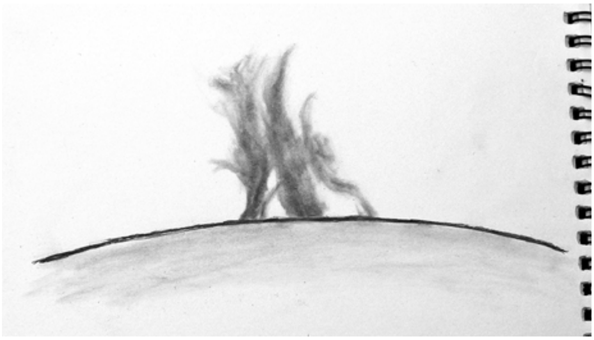

Fig. 5.73 Solar prominence, 190°–200° PA—October 21, 2013, 21:00–21:20 UT. TeleVue Pronto ED 70 mm f /6.8 fitted with a Coronado SolarMax 70 mm H-alpha filter, 8 mm TeleVue zoom, 60×. Antoniadi II–III. HB graphite pencil on white Strathmore Artagain paper. (By Richard Handy)

Warning! ALWAYS use a suitable filter when directly observing the Sun

5.3.1 *Mixed Media on Black Paper (By Erika Rix)*

The media mixture in this tutorial may seem just as complex as the features in the chromosphere, but with a little practice, you will discover that each tool has a specific purpose for rendering the Sun in H-alpha. Use the following suggested materials to start with, but as time progresses, find a combination that works best for your drawing style.

Suggested Materials

- Black acid-free paper, 60 lb (160 g/m^2), 9″ × 12″
- Pastel or charcoal pencils, white and black
- Color pencil, white
- Oil-based pencil, black
- Artist pen, black, F (0.5 mm) tip
- Hard pastel stick, white
- 6-in. circular protractor
- White vinyl eraser pencil, sharpened with a craft knife to a wedge or a point
- Bulb blower

Step 1

Trace the outline of the circular protractor onto your paper using a white color pencil. Holding the white pastel stick on its side, use medium pressure with broad strokes along the inside edge of the line. Continue on to fill in the remainder of the circle to create the background that represents the solar disk (Fig. 5.74). The coating should be light, and textured.

Step 2

Using either your fingertips or tissue (a chamois may remove too much pastel), blend with a circular motion until almost smooth. Slight texture should remain to represent a hint of the chromospheric network, yet smooth enough to prevent the details of the active region from becoming lost within the background (Fig. 5.75). Use the bulb blower to blow the dust residue from the paper, making sure that you are downwind from the telescope optics before doing so.

Step 3

Remove excess pastel from the outer edges of the disk with the eraser (Fig. 5.76).

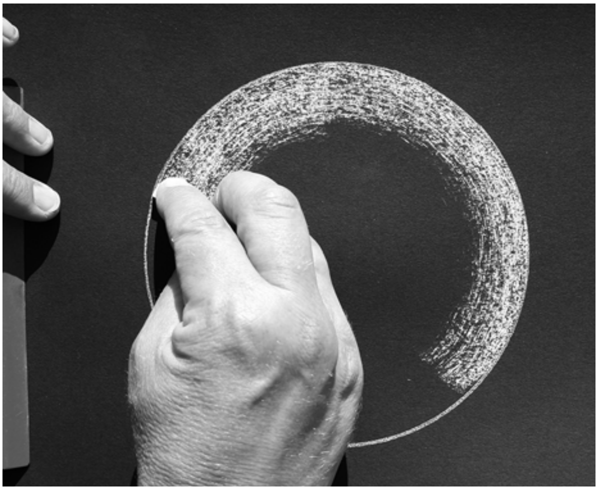

Fig. 5.74

Fig. 5.75

Step 4

The prominences are added first as positional references during the remainder of the sketch. Use a sharpened white pastel pencil to render the brightest areas of the prominences around the limb. Cross-reference them to each other and with the

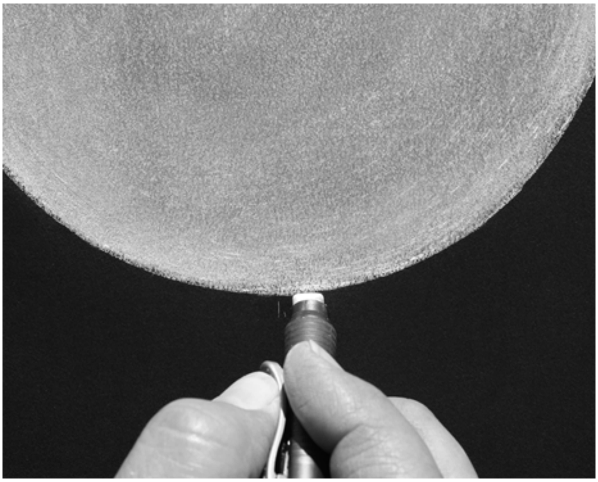

Fig. 5.76

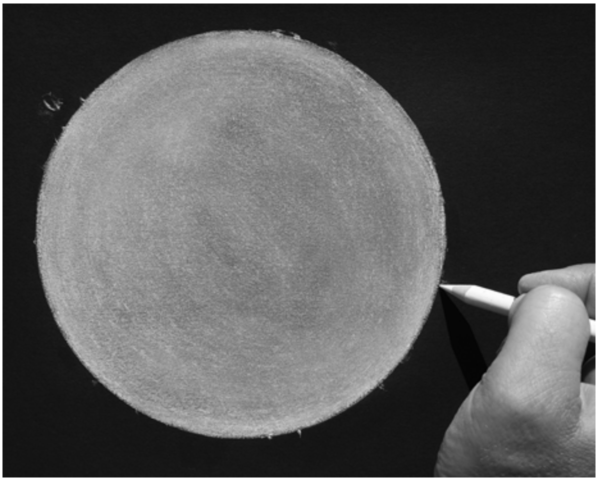

Fig. 5.77

eyepiece view for accurate placements and proportions. The faintest strands of prominence are then added with a very sharp white color pencil (Fig. 5.77). Use the solar cloth to improve the contrast through the eyepiece.

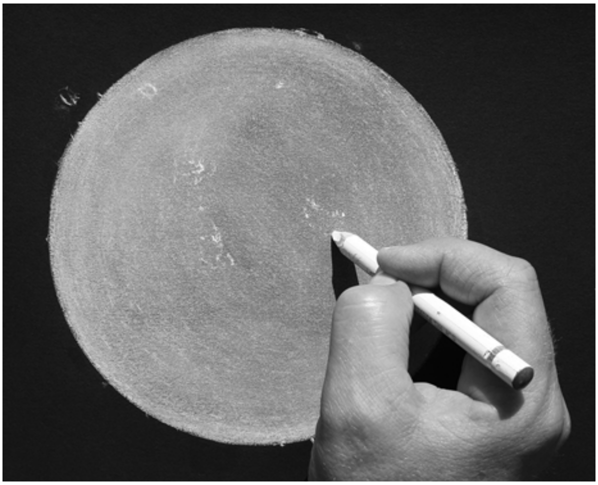

Fig. 5.78

Step 5

Begin adding plages with the white pastel pencil. Adjust the bandwidth tuning to draw out these features. Again, cross-reference them to each other, the eyepiece view, and the rendered prominences for accuracy (Fig. 5.78).

Step 6

Plot the umbral regions of the sunspots first with the artist pen (Fig. 5.79).

Step 7

Begin adding filamentary features with the black oil pencil. Oil pencils work very well over pastels, resulting in rich contrast that can be adjusted by pressure. Alternate between the oil pencil and the white pastel pencil for filaments and plages, working in wedges across the solar disk (Fig. 5.80).

Step 8

To add depth and contrast that is often observed around active regions, use a black pastel pencil very lightly around the plages. Refer back to the eyepiece view so that those areas are recorded faithfully (Fig. 5.81).

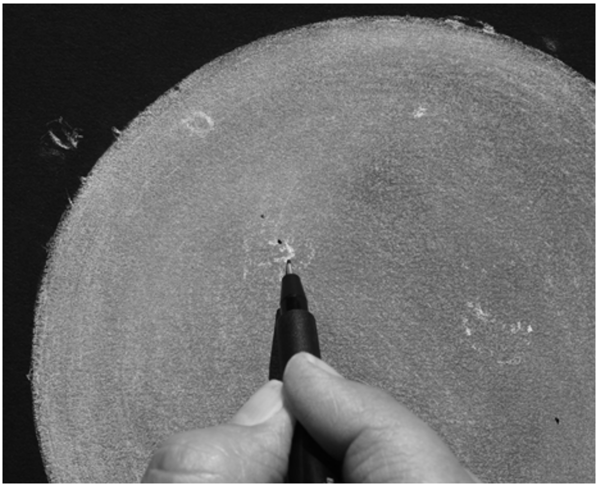

Fig. 5.79

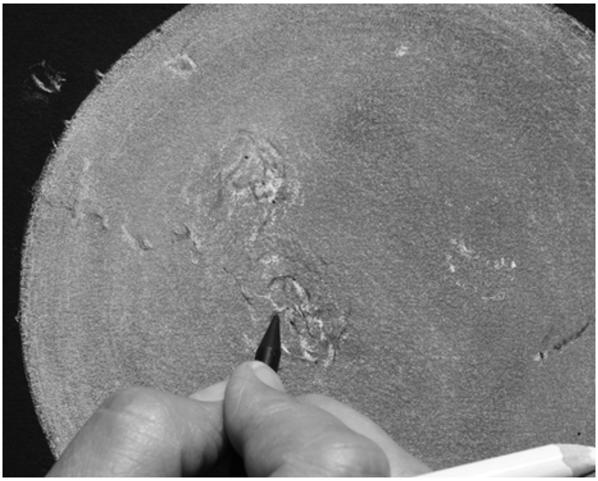

Fig. 5.80

Step 9

Scan the solar disk once more, adjusting the tuning as needed to check for final details that should be added to the sketch. Record observation data relevant to your session and mark orientation on the sketch. Figure 5.82 shows the completed sketch.

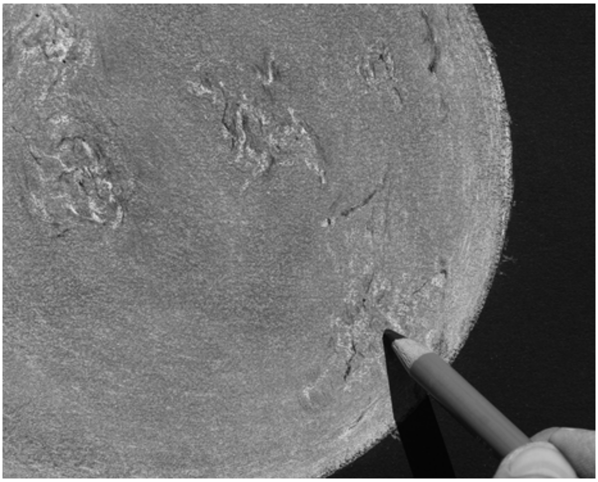

Fig. 5.81

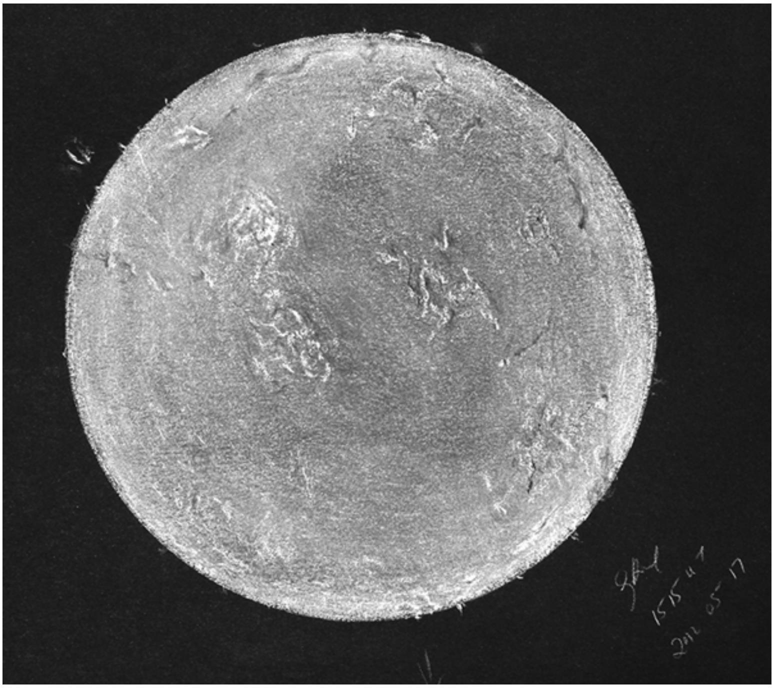

Fig. 5.82 The Sun in H-alpha, NOAA 11476, 11474, 11475, 11471—May 7, 2012, 15:15 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, Baader Planetarium Hyperion 8–24 mm Mark III set at 8 mm, 50×. SE winds at 4 mph, partly cloudy, Wilson 4.5, 4/6 transparency. Black Strathmore Artagain paper, white Conté crayon and pastel pencil, white Prang color pencil, Derwent charcoal pencil, black oil pencil, black felt-tipped pen. (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

5.3.2 *Pastels and Colored Pencils on Black Paper (By Richard Handy)*

A combination of orange and red pastels and pencils are used in this technique to produce the colorful hues representative of the eyepiece view. Make sure to grab a paper towel so that you can wipe your hands frequently during the observing session.

Suggested Materials

- Strathmore Artagain 400 series, coal black drawing paper, 60 lb (160 g/m^2), 9″ × 12″
- Prismacolor color pencil, Carmine Red PC 926
- Dry pastel sticks, orange and red
- Blending stump
- Art gum eraser
- Cosmetic brush

Step 1

Draw the outline of the solar disk using the red pencil and a dinner plate as a template. An orange pastel is placed on its side and swept in arcs. After several applications the first layer is complete (Fig. 5.83).

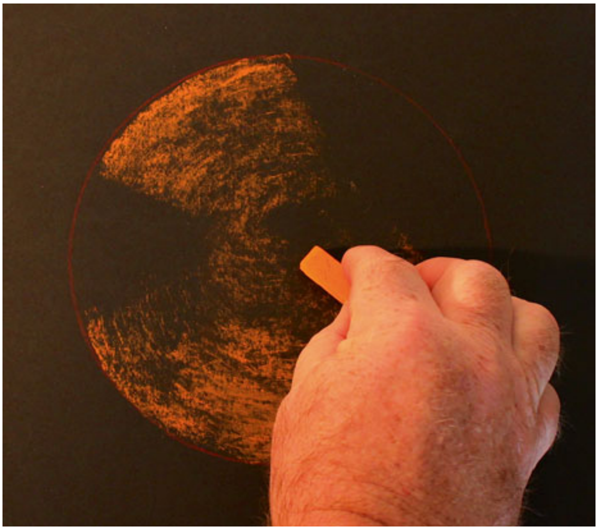

Fig. 5.83

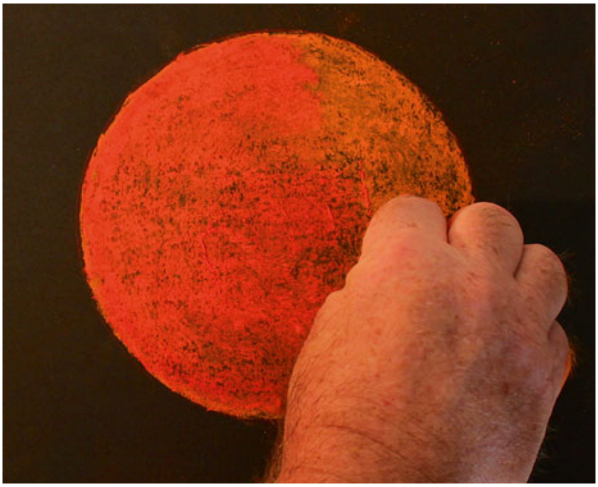

Fig. 5.84

Step 2

An additional layer of red pastel is similarly applied, resulting in a relatively even red-orange disk (Fig. 5.84).

Step 3

A clean blending stump is used to remove pastel from the disk to create the appearance of filaments. Follow their contours as seen through the eyepiece (Fig. 5.85).

Step 4

Prominences along the solar limb are drawn with the red pencil. Cross-reference them to the filaments and the eyepiece view for accuracy (Fig. 5.86).

Step 5

The corners of a black pastel work well to draw the sunspots. Use care to correctly position the pastel, as it is not easy to correct a mistake without disturbing the evenness of the previously applied pastel layers (Fig. 5.87).

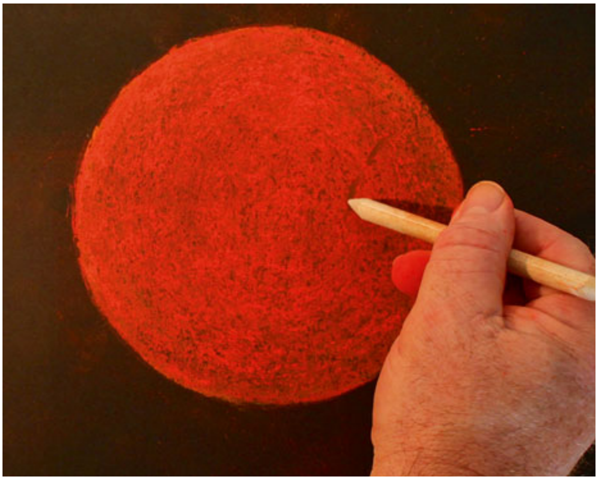

Fig. 5.85

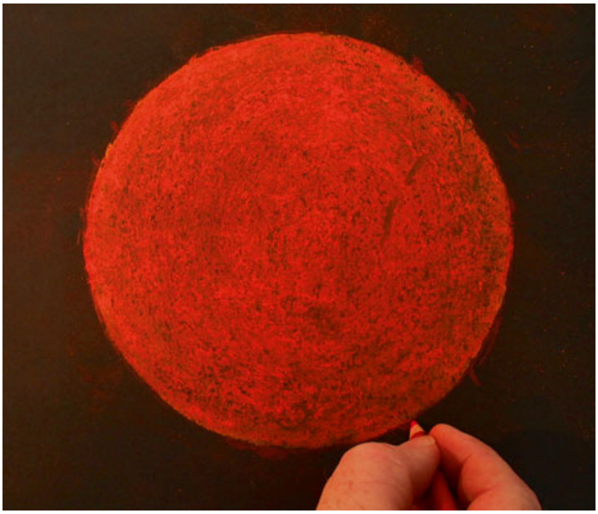

Fig. 5.86

Step 6

As demonstrated in Fig. 5.88, an orange pastel is used to create the plages and other bright areas often associated with active regions.

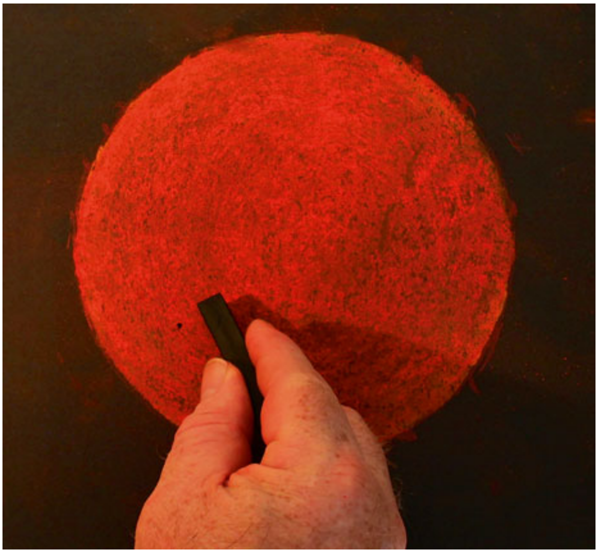

Fig. 5.87

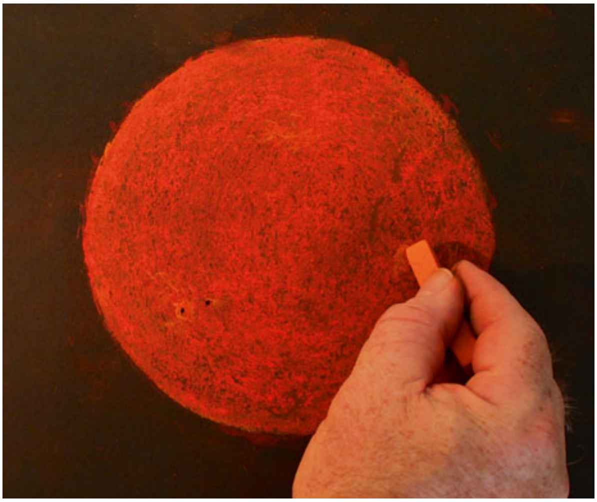

Fig. 5.88

Step 7

An art gum eraser does a great job of cleaning up any errant marks and pastel dust outside of the rendered solar disk. The eraser debris can be whisked away using the cosmetic brush (Fig. 5.89).

Warning! ALWAYS use a suitable filter when directly observing the Sun

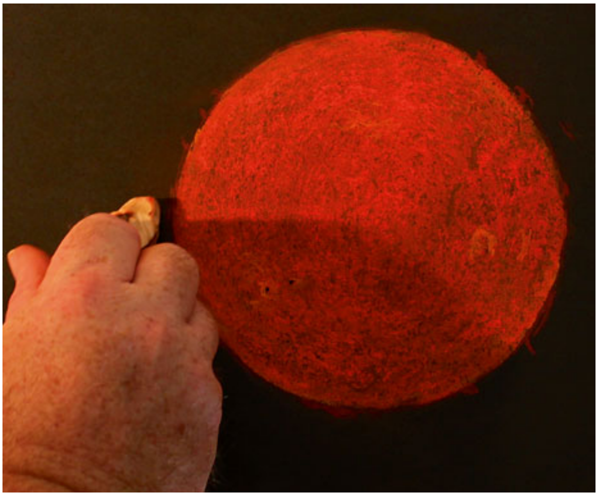

Fig. 5.89

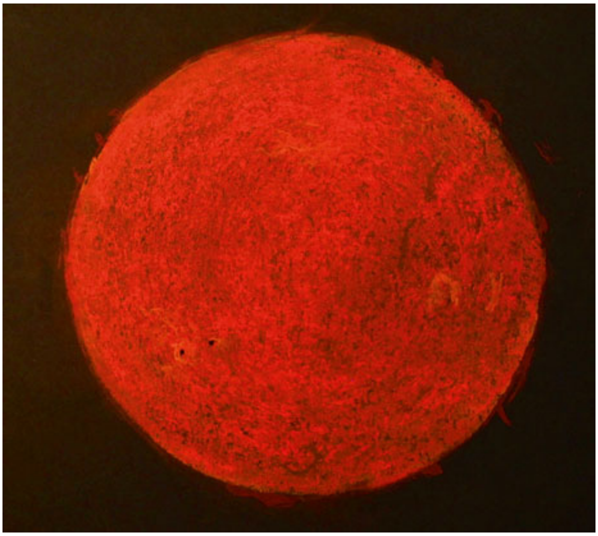

Fig. 5.90 The Sun in H-alpha—March 12, 2013, 18:00–18:50 UT. TeleVue Pronto ED 70 mm f /6.8 fitted with a Coronado SolarMax 70 mm H-alpha filter. Antoniadi III. Carmine Red PC 926 Prismacolor color pencil, orange and red pastels, and a blending stump on black Strathmore Artagain paper. (By Richard Handy)

The completed sketch is shown in Fig. 5.90.

5.3.3 Color Pencils on Black Paper (By Sally Russell)

The media chosen for making a drawing of the Sun influence the way in which the sketch is constructed—the process will be different when using a dark medium on a light paper compared with using a light medium on a dark paper. In this example, I was trying to find a way to represent the glowing Hydrogen-alpha Sun in color on black paper. The swirling active regions with their bright plages were very conspicuous, but white is too harsh to use on its own to represent plage. So instead, I used it as a base layer to impart brightness, and then toned it down by adding a top layer of color. The Canford paper used in this example has a reasonable tooth so picks up the watercolor pencil pigment very easily.

Suggested Materials

- Black drawing paper (Daler-Rowney Canford, 90 lbs, 150 g/m^2, size 8¼″ × 11¾″, UK size A4, was used in this example)
- Watercolor pencils—orange (Derwent Watercolor Orange Chrome 10), pale orange (Faber-Castell Albrecht Durer Cadmium Orange 8200–111), white (Derwent Graphitint White 24), deep violet-blue (Derwent Inktense Violet 108)
- Plastic eraser
- Compass

Step 1

I drew a 5-in. diameter circle template using a compass and the orange pencil. The pencil tip was gently rounded by scribbling with it on a scrap piece of paper—this produced a soft line which was easy to blend into the background later on.

Step 2

Next, I added anchor points by lightly sketching the positions and extents of the brightest plage regions with the white pencil (Fig. 5.91). To check for accuracy of position, I rapidly scanned back and forth between the eyepiece view and my paper to compare the layout. Any features that had been drawn noticeably out of place were erased and re-drawn.

Step 3

There were a few small prominences present that day, so I sketched those in next using the orange pencil. They were very small on this disk scale—when drawing prominences, be careful not to supersize them! As prominences are conveniently

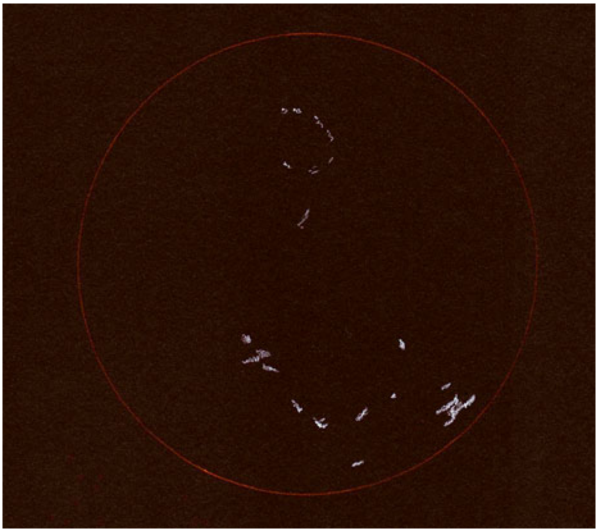

Fig. 5.91

placed around the Sun's limb (and therefore easily associated with clock positions), it is particularly useful to imagine the solar disk as a clock-face when adding prominences to your sketch. Once drawn, they not only help to marry the eyepiece view with your sketch, but they also act as additional markers for positioning other features on the disk (Fig. 5.92).

Step 4

The next stage of the sketch is depicting the background chromosphere. The ever-changing solar surface precludes us from being able to accurately draw every last spicule and super-granule cell, but it is still possible to make a very good representation of the overall view. Still using the orange pencil, I made small 1–2 mm marks, wiggling the pencil back and forth in a random motion to cover the paper evenly (Fig. 5.93). Note that I rotated the sketch while working so as to always keep a comfortable sketching angle for my hand (Fig. 5.94). Taking my time so that the background was kept even, I sketched right up to and around the previously drawn plage areas (Figs. 5.95 and 5.96). If you try this method of drawing the background, it is a good idea to rotate your pencil every so often while you work so that a flat patch isn't created on the lead!

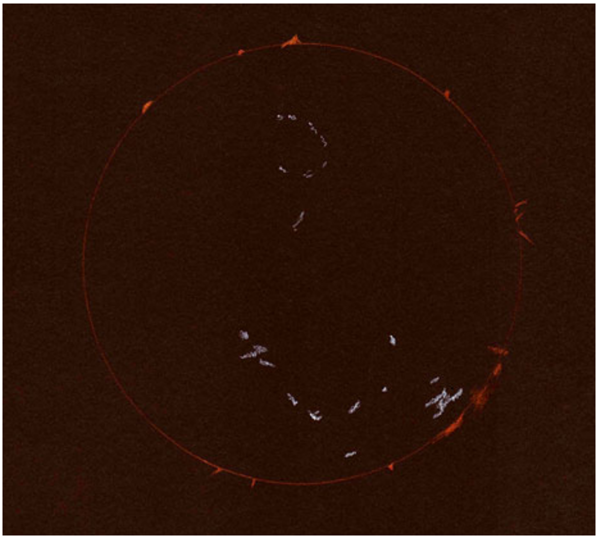

Fig. 5.92

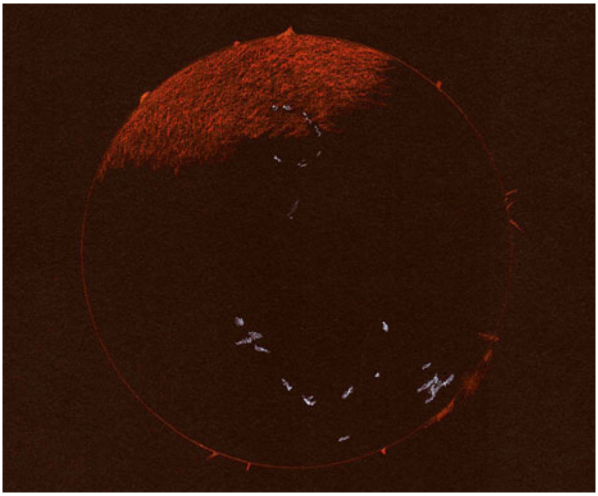

Fig. 5.93

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 5.94

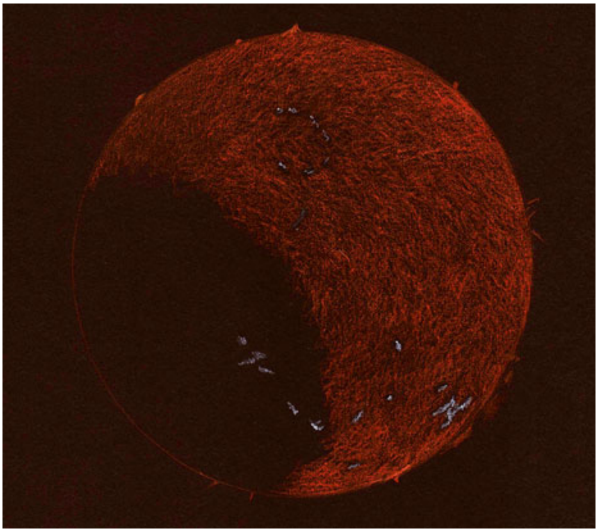

Fig. 5.95

Step 5

I prepared to add the sunspots and filaments. The correct placement of these was straightforward as I used the previously sketched features as markers. Since they were the darkest markings on the disk, they could be added last on top of the lighter

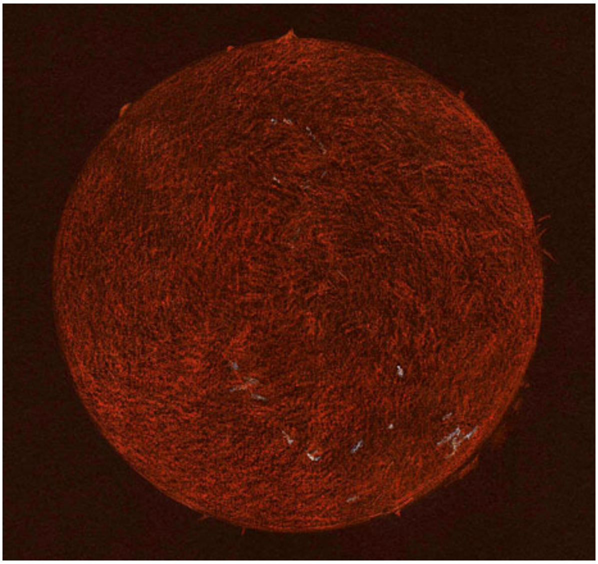

Fig. 5.96

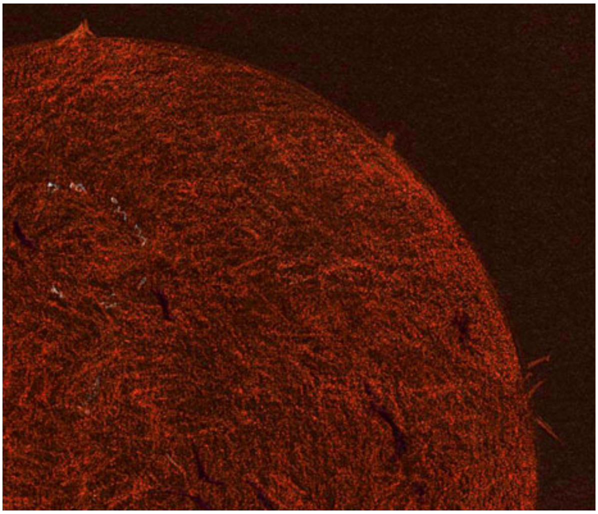

Fig. 5.97

background. I used a deep violet-blue pencil to sketch them, as this color is considerably less harsh than black, but is still dark enough to show a good (and more realistic) contrast with the orange background (Fig. 5.97).

Warning! ALWAYS use a suitable filter when directly observing the Sun

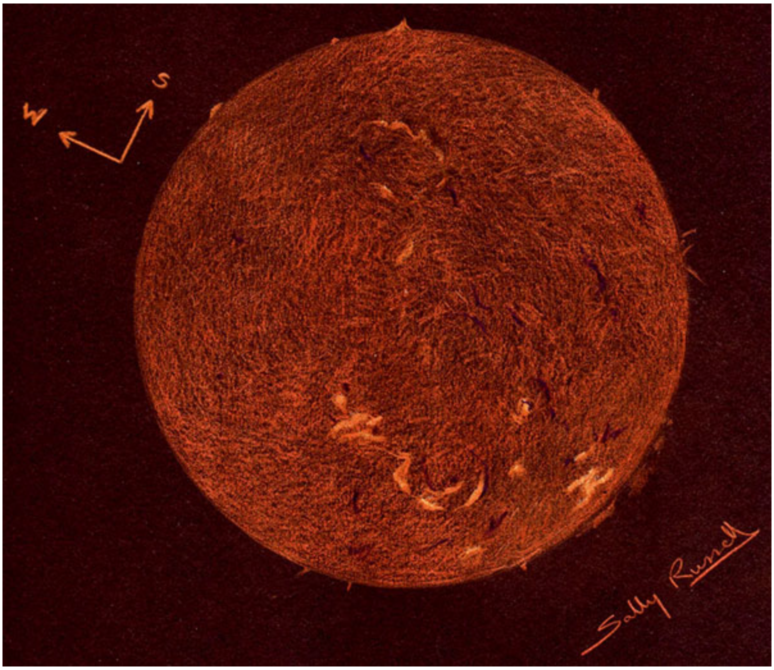

Fig. 5.98 The Sun in H-alpha—April 13, 2014, 14:00–16:40 UT. Coronado double-stacked PST, Alt-Az mount, 8-24 mm zoom eyepiece set at 12-16 mm, 25× through 33× magnification. Antoniadi I–II, clear, calm, 59 °F (15 °C). Black Daler-Rowney Canford paper, Derwent watercolor pencil Chrome 10, Faber-Castell Albrecht Durer Cadmium Orange 8200–111 pencil, Derwent Graphitint pencil White 24, Derwent Inktense pencil Violet 108. (By Sally Russell)

Step 6

To finish, I went over the previously drawn plage regions with the pale orange pencil. This softened the harshness of the white areas while keeping them bright enough to show up clearly against the general background. The final step was to determine and mark the cardinal directions on the paper. Fig. 5.98 is the finished sketch.

5.3.4 Charcoal and Ink on White Paper (By Erika Rix)

Using a similar technique as described in *Charcoal on White Paper* (by Erika Rix) in Sect. 5.2 *Prominences and Filaments*, an artist pen is added to render the sunspots for this full-disk exercise. Make use of a solar cloth to minimize the Sun's glare on the white paper.

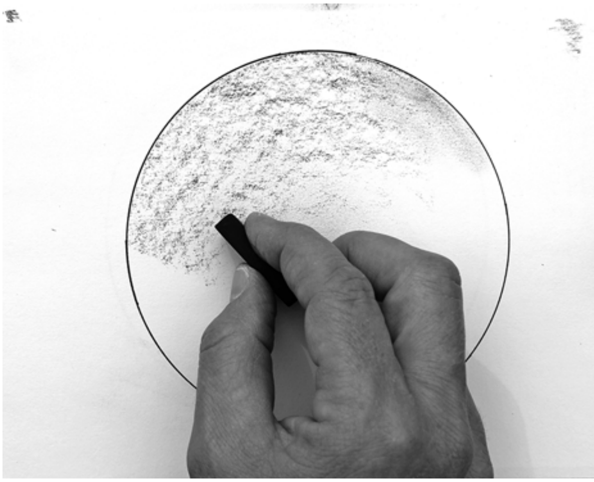

Fig. 5.99

Suggested Materials

- White paper, 8″ × 8″ minimum
- Charcoal stick
- Charcoal pencil
- Artist pen, black, F (0.5 mm) tip
- Blending stump, large
- 6-in. circular protractor
- White vinyl eraser pencil, sharpened with a craft knife to a wedge or a point

Step 1

Draw a circle onto the paper with the protractor and charcoal pencil. Then, using the charcoal stick on its side, lightly fill in the circle to represent the solar disk. Try to avoid creating harsh lines. The result should be a slightly textured layer of charcoal (Fig. 5.99).

Step 2

The tooth (surface texture) of the paper will vary depending on the type you use. For really smooth paper, a large blending stump or chamois works well to blend the charcoal while still leaving the mottled effect of the chromospheric network. If the paper tooth is coarser, try blending with your fingertips (Fig. 5.100).

Fig. 5.100

Fig. 5.101

Step 3

Sharpen the eraser pencil to a stocky point with the craft knife (Fig. 5.101). This will prepare it for drawing the plages by removing the layer of graphite to expose the white paper underneath. If you prefer a firmer wood-encased eraser pencil,

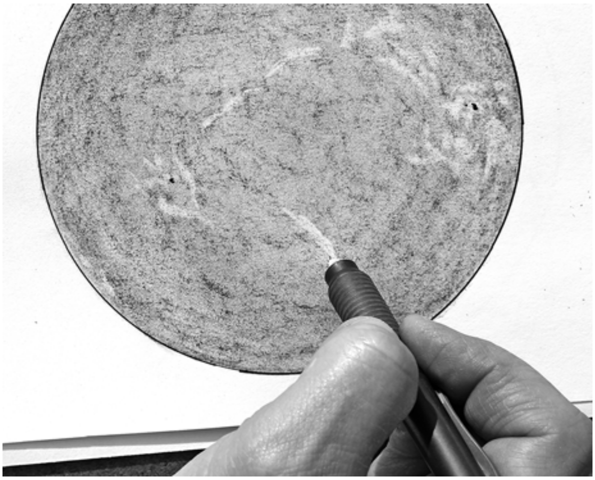

Fig. 5.102

choose the types with the vinyl eraser core rather than the pink pearl. The latter may leave pink streaks on the sketch instead of clean erasures.

Step 4

Use the sharpened eraser pencil to begin drawing the plages as well as the brightened areas found near filaments (Fig. 5.102). Include the sunspots at this time with the artist pen. Look closely at their positions within the associated plages.

Step 5

The filaments and prominence are added next with the charcoal pencil. Cross reference their positions and proportions with the sunspots and plage regions. Refer back to the eyepiece view often. Notice in Fig. 5.103 that the filaments meander with several associated strands nearby. With close observation through the eyepiece, these areas are seldom thick, puffy plumes, but rather layers of intricate densities. Try to capture their details faithfully by adjusting the angle and pressure of your charcoal pencil.

Step 6

With light pencil pressure, add faint layers of charcoal around the plages for contrast and to set them apart from their surroundings. Resist the urge to rush through

Fig. 5.103

Fig. 5.104

these final two steps, as your attention to detail will create a more realistic rendering true to the eyepiece view (Fig. 5.104).

The completed sketch can be viewed in Fig. 5.105.

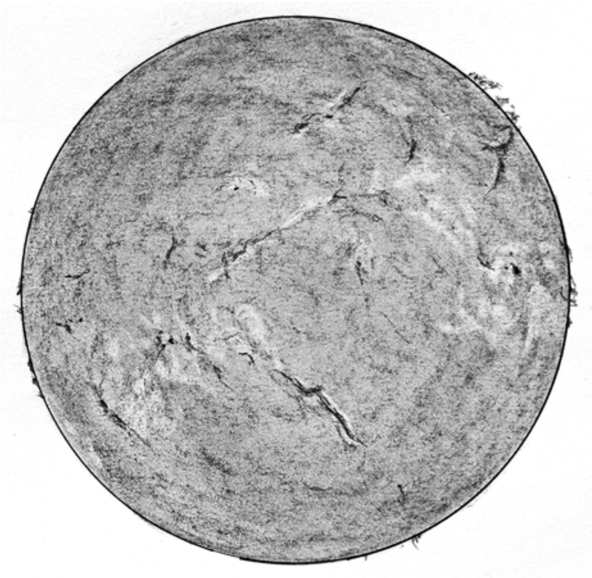

Fig. 5.105 The Sun in H-alpha, ARs 2186, 2187, 2192, 2193—October 19, 2014, 22:00 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, Baader Planetarium Hyperion 8–24 mm Mark III. White card stock, charcoal stick, Derwent light charcoal pencil, Faber-Castell PITT artist pen F. (By Erika Rix)

5.3.5 Graphite on White Paper (By Sally Russell)

Sketching the entire disk of the H-alpha Sun might seem like a daunting task, but if you have a robust method for tackling it, then even the busiest disk of activity can be captured onto paper in a few logical steps. Before attempting a full disk drawing, you may find it worthwhile sketching smaller areas and individual features as practice first.

Study the eyepiece image of the Sun's disk for a good while before you begin your sketch. It really helps if you can mentally visualize the layout and orientation of the visible features due to your familiarity of the view. Look first to see where the sunspots/active regions are, then look at the filaments. At what angle are they lying across the solar disk and what proportion of the disk do they stretch across? Then observe the prominences and their proximity to other features on the disk. If you break down the whole image into its constituent parts in this way, it can help to fixate the view in your mind.

While you are observing and sketching, you may find that you need to re-tune your telescope or adjust the magnification as the observing conditions fluctuate. I like to use my H-alpha solar telescope on an alt-az mount so that I can easily move the image around the field as required to favor prominences, filaments, or active regions.

I actually prefer this to a stationary (tracked) view, as I find the movement helps me to detect additional features more easily. Thin clouds passing through the field of view can also help to bring out disk detail.

Suggested Materials

- White drawing paper (Daler-Rowney heavyweight cartridge paper, 135 lbs, 220 g/m^2, size 8¼″ × 11¾″, UK size A4, was used in this example) on a clipboard
- B, 2B, 4B graphite pencils
- Plastic eraser

Step 1

I started this sketch using a 2B pencil, and very lightly drew a 5-in. diameter circle with a compass. Any alternative circular template could have been used. A disk this size is big enough to permit large amounts of detail to be added. You would still be able to capture a fair amount of detail if working on a smaller scale, so choose a disk size that doesn't overwhelm you.

Step 2

Using a slightly harder B pencil, I began sketching the main features. As always when sketching the solar disk, if you liken it to a clock-face, then you can use estimated o'clock positions to help with the placements of prominent features. If there are features conveniently placed across the diameter of the disk, they can also serve as good anchor points for the remainder of your sketch.

I mapped out the positions of the darker features first, starting with the sunspots. If you think of each sunspot being on an imaginary line drawn through the center of the disk, then to help position the sunspot on your sketch, estimate the angle of the line through the center disk (e.g., from 10:30 o'clock to 4:30 o'clock), and the proportion of the line on either side of the sunspot. That ratio (e.g., 1:4, where the sunspot would be 20 % of the diameter away from one edge of the disk) is a useful aid once you have taken your eye away from the eyepiece. I drew each umbra at its relative observed size using a small circular motion with the pencil. I reapplied the graphite as many times as was needed to get the correct depth of tone (Fig. 5.106).

Step 3

Next, I sketched in the filaments, still using the B pencil. By holding the pencil at a shallow angle so that most of the lead was in contact with the paper, I was able to draw softer lines for the broadest filaments. During this step, I find it very useful to

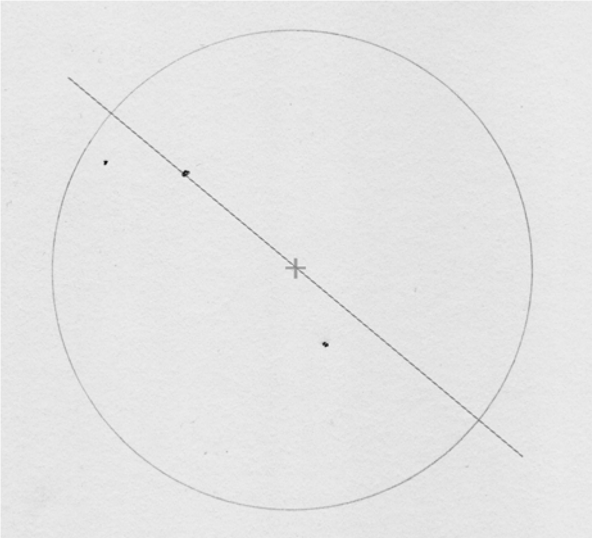

Fig. 5.106

think of the solar disk as being like a pizza divided into four, and observe each quadrant in turn to consider the layout of all the features relative to each other. Some will be strung out in a line or a curve. Perhaps others will form a triangle with each other or with the previously drawn sunspots. These visualizations will help with positioning as you transfer the observed view onto your drawing (Fig. 5.107). At this stage of a sketch, I keep checking rapidly back and forth between the eyepiece view and the mapped out features, because now is the time to erase and re-sketch anything that seems slightly out of place.

Step 4

Once the sunspots and filaments have been sketched on the disk, they will act as anchor points to help position the prominences. At this scale, the prominences will be drawn relatively small, just a few millimeters in height and/or length. Even if they are quite striking to the eye, be very mindful of this and take care not to sketch "monster proms" out of kilter in scale with the rest of your drawing!

I marked the relative positions of the prominences around the Sun's limb with light dots, using the surrounding features as guides. I then built on these, making light marks to show both their height and extent along the limb. To help scale the size of the prominences, again consider the height of each one as a percentage of the Sun's disk diameter—often it is just a few percent. Working from these anchor points, I drew the final prominence shapes (Fig. 5.108).

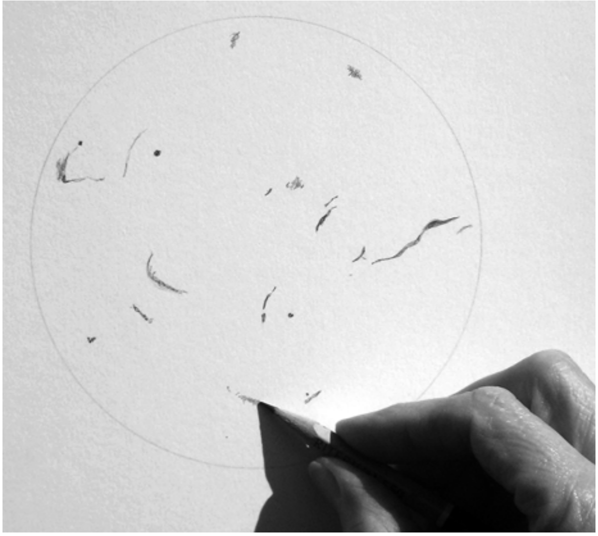

Fig. 5.107

Fig. 5.108

Fig. 5.109

Step 5

To represent the plage areas, I first drew their outlines as very faint dotted lines using a softer 2B pencil with a rounded point. These faint outlines will be incorporated when the solar background is added in, and will not be visible in the completed sketch. With all the major features having been drawn, this is now an accurate diagrammatic representation of the H-alpha Sun (Fig. 5.109). You might consider the sketch complete at this point, or choose to draw in a background representative of the granular-looking solar surface.

Step 6

It is virtually impossible to depict the constantly changing micro-detail of the H-alpha solar surface, especially at this scale. But to achieve a reasonable effect, I use a 4B pencil with a rounded point. Holding it lightly on the paper, I make very small movements, wiggling the pencil back and forth randomly, approximately a few millimeters at a time, to produce a mottled finish (Fig. 5.110). This method produces a fair approximation of the H-alpha solar surface. Personally I like the visual appearance of the finished sketch with its darker background, but purists might say that this step should be omitted! Try experimenting with this mottling technique on a scrap piece of paper before attempting it on your own sketch.

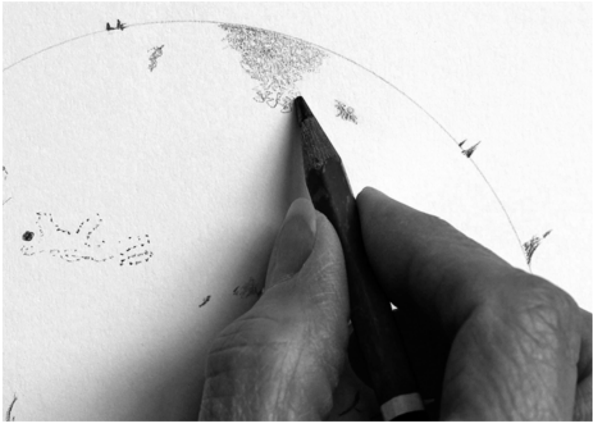

Fig. 5.110

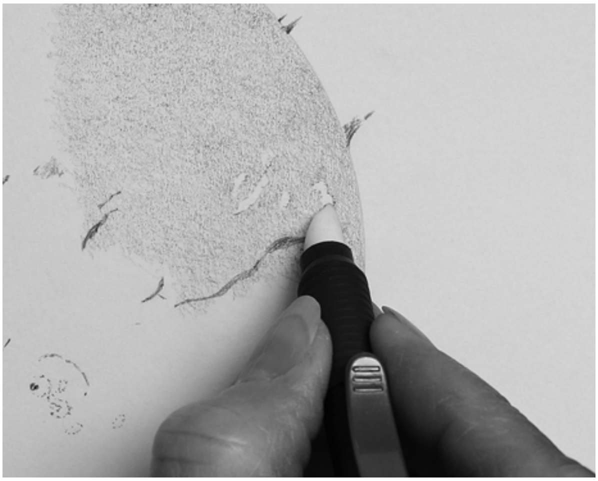

Fig. 5.111

While creating the background texture, I drew over the sunspots and filaments, and then worked right up to, and included, the dotted lines of the plages so that those areas were consequently left as blank white zones amidst the mottled background. To ensure that no hard lines or dashes were left visible, I used a plastic eraser that had been cut to a point to lighten or remove any dots that were rendered too dark (Fig. 5.111). Every so often, I held the sketch at arm's length to check that the mottling effect was still random and uniform rather than patchy. Some of the lighter filaments needed to be touched up with graphite so that they still showed up against the finished background.

Fig. 5.112

I prefer to work in sections from the limb inwards, gradually moving around the disk. The paper is rotated as I work so that my hand is always held at a comfortable angle. A piece of clean scrap paper placed over the sketch can be used for your hand to rest on. This helps to prevent smudging of the previously drawn areas (Fig. 5.112). Generally the limb area appears slightly darker and gradually lightens towards the center of the disk, so I used a little more pressure on the pencil when working at the limb to achieve this effect. I do not recommend blending the background when it is complete, as it will blur the mottling and undo all your hard work to achieve the texture!

Step 7

To finish the sketch, I used a 4B pencil to redefine any filaments or features that needed further enhancement. The 4B has a soft lead that produces deeper graphite tones. The final touches were to record the finish time and to determine, and include, the cardinal directions.

A program such as *TiltingSun* (Chap. 1—*Introduction to Solar Observing and Sketching*, Sect. 1.2 *Essential Tips*, *Determining Disk Orientation*) can be used to calculate the disk orientation and the position angles of prominences.

Figure 5.113 is the finished sketch.

Fig. 5.113 The Sun in H-alpha—August 3, 2012, 13:57–15:15 UT. Coronado double-stacked PST, Alt-Az mount, 8-24 mm zoom eyepiece set at 16-24 mm, 16× through 25× magnification. Antoniadi II, sunny spells, light wind, 68 °F (20 °C). Daler-Rowney heavyweight cartridge paper, B, 2B, 4B graphite pencils. (By Sally Russell)

5.3.6 Textured Disk in Graphite on White Paper (Technique of Alan Strauss)

The previous *Graphite on White Paper* technique demonstrated how to texture the disk after the main features were added to the sketch. For this tutorial, several sheets of textured disks are created in advance to save time while sketching at the eyepiece.

Suggested Materials

- White acid free printer paper 8.5″ × 11″, with preprinted circle template
- HB graphite pencil
- Mechanical pencil
- Blending stump, large
- Plastic eraser

While creating the textured appearance of the chromosphere, refer to plates a, b, and c in Fig. 5.114 during *Step 1* and *Step 2* of this tutorial.

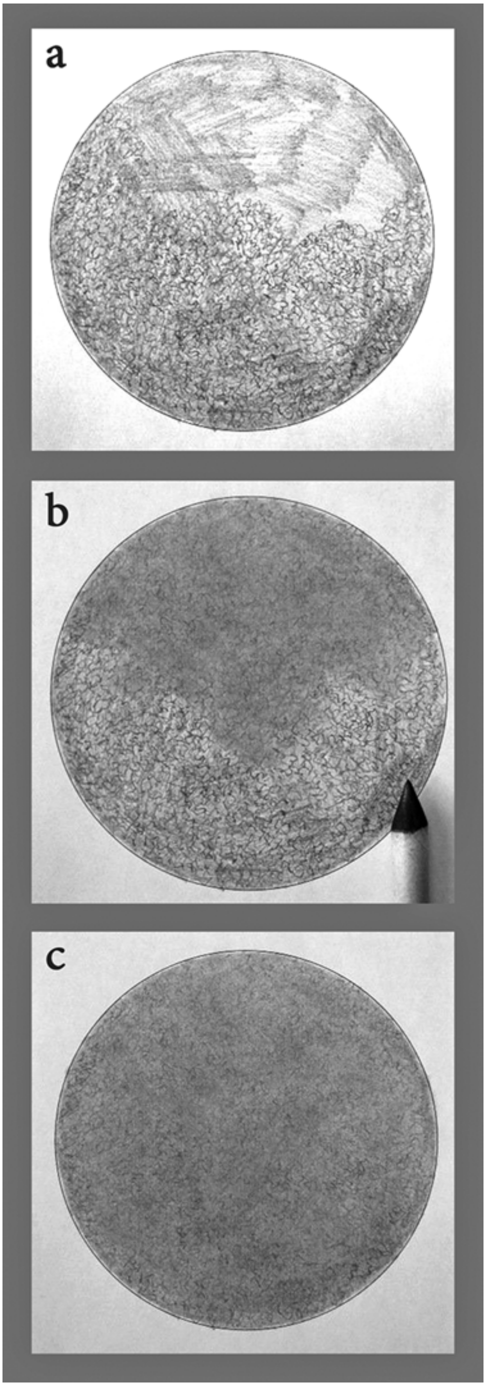

Fig. 5.114 The three stages of creating a textured solar disk to represent the chromospheric view. (Courtesy of Alan Strauss, Arizona, USA)

Step 1

Apply an even layer of graphite with the HB pencil to shade in the preprinted circle template. The pencil should be held at a shallow angle to create blunt strokes.

Next, sharpen the HB pencil and use it to apply random, light squiggly lines over the shaded disk. Avoid producing straight lines or circles, as they will show through the finished sketch (*Plate a*).

Step 2

Blend the two layers of graphite with a large blending stump as shown in *Plate b*. Hold the stump as a shallow angle with medium pressure, and using small circular motions, blend until the disk is uniformly smooth. Hints of texture should still be seen to represent the H-alpha view of the Sun (*Plate c*).

> *Tip*
>
> It is quite a time consuming process to create the textured solar disk. Save valuable time at the eyepiece by drawing several sheets of textured disks in advance. When you are ready to observe, simply grab a prepared template so that the filaments, plage, and other chromospheric features can be added to it.

Step 3

Since plages appear as bright areas in the chromosphere, expose the paper where they are located by using the eraser to remove the graphite. Erase those areas slightly larger than the actual regions, so that the edges of plages can be filled back in more accurately with the graphite pencil.

Step 4

Use the HB pencil to draw the prominences and filaments as observed. Pay particular attention to the contrast and shape variances. The more accurately they are drawn, the more realistic your sketch will be. Refer back to the eyepiece view with each addition and cross-reference their positions with the plages that were added in the previous step.

Step 5

Return to the plage areas and use the HB graphite pencil to render any sunspots, filaments, or fibrils that can be seen.

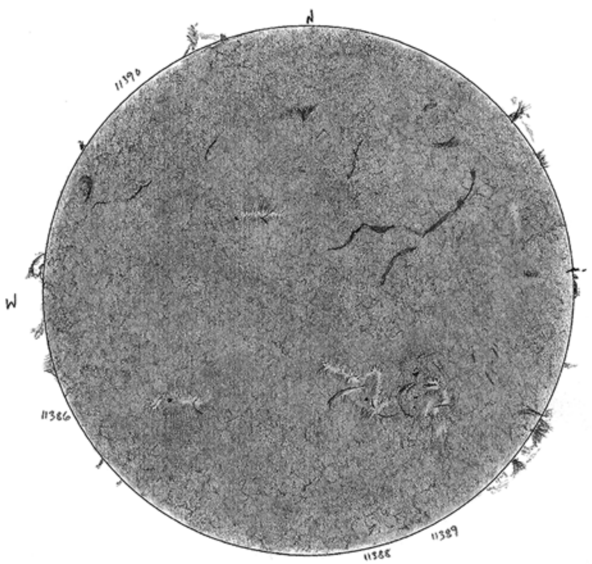

Fig. 5.115 The Sun in H-alpha, NOAA 11386, 11388, 11389, 11390—January 1, 2012. Lunt Solar Systems LS60THa Solar Telescope, pressure-tuned, Baader 8-24 zoom eyepiece. HB graphite pencil, mechanical pencil, white paper with a preprinted circle template. (Courtesy of Alan Strauss, Arizona, USA)

Step 6

If magnetic field lines or other fine details are observed, use the mechanical pencil to render them. Its thin, uniform line width is ideal for recording these kinds of features. Figure 5.115 shows a highly detailed completed sketch using the technique described in this tutorial.

5.3.7 Digital Noise and Coloring (Technique of Maurice Toet)

Colorization and digital noise can be added to a basic black and white sketch to create a beautiful, realistic finished sketch. The following technique describes how.

Suggested Materials

- White acid free drawing paper, 9″ × 12″
- HB graphite pencil
- Compass
- Adobe Photoshop (or similar photo editing software)

Warning! ALWAYS use a suitable filter when directly observing the Sun

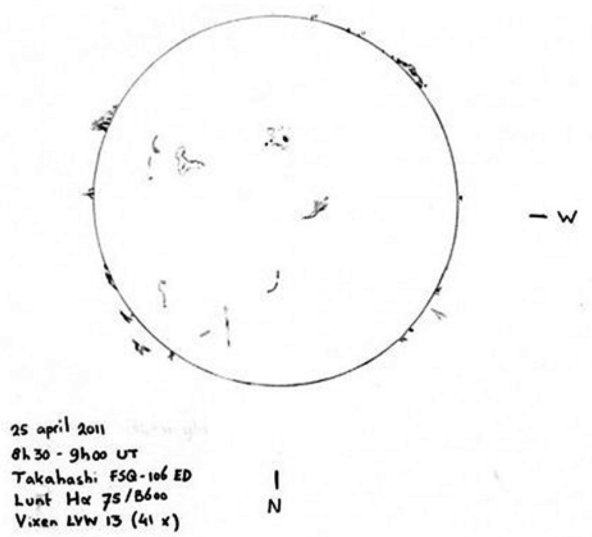

Fig. 5.116 Original black and white sketch of the Sun in H-alpha—April 25, 2011, 08:30–09:00 UT. Takahashi FSQ 106 mm ED, Lunt H-alpha 75/B600, Vixen LVW 13 mm, 41×. HB graphite pencil on white paper, then digitally colorized and noise added using Adobe Photoshop. (Courtesy of Maurice Toet, Zoetermeer, Netherlands)

Step 1

Using the compass, draw a 4-in. to 5-in. diameter circle to represent the solar disk. The HB pencil is then used to render any prominences, filaments, plage and sunspots observed through the eyepiece (Fig. 5.116).

Step 2

Scan or photograph the sketch, and then open the file in Adobe Photoshop. Select a black foreground color and then click on the *Magic Wand Tool*. Next, click on an area outside of the solar disk on the image to highlight it. Select the *Paint Bucket Tool* and then click in the highlighted area on the sketch image. The area around the solar disk will become black.

Step 3

Click on the *Select* tab on the menu bar. Select *Inverse* so that the solar disk is highlighted. Click on the *Image* tab on the menu bar, and then choose *Adjustments, Selective Color*. Click on the arrow next to *Colors* and choose *Whites* from the drop down menu. Moving the *Cyan* slide bar to the extreme left, and both the *Magenta* and *Yellow* slide bars to the right, will produce a bright orange-red disk color. Adjust the slide bars until you find the right combination to match the colors of the eyepiece view. Press *OK*.

Next, select the *Neutrals* from the drop down menu and move the slide bars to adjust the colors of the solar features. Press *OK*.

Step 4

Use the *Magic Wand Tool* to click on the solar disk area to highlight it. Choose *Filter* from the top menu bar, and then click on *Noise*. Select *Add Noise*. Adjust the *Amount* and use the *Uniform* distribution. Make sure to tick the *Preview* box so that you can view what the noise will look like before clicking *OK*.

Step 5

While the disk is still highlighted, mild blurring toward the limb of the disk can be acquired by clicking *Filter, Lens Correction,* and *Custom.* Under *Vignette,* make adjustments to the *Amount* and *Midpoint*. Press *OK*. Use the *Magic Wand Tool* to de-select the solar disk before saving your colorized image. Figure 5.117 shows the original sketch after adding color and digital noise.

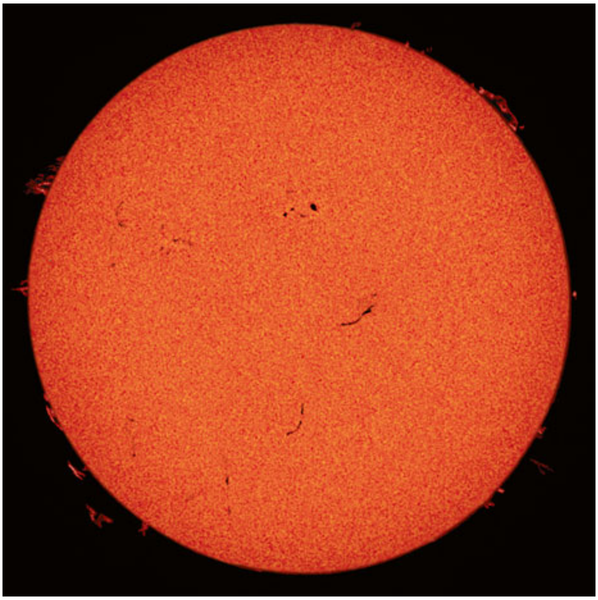

Fig. 5.117 Original sketch of the Sun in H-alpha after color and noise were added digitally with Adobe Photoshop. (Courtesy of Maurice Toet, Zoetermeer, Netherlands)

Warning! ALWAYS use a suitable filter when directly observing the Sun

5.3.8 *White Pastel on Black Paper with Digital Finishing (Technique of Roel Weijenberg)*

Attention to detail is essential when striving to create a realistic drawing of your observation. Subtle nuances with each stroke, even with the gradation of the amount of pastel used from the limb to the center of the disk, become apparent when color is digitally added afterward. The following tutorial demonstrates how to achieve an optimal white on black sketch to serve as a foundation for colorization.

Suggested Materials

- White soft dry pastel stick
- White pastel pencil
- Black acid free paper, 14″ × 14″ or larger is recommended
- Kneaded gum eraser
- Dinner plate, 12-in. diameter or larger for a circle template
- Computer graphics program

Step 1

Create a *blank* solar disk by using the pastel pencil to lightly trace the dinner plate onto the paper. Fill in the circle with the white soft pastel stick. Apply more pastel towards the center; this will create the appearance of a spherical surface (Fig. 5.118).

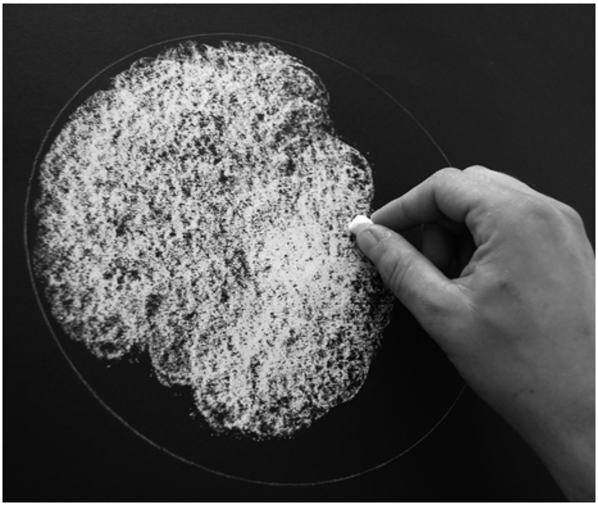

Fig. 5.118

Tip

The larger the sketch, the easier it is to render details when using pastels.

Fig. 5.119

Step 2

Lightly blend the pastel into the surface of the paper with your fingertips; a blending stump has the tendency to lift too much of the pastel from the paper. Blend just enough so that the disk is smooth but still has enough texture from the paper's tooth to represent the grainy appearance of the chromosphere. Rotate the paper as you work your way around the circumference of the disk so that a crisp edge is retained (Fig. 5.119).

Step 3

Hold the paper vertically so that excess pastel dust will fall off without smudging the drawing. Use a kneadable gum eraser to produce a clean, sharp limb edge. The blank solar disk is now ready to use (Fig. 5.120).

Fig. 5.120

Tip

Save time by preparing several blank solar disks in advance. They can be stored in a drawer, ready to take outside at a moment's notice to be completed during an observing session.

Step 4

Use a sharpened white pastel pencil to draw the prominences along the limb. Apply light pencil pressure for the fine lines and more pressure for the thicker, brighter regions. Pay close attention to their positions and sizes relative to each other and to the solar disk. Refer back to the eyepiece view often as a reference (Figs. 5.121 and 5.122).

Step 5

Sunspots, filaments, and areas of dark contrast can be produced with the kneadable eraser. Mold the eraser into a point and use it like a pencil to sketch their dark shapes as they appear in the eyepiece. The eraser lifts the pastel to expose the paper underneath. Use the pastel pencil to highlight the brightest regions on the disk to complete the pastel sketch.

Fig. 5.121

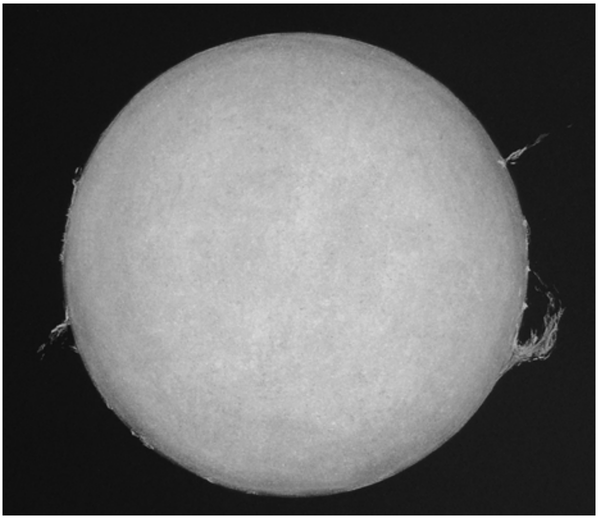

Fig. 5.122 White pastel sketch of the Sun after adding the prominences with a pastel pencil. (Courtesy of Roel Weijenberg, Deventer, Netherlands)

Warning! ALWAYS use a suitable filter when directly observing the Sun

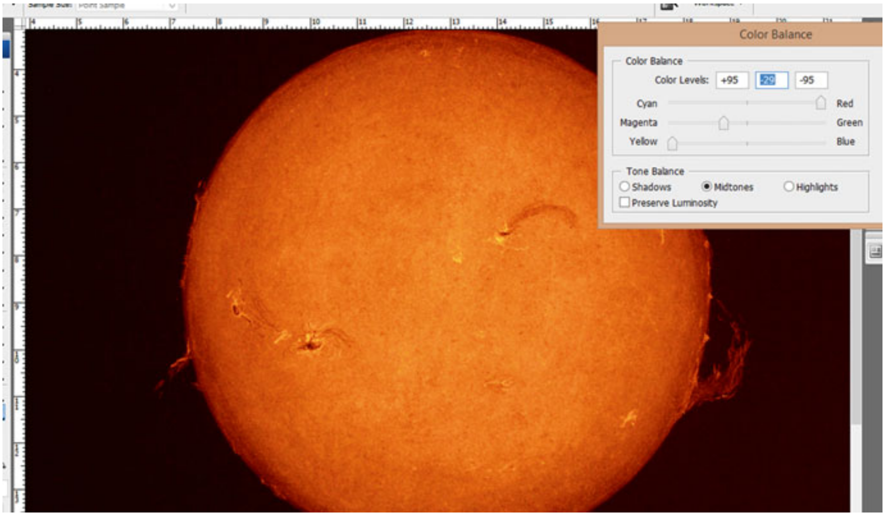

Fig. 5.123 Adjusting the color balance of the pastel sketch. (Courtesy of Roel Weijenberg, Deventer, Netherlands)

Step 6

To add digital coloring for a more realistic look, scan or photograph your sketch. Then, using photo-editing software, use the program's *Color Balance* slide bar (usually found under *Image* and then *Adjustments*) to adjust the color of the sketch to red or yellow until it matches the eyepiece view of the Sun (Fig. 5.123).

Figure 5.124 shows the finished sketch after digital coloring. Notice how the disk appears spherical as a result of pastel density. Less pastel was used to create a dimmer limb, and then progressively brightened with more pastel used toward the center of the disk.

Another technique of digital processing can be seen in Fig. 5.125. The original sketch was redrawn in Adobe Photoshop. The purpose was to produce a clean version that could easily be manipulated for color and contrast. The new drawing was layered over the original so that comparisons and fine adjustments could be made for accuracy. The digital drawing was then layered over an actual image of the Sun to produce the mottled appearance of the chromospheric network. The two versions of the sketch depict the before and after images of adding digital coloring.

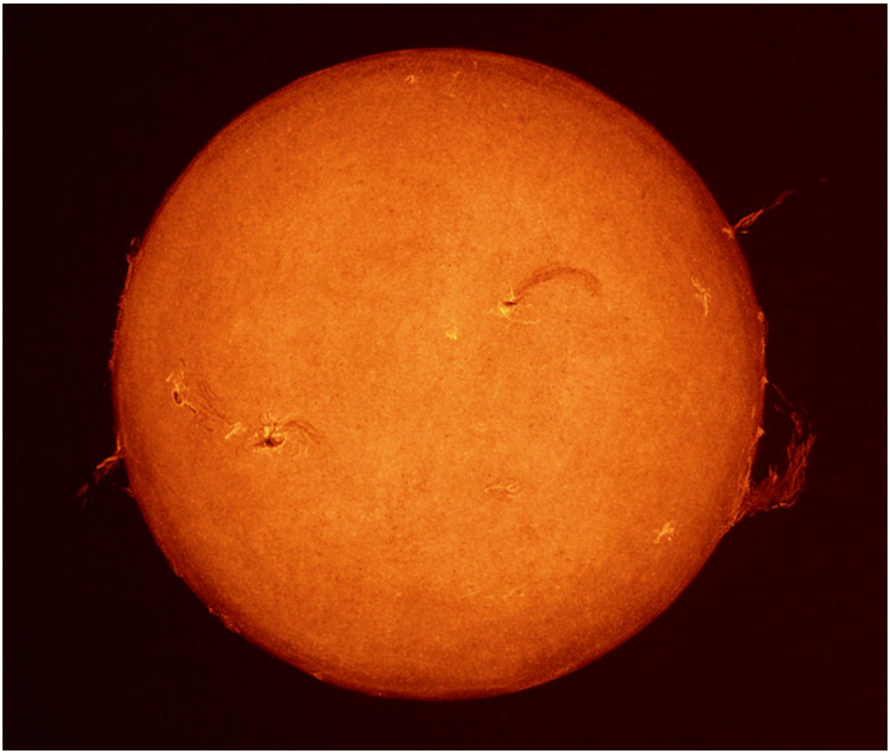

Fig. 5.124 The Sun as viewed through a 70 mm H-alpha telescope. White pastel on black paper, digitally colorized using photo-editing software. (Courtesy of Roel Weijenberg, Deventer, Netherlands)

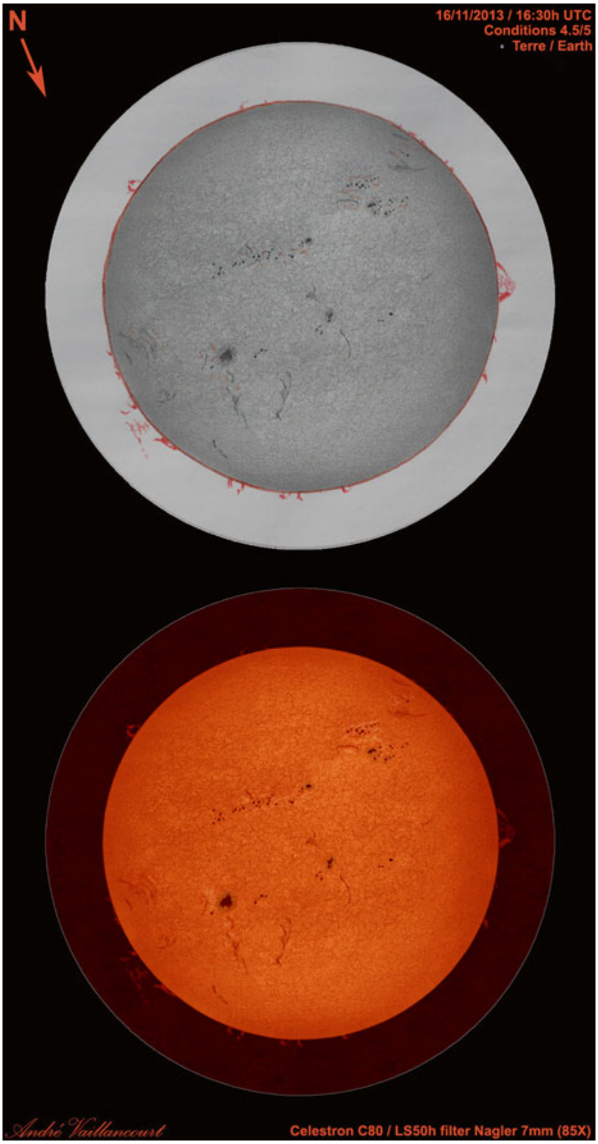

Fig. 5.125 Two versions of the Sun in H-alpha—November 16, 2013, 16:30 UT. Celestron C80 fitted with a Lunt Solar Systems LS50h H-alpha filter, Nagler 7 mm, 85×. Original sketch using color pencils on white paper, then finished digitally by incorporating it with an image of that day's Sun for the mottled texture using Adobe Photoshop. (Courtesy of André Vaillancourt, Québec, Canada)

Chapter 6

Calcium K Filters

The Calcium K (CaK) spectral emission line occurs at the violet end of the visible solar spectrum with the somewhat short wavelength of 393.4 nm. It indicates strong magnetic activity in the chromosphere and is associated with the chromospheric network. A CaK filter isolates the layer of the Sun that is below and slightly cooler than that observed at the Hydrogen-alpha wavelength of 656.3 nm.

The general consensus is that the primary purpose of a CaK filtered instrument is imaging, nonetheless, there are some folk who are successfully able to observe visually in that wavelength. The view is of a ghostly purple disk at the limit of human vision. Sensitivity of the eye to this wavelength is extremely variable and drops off with advancing age, so the image may not be visible to everyone. Some observers have reported, however, that laser surgery of their eyes (carried out for medical reasons) has serendipitously improved their ability to see the CaK view.

6.1 Whole Disk

6.1.1 Graphite Pencil and Chalk Pastel on White Paper (By Sally Russell)

When this observation and sketch sequence were carried out, there were three active regions visible—AR1834, AR1835, and AR1836. Given that the CaK view can be visually difficult (and is ghostly at best), it was important to gain the greatest chance of observing any detail. I used a driven mount to keep the Sun centered in my eyepiece, which in turn permitted me to push the magnification as high as the

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical Astronomy Series 178, DOI 10.1007/978-1-4939-2901-6_6

conditions would allow. The contrast between the white and colored regions in the sketch has been slightly exaggerated compared to the subtle view as seen through the eyepiece.

I used a solar hood to seal out extraneous light. For visually observing in CaK, I would say this is an absolute necessity! Use of the hood meant that I could keep both eyes open to prevent eye fatigue, and because my eyes could become reasonably dark adapted, I was able to see more detail. Each time my eyes moved from the sketch paper to the eyepiece, I had to spend a few minutes for my eyes to re-acclimatize to the large change in light level.

When sketching on white paper, the contrast between the dim, ethereal telescopic view and the paper glare is very great. The advantage of using white paper, however, is that it can be easier to depict the plage areas lightly, and then build on this under-drawing, rather than having to add light features onto a dark background, as would be necessary if using black paper. Everything is a trade-off, of course, as this method gives a color CaK sketch set on a white background, which is not quite a true representation of the overall view through the eyepiece.

Equipment Used

Coronado CaK PST, TeleVue 8-24 zoom (24, 16 and 12 mm used), magnification 16-33×, driven mount, solar hood.

Suggested Materials

- White drawing paper (Daler-Rowney heavyweight cartridge paper, 135 lbs, 220 g/m^2, size 8¼″ × 11¾″, UK size A4, was used in this example)
- 4B graphite pencil
- Chalk (hard) pastel in suitable purple color
- Blending stump
- Rag for wiping hands
- Plastic eraser

Step 1

Using a compass and the 4B pencil, I lightly drew a 4-in. diameter circle template for the Sun's disk. I chose a soft pencil so that the graphite line could easily be blended into the background later on.

Step 2

With the same pencil, I marked the sunspot positions on the disk. The main sunspots, part of AR1835 and AR1836, were effectively positioned along a solar diameter running from 2 o'clock to 8 o'clock (if you imagine the Sun's disk to be a clock face),

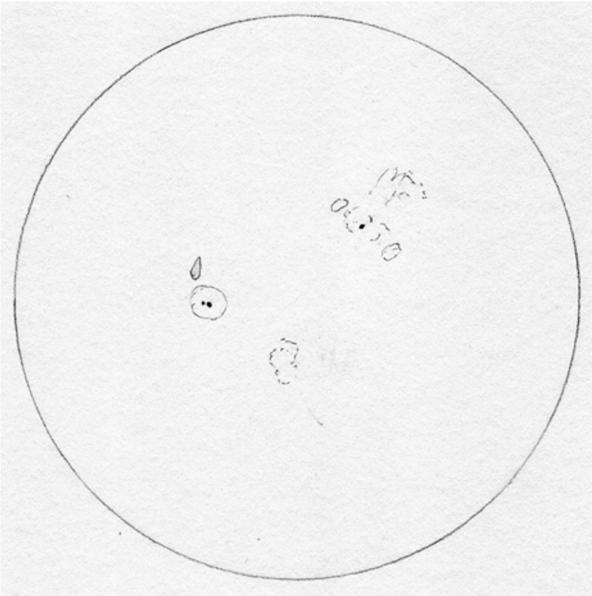

Fig. 6.1

with the bottom plage area representing AR1834 forming an isosceles triangle with them.

This method of estimating sunspot positions is generally very reliable. Just imagine a line passing through the center of the Sun's disk, and then estimate how far along the line (e.g., from the center or from the limb) each sunspot resides. This method will also work for positioning any type of solar feature on a whole disk sketch. In CaK, generally very little detail is visible within the sunspots themselves, and they are just seen as black dots. To finish the under-drawing, I lightly marked the extent of the plage regions with a light pencil line (Fig. 6.1).

Step 3

To represent the CaK-colored surface, I chose a purple chalk pastel of suitable hue. The heavyweight paper I used has a medium "tooth," so it picks up the color easily and produces a mottled texture. Lifting pastel onto my fingertip by rubbing it across the stick of chalk, I applied the pastel to the sketch gently with my finger, blending the color onto the paper. Starting at the top limb, I worked around the plage areas first so as to leave them bare (Fig. 6.2). I worked downwards and from left to right, as I am right-handed. Because the under-drawing is made using graphite, there is little risk of smearing it. This method of softly adding pastel gives consistently smooth results, whereas applying the pastel stick directly onto the paper can make very strong marks which are more difficult to blend afterwards.

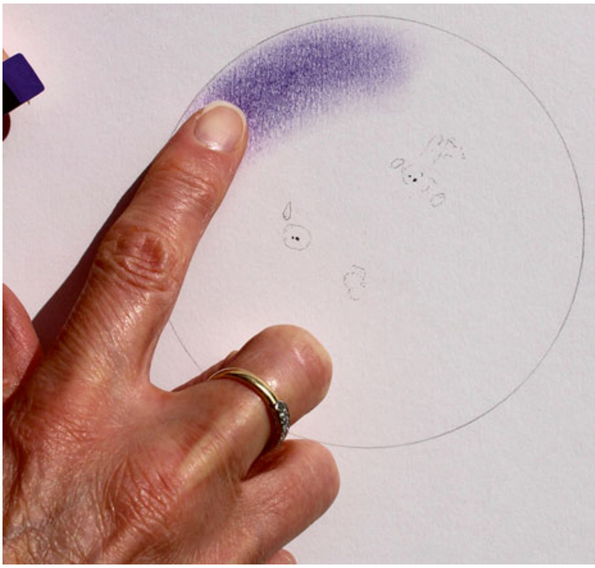

Fig. 6.2

Though it's best to stay within the boundaries of the circle template if you can, don't worry if you go slightly beyond; excess pastel can be removed later with a plastic eraser. I blended pastel over the colored areas a few times (using the same technique, with a "loaded" fingertip) until enough layers had been added and the colored background was deep enough in tone (Figs. 6.3 and 6.4).

Step 4

To define the areas around the plage regions where the color versus lighter background juxtaposition is greatest and a fingertip is too large to add the color accurately, I used a loaded blending stump with a dabbing motion (Fig. 6.5). To load a blending stump, either rub the tip directly across the pastel stick or rub pastel onto a scrap piece of paper, and then load up the blending stump from the paper.

Step 5

I blended the colored background with my fingertip until it was even, using a gentle circular motion across the whole area right up to the edge of the disk to define the limb. Small touches of color were added with the blending stump as necessary. This included very light dabs of color onto the plage areas, as visually they are not pure white. Final

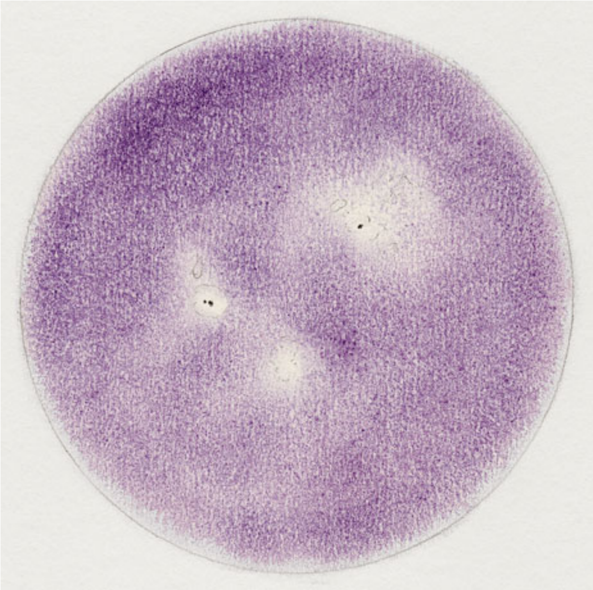

Fig. 6.3

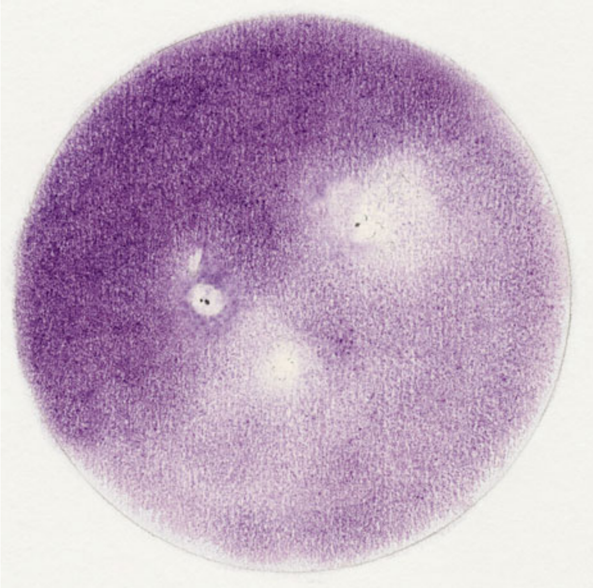

Fig. 6.4

Warning! ALWAYS use a suitable filter when directly observing the Sun

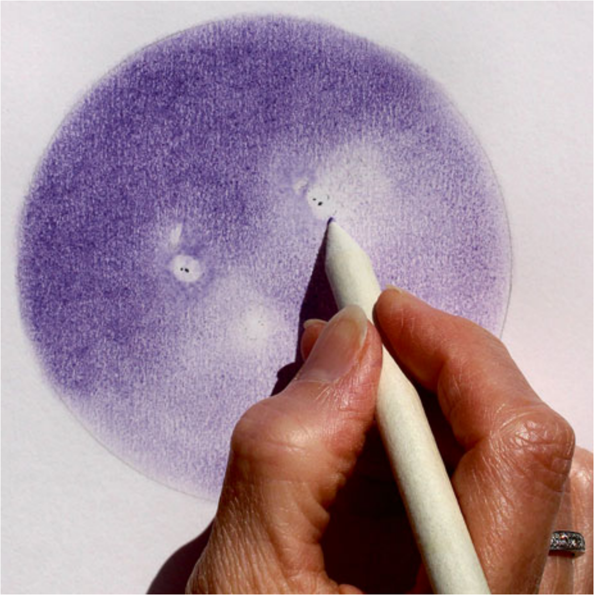

Fig. 6.5

checks were made at the eyepiece for any fine detail of plage that had previously been missed. The sketch was adjusted to include these by careful erasing of the colored background using a plastic eraser that had been cut to a point (Fig. 6.6).

To finish, I made a note of the cardinal directions and erased any overspill of color beyond the template line. Figure 6.7 is the final sketch.

Figure 6.8 is another example of a colored full disk sketch using the alternative media of purple and white watercolor pencils on black paper.

Focused regions of the Sun can also be rendered, as seen in Fig. 6.9. By concentration on a smaller section while using a larger sketch area, the observer was able to include a significant amount of detail within his drawing. Conté crayons, pastels, and Strathmore Artagain paper were used during the observation.

6.2 Sketching from an Electronic Eyepiece and Screen View

6.2.1 *Graphite (By Sally Russell)*

With the CaK spectral line being near the visual wavelength observing limit for most people, the use of low-technology imaging can provide a convenient alternative method of observing the CaK Sun. A simple electronic eyepiece can be used to

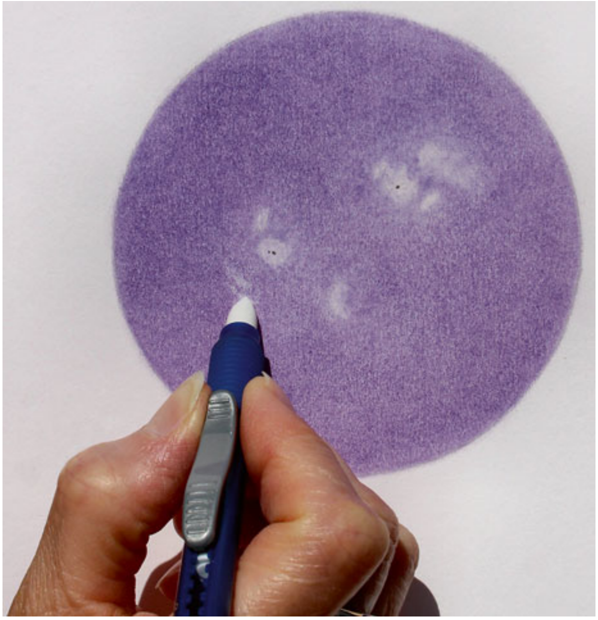

Fig. 6.6

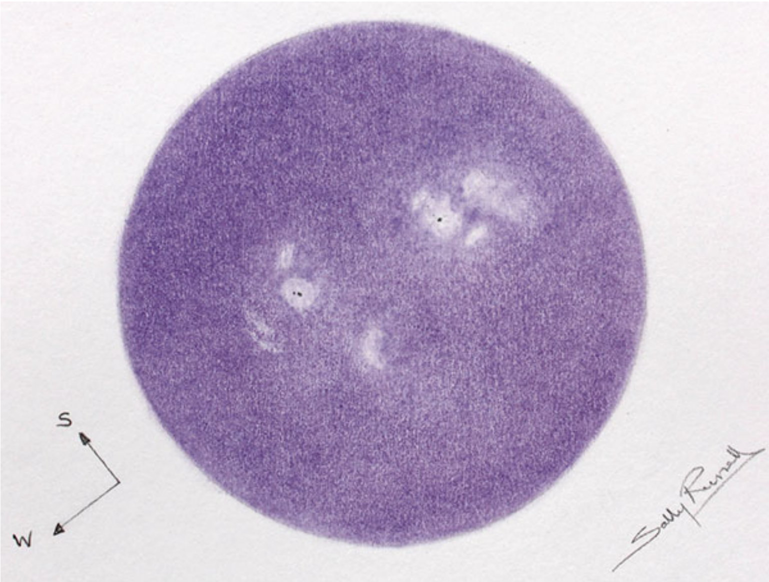

Fig. 6.7 Calcium K sketch of the Sun—August 31, 2013, 08:40–12:18 UT. Coronado CaK PST, TeleVue 8–24 zoom (24, 16 and 12 mm used), magnification 16-33×, driven mount, solar hood. Clear with slight haze and slight breeze, 66 °F (19 °C), Antoniadi I–II. Graphite and purple pastel on white paper. (By Sally Russell)

Warning! ALWAYS use a suitable filter when directly observing the Sun

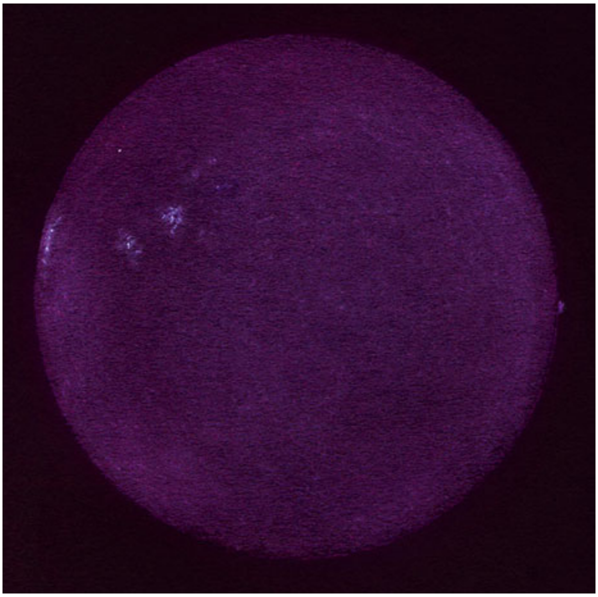

Fig. 6.8 Calcium K sketch of the Sun showing prominence at 90° PA—July 7, 2007, 12:35–12:48 UT. Coronado CaK PST, TeleVue 8-24 mm zoom at 16 mm, 25×, Alt-Az mount. Purple and white watercolor pencils on black paper. (By Sally Russell)

Fig. 6.9 AR11040 in Calcium K—January 14, 2010. Lunt Solar Systems B1800 CaK filter module on an Explore Scientific 127 mm ED refractor. Conté crayons, pastels, Strathmore Artagain paper. (Courtesy of Stephen Ramsden, Georgia, USA)

give a real-time black and white image on a television or laptop screen from which a sketch can be made. Though this method might not be for the purists who demand to sketch from a wholly visual view, for many people this is likely to be the *only* way of achieving a live CaK observing and sketching experience!

I would strongly recommend that you use a driven mount if you wish to attempt this method of observing and sketching the CaK view. The field of view of the electronic eyepiece is relatively small, similar to that of a standard 4 mm eyepiece. With an alt-az mount, constant manipulation of the slow motion controls is required to keep the live image centered on the screen. Because the screen is separate from the telescope itself, it becomes a major challenge to sketch in addition to maintaining the image on screen.

Equipment Used (See Fig. 6.10)

CaK PST on a driven mount, battery-powered Meade electronic eyepiece with video output and a 1.6× supplementary lens to achieve focus, a 5-in. portable LCD TV with a 12 V power supply, solar hood (a box-type solar shield can be used instead so that the TV screen can be seen more easily).

Fig. 6.10 Clockwise from *upper left*: electronic eyepiece, video output cable, 5-in. portable LCD TV, Coronado CaK PST, ×1.6 supplementary lens. (By Sally Russell)

Tip

Electronic eyepieces with USB outputs are now widely available—I just happened to have access to the older type of equipment listed here.

Power up the TV (or laptop) and arrange it so that there is minimal glare on the screen. You might need a cardboard box cut as a shield or a solar hood to achieve this. Alternatively, you can set up the screen in a shaded area near your telescope.

Use a solar finder to approximately align the Sun into the field of view. It really helps if you are one of the lucky ones able to see the CaK image visually, as you can then use an eyepiece to get the solar image properly centered. Use a solar hood to exclude as much light as possible when observing.

Set up the electronic eyepiece with the supplementary lens attached, if needed, and connect it to the TV (or laptop). Then, put it into the eyepiece holder and make sure it is switched on. Adjust the gain on the electronic eyepiece to produce a good on-screen view with suitable contrast—this is the trickiest part of the procedure. Adjust the TV/laptop settings to further enhance the contrast until you are satisfied with the on-screen view.

With this equipment configuration, it is only possible to fit part of the Sun's disk on the screen due to the high power view. It is useful to include an area of the solar limb in the sketch, as this will give a sense of structure and scale. The electronic eyepiece output produces a black and white image, so graphite pencil on white printer paper is a simple and convenient medium for recording the observation.

Suggested Materials

- White drawing paper (Daler-Rowney heavyweight cartridge paper, 135 lbs, 220 g/m^2, size 5¾″ × 8¼″, UK size A5, was used in this example) on a clipboard
- 4B graphite pencil
- Small rag or piece of chamois leather
- Plastic eraser, cut to a point
- Small blending stump

On the day of this observation and sketch, the Sun was fairly active with numerous sunspot groups present. Four of these groups were ideally placed with AR1613 and AR1614 near the limb, and AR1611 and AR1612 nearby and slightly further onto the Sun's disk.

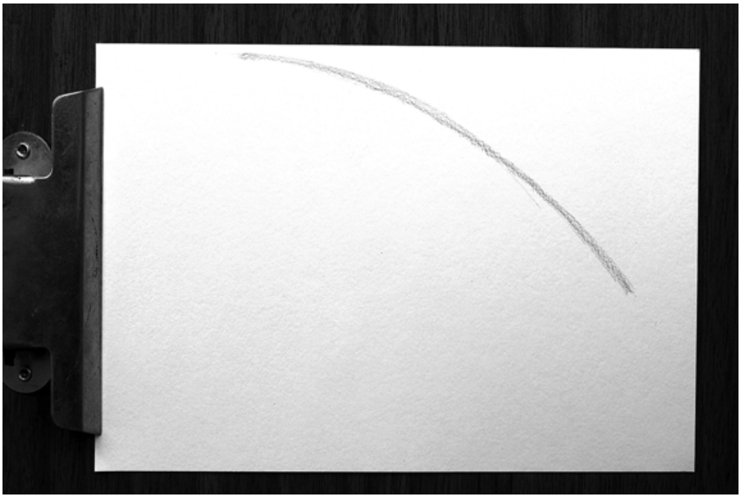

Fig. 6.11

Step 1

Using a soft 4B graphite pencil, I lightly sketched in the arc of the Sun's limb. I like to do this freehand, keeping the heel of my hand resting in position on the paper and then rotating my hand around this point (like a compass) while the pencil rests lightly on the paper. By repeating this a few times, I end up with a broad, light arc of graphite (Fig. 6.11). Depending on the scale of your drawing, a template (such as a large dinner plate) is often not of sufficient diameter to give a wide enough arc.

Step 2

To give good paper coverage, the 4B pencil is held nearly flat so that the graphite is in maximum contact with the surface of the paper. I lightly shaded in the whole area under the limb, and then gently blended that section with my fingertip so that some mottled texture was still visible to represent the granular appearance of the solar surface (Figs. 6.12 and 6.13) A dry rag or piece of chamois leather could also be used for the blending process.

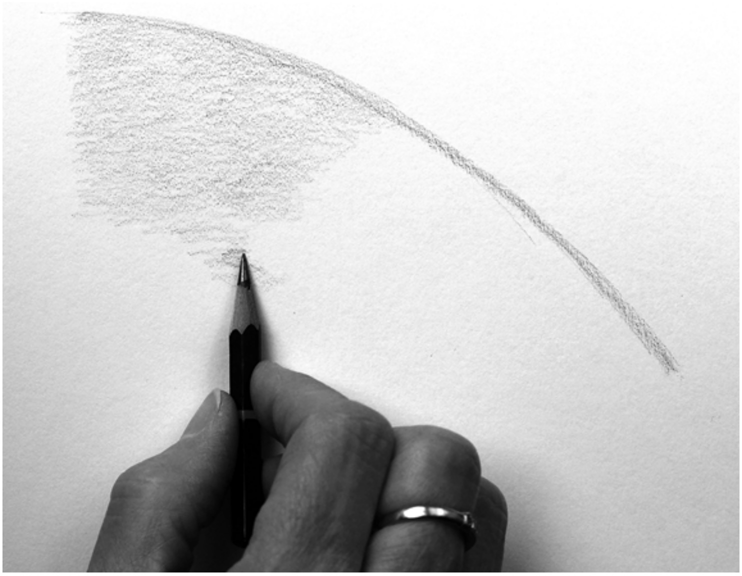

Fig. 6.12

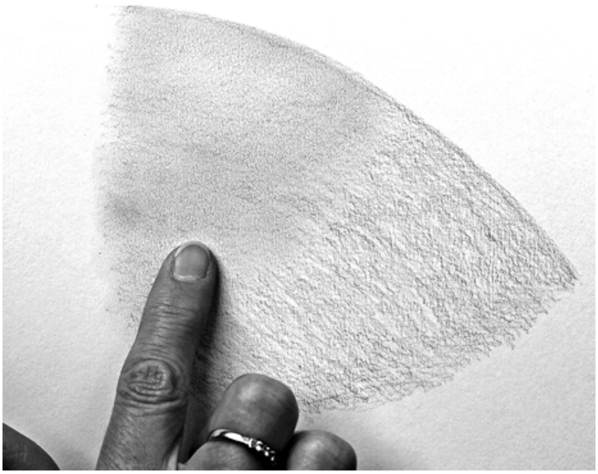

Fig. 6.13

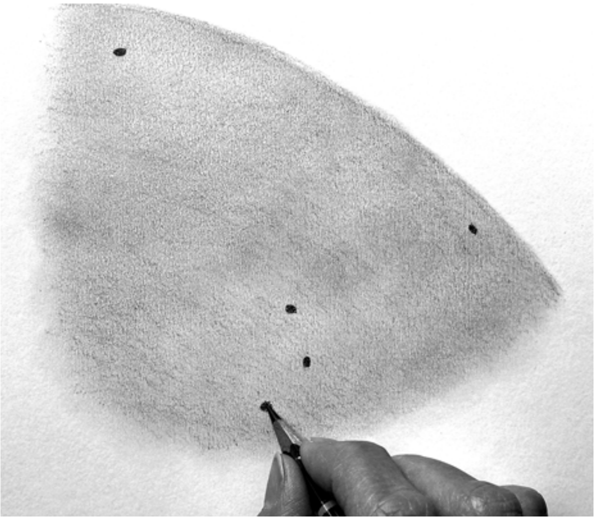

Fig. 6.14

Step 3

Continually checking back and forth between the screen and paper to make sure that I had their positions correct, I made very light marks with my pencil to represent the sunspots. Having drawn the background first, it can be difficult to cleanly erase and then re-draw sunspots that were incorrectly positioned. But by making the marks very light initially, any that *are* incorrect can easily be blended out into the general background using the point of a blending stump. Once satisfied with their positioning, I went over the sunspots again with the graphite pencil to deepen their tones (Fig. 6.14).

Step 4

The CaK view is characterized by light areas of magnetic activity often intricate in appearance but containing little tonal gradation. To represent this detail, I used a plastic eraser that was cut to a fine point, and then began to carefully remove the previously drawn background in the regions surrounding each sunspot (Fig. 6.15). Then, using these regions as markers and with the same technique, the remaining major light areas were added (Fig. 6.16). The advantage of this negative drawing technique is that the finished sketch is free of any hard lines, giving a realistic, rather than a diagrammatic, appearance.

To complete the sketch, I scanned the solar disk and added any remaining fine details. The cardinal directions were noted (Fig. 6.17).

Fig. 6.15

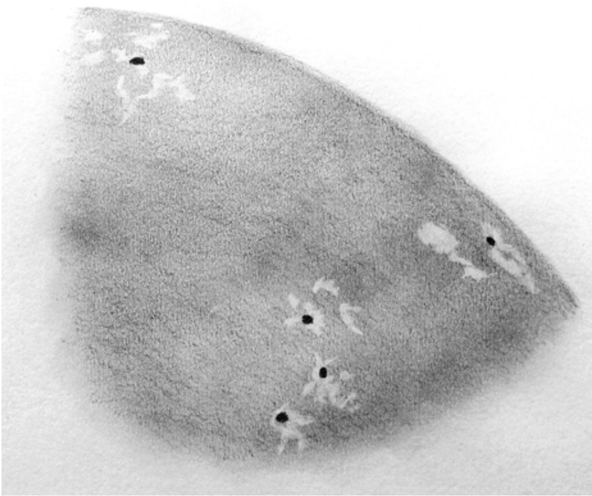

Fig. 6.16

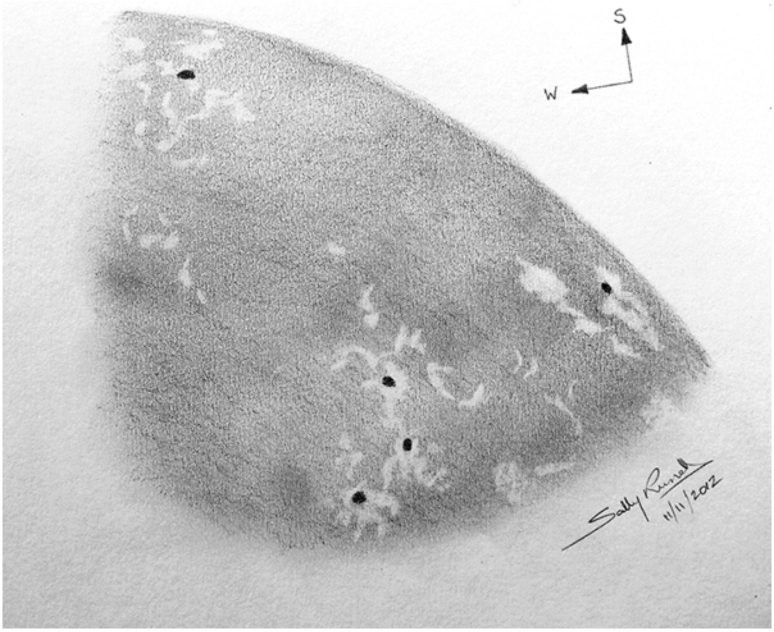

Fig. 6.17 Calcium K sketch of the Sun, drawn from screen view—November 11, 2012, 12:10–13:00 UT. Coronado CaK PST, Meade electronic eyepiece, 1.6× supplementary lens, driven mount, solar hood. Clear and calm, 53 °F (12 °C), Antoniadi II. (By Sally Russell)

Chapter 7

Filter Combinations

Whether viewing the Sun in white light and the Hydrogen-alpha (H-alpha) spectral line, H-alpha and Calcium K (CaK), or any other combination, the use of each filter opens a discrete window into the solar spectrum. Multiple filter views, when captured in a single sketch or compared side by side, can convey an insight to the energetic phenomena that animate our star. The combined sketches can also provide a valuable record of the relationship of features that exist between the atmospheric layers of the Sun.

When combining two-filter observations into one sketch, you will find it much easier if the views through both telescopes have the same orientation. It is possible, however, to combine two differing orientation views in the same sketch, e.g., using a Coronado Personal Solar Telescope (PST) and a standard refractor combination, or that of a refractor and a reflector. First, rotate the drawing so that both match either north to south, or east to west. Then it's just a matter of mentally mirroring the details as you sketch. It does take more effort, but with a little practice, it is manageable.

7.1 Schematic Sketches

A colorful selection of markers or ink pens can be used to delineate solar features observed in various wavelengths. The style of drawings produced with this type of medium are diagrammatic, with each layer of the Sun depicted by a designated set of colors for a combined sketch.

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7.1.1 Hydrogen-Alpha and Calcium K (By Sally Russell)

Both the H-alpha and Calcium K Personal Solar Telescopes have the same 400 mm f/10 optical configuration. Since the orientation of the visual image corresponds directly between the two telescopes, which is optimal for a drawing overlay, they make ideal partners for attempting a combination sketch at these two wavelengths.

Due to its internal pentaprism, the visual view through a PST is inverted compared to that of a refractor fitted with a mirror diagonal. Therefore, it is unfortunately very difficult to do a white light/PST H-alpha, or white light/PST CaK, combined sketch.

When this observation and sketch were carried out, there were two main active regions, AR1967 and AR1968, present in the central region of the Sun's disk. These were more obvious when viewed in H-alpha (due to the use of a double-stack filter which enhances surface detail), so I observed in this wavelength first.

Suggested Materials

- White drawing paper (Daler-Rowney heavyweight cartridge paper, 135 lbs., 220 g/m^2, size 8¼″ × 11¾″, UK size A4, was used in this example)
- HB and B graphite pencils
- Plastic eraser
- Colored gel pens, 0.5 mm tips—red, black and light purple

Step 1

Using the HB pencil, I lightly drew a 4-in. diameter circle as my template.

Step 2

I always study the H-alpha Sun for a while before I start sketching. This is so I can gauge the positions of all the features relative to one another. It helps me transfer the outline view onto my sketch. Through each sunspot, I imagine a line drawn through the center of the disk, then consider how far along the line the sunspot resides. For example, using an imaginary line that runs from 8 o'clock to 2 o'clock in Fig. 7.1, the small sunspot pair is nearly 60 % of the way across the disk.

In a similar fashion, I scan all around the limb of the Sun to estimate the position and extent of any prominences, and note whether there are any that lie directly across the disk from one another. All of this helps to keep the view in my mind when I take my eye away from the eyepiece to sketch.

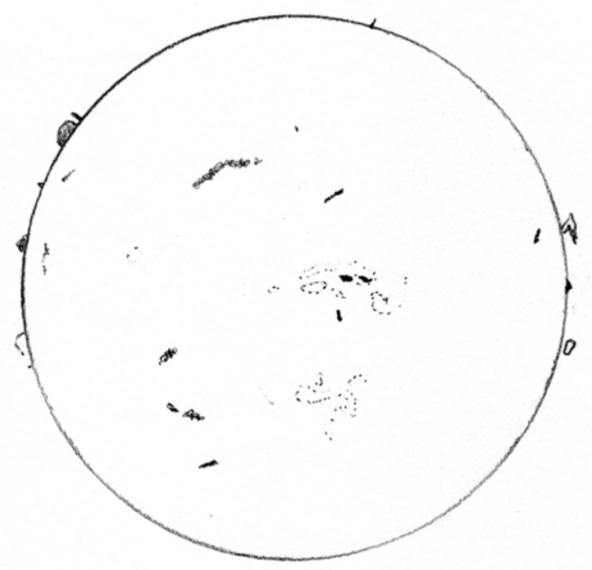


Fig. 7.1

Using the B pencil, I started by lightly sketching the prominences, all of which were very small on the scale of the sketch. The small sunspot pair was added. Next, I sketched the positions of the plage regions as simple dotted outlines. I used the previously drawn sunspots and prominences as my marker points to help place the plage regions. To finish the schematic under-drawing, I then lightly added the filaments. Figure 7.1 shows the initial outline sketch.

Step 3

I drew over the previously sketched H-alpha features using the red gel pen, and then used the black gel pen over the sunspots. Once the ink had dried, I carefully erased the graphite from underneath with a plastic eraser (Fig. 7.2).

Step 4

I swapped over to the CaK PST, and used a solar hood to help with dark adaptation while observing the CaK view. See Chap. 6—*Calcium K Filters* for more information regarding observing at this wavelength. As when viewing the Sun in H-alpha, I again spent time studying the Sun before starting the second part of the sketch.

Fig. 7.2

On this occasion, there were no prominences visible in CaK. The sunspots were more obvious and numerous than they had appeared in the H-alpha wavelength.

There were two broad, but less extensive, plage areas visible in the CaK view. Using the main sunspots as my marker points, I added the additional smaller sunspots with the B pencil, and then drew dotted outlines for the CaK plage as seen in Fig. 7.3.

Step 5

Using the purple gel pen, I drew over the CaK features by still using dotted lines for the plage areas, and I also drew over the additional sunspots with the black gel pen. Again, once the ink had dried, I carefully erased the graphite from underneath with a plastic eraser.

Figure 7.4 is the finished schematic sketch after the cardinal directions had been added.

Another example of an H-alpha/CaK schematic sketch is shown in Fig. 7.5, from February 16, 2014.

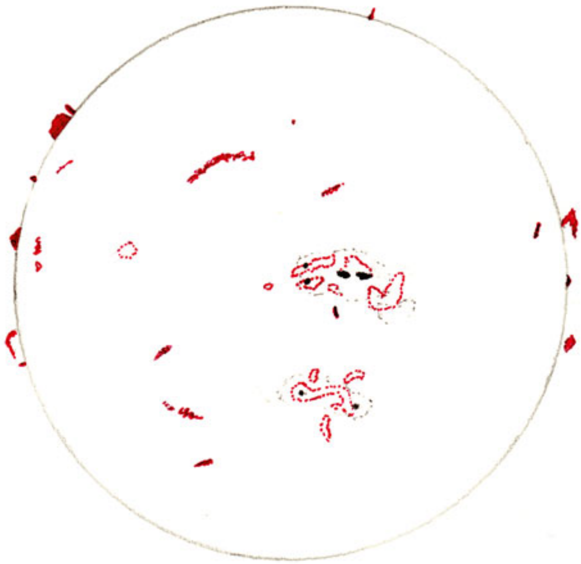


Fig. 7.3

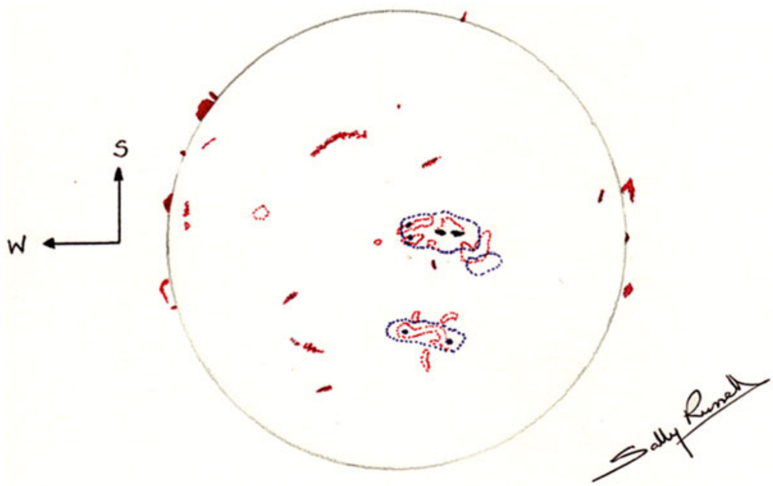


Fig. 7.4 H-alpha and Calcium K combined schematic sketch—February 2, 2014, 11:42–12:20 UT (H-alpha), 12:25–12:45 UT (CaK). Coronado H-alpha PST with additional 40 mm filter to double stack, Coronado Calcium K PST, Alt-Az mount, 8–24 mm zoom eyepiece at 16 mm, 25×, and solar hood. Patchy clouds then haze, calm, 49 °F (9 °C), Antoniadi II. Daler-Rowney heavyweight cartridge paper, HB and B graphite pencils, gel pens, 0.5 mm tips—*red*, *black* and *light purple* (By Sally Russell)

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 7.5 H-alpha and Calcium K combined schematic sketch—February 16, 2014, 09:30–09:50 UT (H-alpha), 09:55–10:18 UT (CaK). Coronado H-alpha PST with additional 40 mm filter to double stack, Coronado Calcium K PST, Alt-Az mount, 8–24 mm zoom eyepiece at 16 mm, 25×, and solar hood. Daler-Rowney heavyweight cartridge paper, HB and B graphite pencils, gel pens, 0.5 mm tips–*red*, *black* and *light purple* (By Sally Russell)

7.1.2 Hydrogen-Alpha and White Light (By Erika Rix)

The initial features that you add to a sketch should provide a strong foundation to build upon. A few sunspots positioned across the solar disk make excellent reference points when positioning other features within your sketch. So when choosing which filter to use first, I prefer the white light filter to the Hydrogen-alpha because of the sharp, undiluted details it provides of sunspots.

Suggested Materials

- White paper, minimum of 8″ × 8″
- #2 graphite pencil
- Markers with ultra fine points—black, red, orange, yellow
- 6-in. circular protractor

Step 1

Begin your session with a white light filter to render the features observed in the photosphere. Lay the protractor onto the paper and trace a light circle around it with the black pen to create an outline of the Sun's disk. The larger the drawing circle, the easier it will be to sketch the details of your observation.

Tip

Exaggerated size and misplacement of features are common mistakes when sketching the Sun. Over sizing results from attempting to sketch highly detailed areas in a limited space. Try starting with a larger circle to represent the solar disk; give yourself room to record the observations. Accurate placement of solar features is simplified when using an imaginary grid for plotting.

Add the most prominent umbrae to the sketch circle first by holding the black marker upright just above where it should be located within the disk outline. Lower the tip onto the paper. The marker pressure and the length of time that its tip is pressed to the paper will affect the size of the spot, so use a light touch while forming the umbral shapes. Fill in the remaining umbrae. Imagine geometric shapes connecting nearby umbrae to help with plotting accuracy.

A sharpened graphite pencil is used next to render the smallest pores and penumbrae. Adjust the pencil's pressure on the paper to depict the tonal variances needed. You could add limb darkening with graphite at this time; however, doing so could make your sketch convoluted with the addition of the H-alpha features (Fig. 7.6).

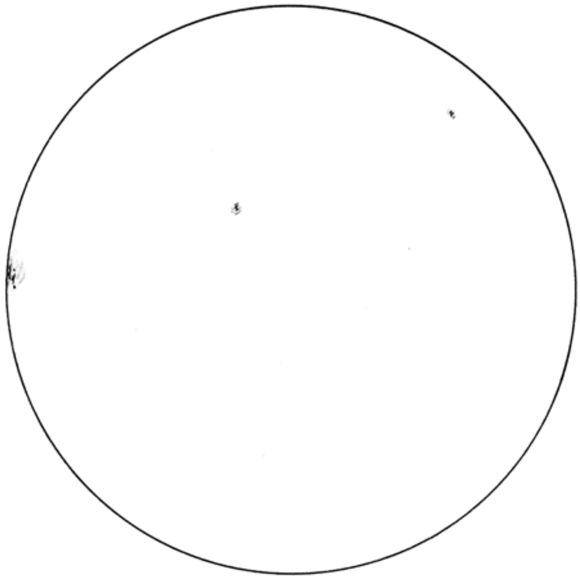


Fig. 7.6

Warning! ALWAYS use a suitable filter when directly observing the Sun

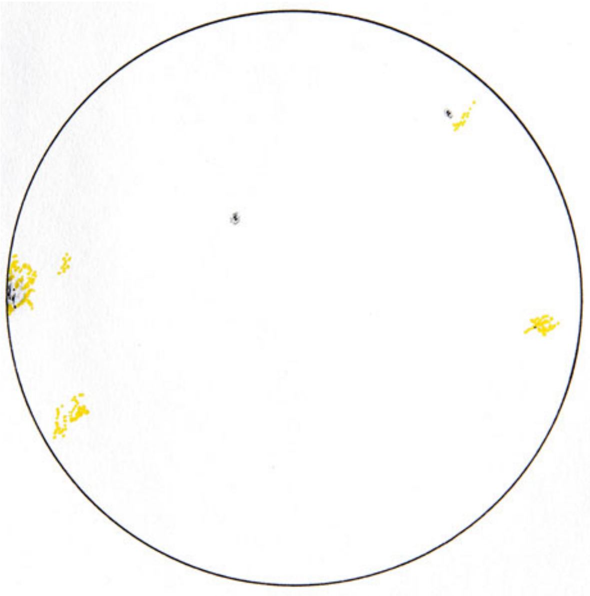


Fig. 7.7

Step 2

Faculae, relatively hot areas associated with sunspots in the photosphere, are usually seen near the limb as patchy brightened areas. They can be roughly stippled onto the sketch with a yellow marker as seen in Fig. 7.7. Scan the eyepiece view of the entire disk and gently tap your telescope to detect areas of contrast. If a zoom eyepiece is used, adjusting the magnification may increase the contrast enough for a better chance at spotting them. During the right conditions, faculae can also be viewed further inward from the limb. To include more information about the observing session, record the eyepiece settings that you used during the sketch as well as the details that were seen at each magnification.

Step 3

Next, switch to an H-alpha filtered telescope to observe the chromosphere. Tune the etalon to an optimal bandpass for viewing prominences, and then slip a solar cloth over your head and eyepiece holder to study the limb. Begin adding the prominences to your sketch with smooth strokes of a red marker. The sunspots and faculae should be used as cross-references to help you accurately draw their proportions and locations. Look for ribbons of prominence reaching into the limb. Refer back to the eyepiece view several times so that the sketch matches your observation.

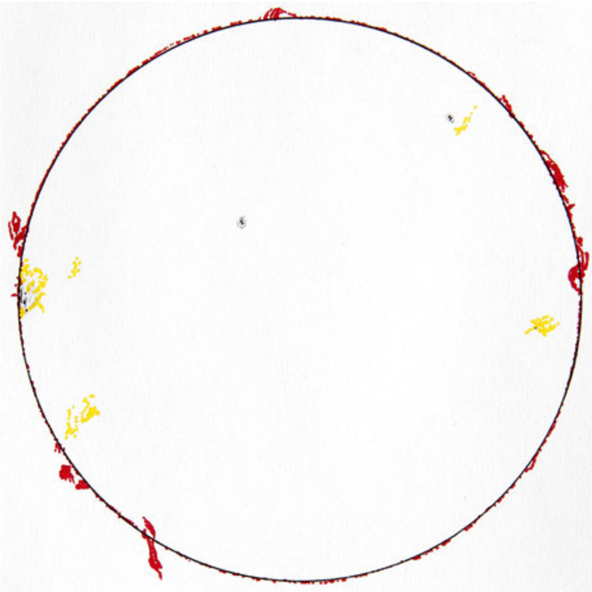


Fig. 7.8

See if you can spot tiny patches of spikes, called spicules, protruding from the limb. If observed, use the red marker to stipple them along the disk's edge (Fig. 7.8).

Step 4

Filaments are also drawn with the red marker while using smooth strokes. Adjust the etalon tuning more toward the red wing of H-alpha to optimize disk details (Fig. 7.9). These elongated, dense features are suspended above the photosphere and into the lower layer of the corona. Held into place by magnetic fields, they generally run along magnetic inversion lines that separate areas of opposite magnetic polarity. Remember, filaments (seen against the solar disk) and prominences (seen against the darkened space surrounding the disk) are one and the same. Their only difference is where they are located.

Step 5

Finally, an orange marker is used to stipple the bright plages, which are associated with, and found above, the faculae regions of the photosphere. These indicate areas of enhanced magnetic fields (Fig. 7.10).

Fig. 7.9

Fig. 7.10

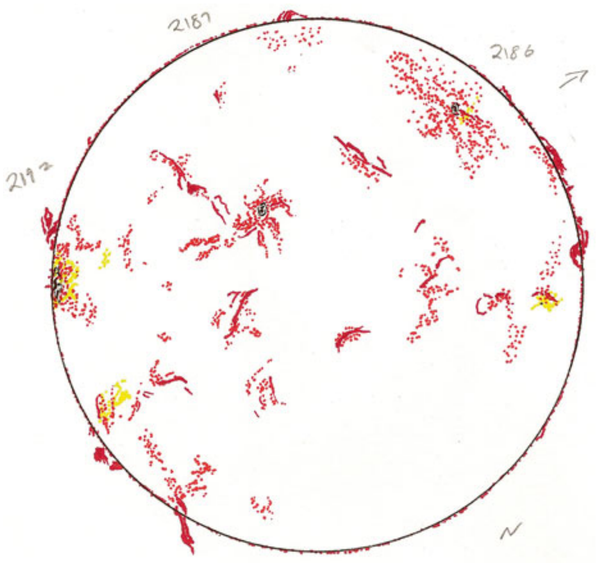


Fig. 7.11 White light and H-alpha combined schematic sketch—October 17, 2014, 15:27 UT (white light), 16:50 UT (H-alpha). 102 mm f/9.8 refractor, Thousand Oaks WL filter, LXD75, 16 mm, 63×. 80 °F, 36% humidity, cloudy, light and variable winds, Wilson II, transparency 6/6. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, Baader Planetarium Hyperion 8–24 mm Mark III set at 8 mm, 50×. 83 °F, 37 % humidity. White card stock, #2 pencil, Sharpie permanent markers with ultra fine points—*black*, *red*, *orange*, *yellow* (By Erika Rix)

Figure 7.11 shows the finished schematic sketch using the combined views of a white light and an H-alpha filter. This type of sketch becomes more meaningful when you begin to study how the features interact within the layers of the Sun's atmosphere.

7.2 Composite Sketches

If you like the concept of schematic sketching, but prefer a more realistic rendering of the features using your regular media, this section provides a few ideas on how to proceed. Although the disk background can be filled in to represent the granular appearance of the photosphere or the more-textured chromospheric network, the two become indistinguishable and add little value to the overall sketch other than providing contrast for the inclusions of plages and faculae. It goes with the old adage, “Sometimes less is more.”

7.2.1 Hydrogen-Alpha and White Light (By Erika Rix)

Any filter combination and media can be used for composite sketches. Experiment to determine what works best for you. I’ve used different types of telescopes, colored pencils, pastels, and papers, but keep coming back to a basic graphite on white paper technique that is anything but artistic. It is, however, packed full of valuable data that is representative of both filters. And after all, isn’t that the purpose of this type of sketch?

Step 1

Draw a circle outline on your paper, or use an observing template with a preprinted disk outline. The size of the circle should be at least 3–4-in. diameter, preferably larger.

Step 2

Observe first with the filter that provides the sharpest, uncluttered view of sunspots. In this example, I chose the white lighter filter over the H-alpha to begin the sketch. Draw the umbrae, followed the by the penumbrae and individual pores if observed. Strive for accuracy when drawing their proportions and positions relative to each other, and also within the disk. Faculae can be added by shading the areas around them, or even by simply outlining them.

To complete the white light sketch, I added notes relevant to the observation. These included observing conditions, sunspot counts, descriptions of the sunspots and faculae, the presence of granulation, and the equipment used.

Step 3

Swapping out the filters, I studied the H-alpha view next. The prominences are added first by using the existing sunspots as references. Pay particular attention to their sizes and positions. Refer back to the eyepiece view several times to ensure that they are not inadvertently drawn too large. Next, include the plages by adding

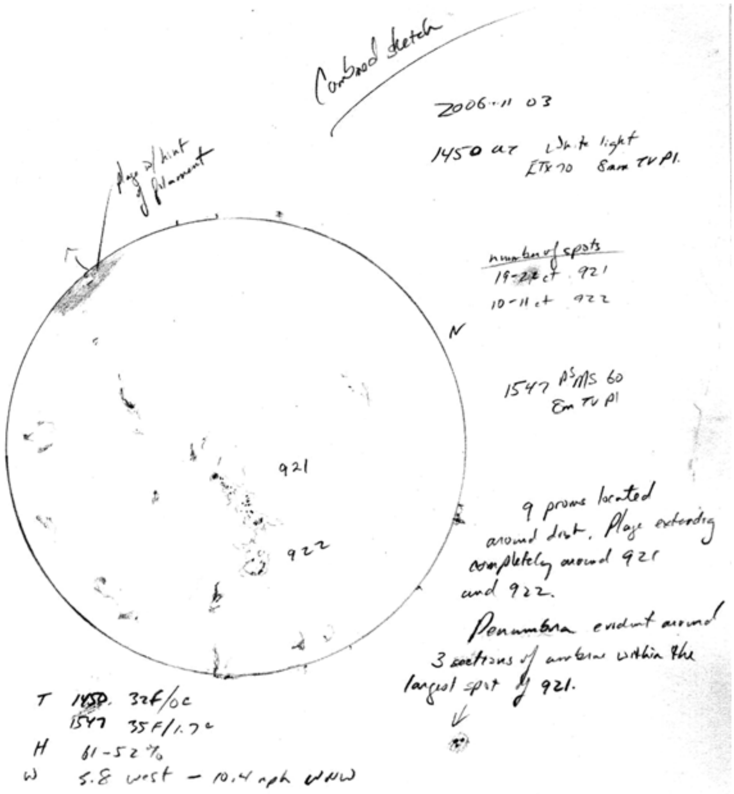


Fig. 7.12 White light and H-alpha combined sketch—November 3, 2006, 14:50 UT (white light), 15:47 UT (H-alpha). Meade ETX70, WL filter, 8 mm TeleVue Plössl, 39×, 32 °F (0 °C), 61 % humidity, 5.8 mph winds. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, 8 mm TeleVue Plössl, 50×, 35 °F (2 °C), 52 % humidity, 10.4 mph winds. Graphite on white paper (By Erika Rix)

faint bands of contrast around them. They should be rendered lightly so as not to be mistaken for the filaments to be added next. Use labels and pointers if necessary. Since the sunspots are seen in higher detail with the white light filter, no further additions should be necessary of those features while observing in the H-alpha wavelength.

As with the white light filter, include the relevant notes of the observation. Figure 7.12 shows an example of this technique.

The composite sketch provided in Fig. 7.13 is very similar, with the exception of the limb darkening effect. The white light view was void of faculae, and the only plages recorded were near the active regions toward the center of the disk.

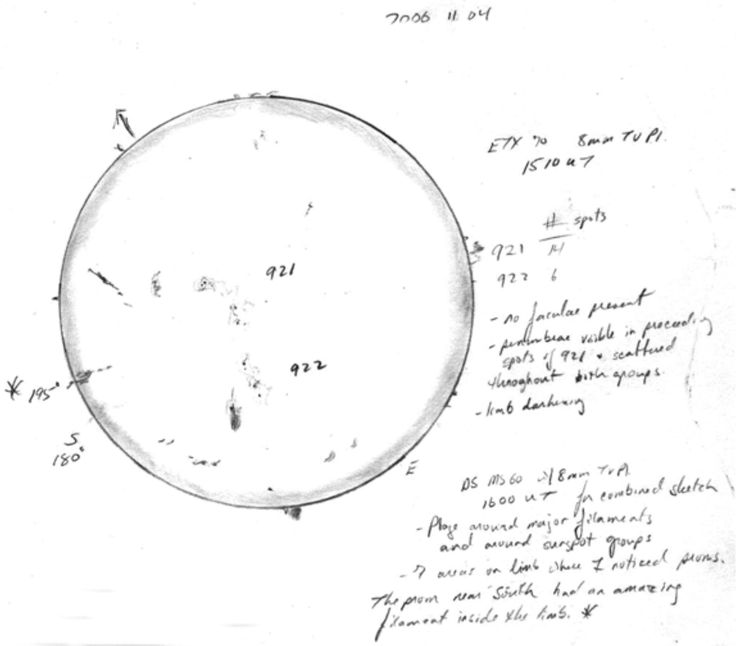


Fig. 7.13 White light and H-alpha combined sketch—November 4, 2006, 15:10 UT (white light), 16:00 UT (H-alpha). Meade ETX70, WL filter, 8 mm TeleVue Plössl, 39×. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, 8 mm TeleVue Plössl, 50×. Graphite on white paper (By Erika Rix)

7.3 Side by Side Comparisons

An alternative method used to compare the views of multiple filters is to create a separate sketch for each in succession. This method provides the most latitude in regard to the differing telescope optical configurations, media, and techniques. To match the orientation between the telescopes used, simply scan the sketches and rotate or flip them as needed using photo editing software. The media and sketching techniques can vary since each represents a different layer in the Sun's atmosphere. For example, the faculae (found in the photosphere) and plages (found in the chromosphere) will not have to overlap each other since a separate sketch will be completed for each.

7.3.1 Hydrogen-Alpha and White Light (By Erika Rix)

Use the media and techniques of your choice to produce a sketch for each filter. For best results, immediately begin the next sketch after changing filters so that the comparisons are relevant to that specific time period.

Figures 7.14 and 7.15 are comparison sketches using a white light filter and an H-alpha dedicated solar telescope. Both sketches were mirrored and rotated so that north is to the top; the preceding limb (west) is to the right.

Notice how the sunspots are easily recognized and have greater detail in the white light sketch, whereas the areas of magnetic activity are more noticeable in the H-alpha rendering with the filaments and plages. And although plages are associated with faculae, they are in abundance in the H-alpha view, while the only faculae apparent the day of the observation were two small regions on the eastern limb.

The sunspots were erroneously plotted a little off from each other when comparing the two sketches afterward. This could have been prevented by using white paper for both filter views, and then placing a solar grid underneath the paper while sketching. Alternatively, the completed white light sketch could have been placed underneath the one being drawn for H-alpha, so that the sunspots would show through the paper while I marked their positions.

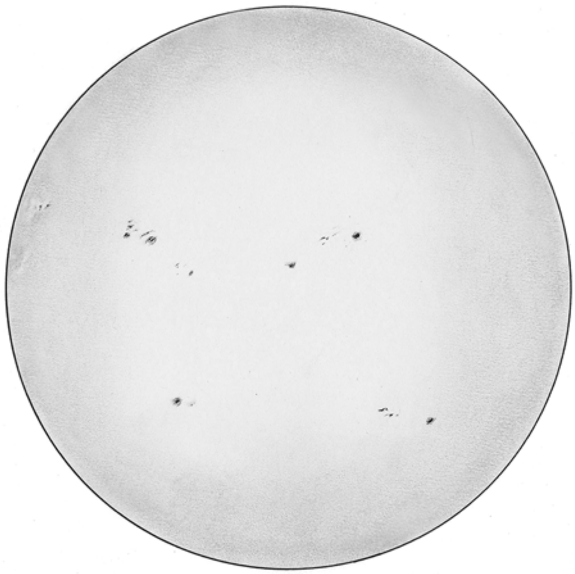


Fig. 7.14 White light sketch of NOAAs 11610 through 11616—November 14, 2012, 13:22 UT. 102 mm f/9.8 refractor, Thousand Oaks WL filter, LXD75, 83×. White card stock, Faber-Castell PITT black artist pen, charcoal pencil, and a #2 graphite pencil (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

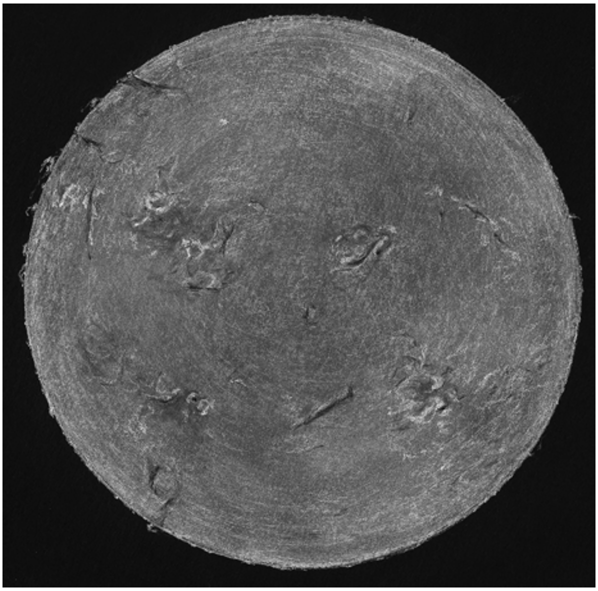


Fig. 7.15 H-alpha sketch of NOAAs 11610 through 11616—November 14, 2012, 14:30 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, 50×. Black Strathmore Artagain paper, white Conté crayon and color pencil, black oil pencil, and a charcoal pencil (By Erika Rix)

Figures 7.16 and 7.17 provide another set of examples using white light and H-alpha filters. Again, the sketches were mirrored and rotated so that north is to the top; the preceding limb is to the right.

Figures 7.18 and 7.19 show a comparison of white light and H-alpha filters using different techniques from the previous two sets of sketches. The orientation for this set has north to the top with west to the left.

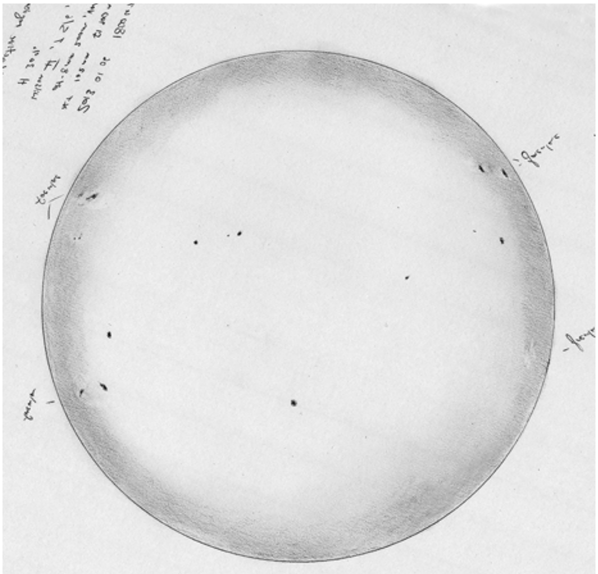


Fig. 7.16 White light sketch—January 6, 2013, 18:00 UT. 102 mm f/9.8 refractor, Thousand Oaks WL filter, LXD75, 83×. Wilson II, 5/6 transparency, 5 mpw winds. White card stock, Faber-Castell PITT black artist pen, charcoal pencil, and a black oil pencil (By Erika Rix)

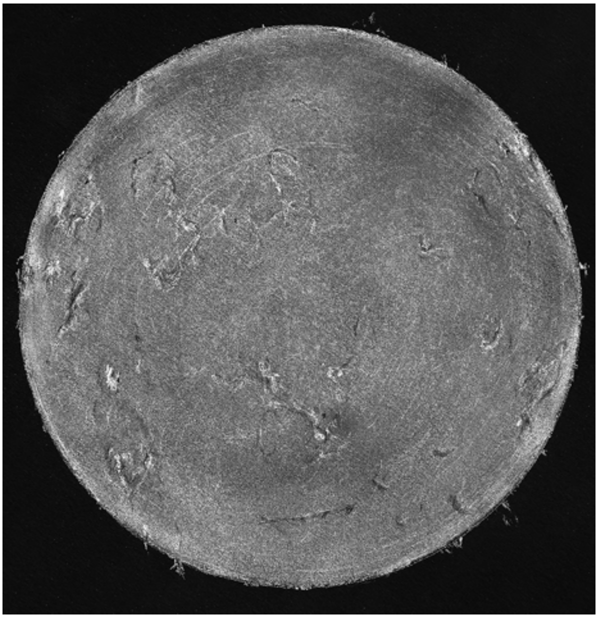


Fig. 7.17 H-alpha sketch—January 6, 2013, 19:56–20:14 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, 50×. Wilson II-III, 5/6 transparency. Black Strathmore Artagain paper, white Conté crayon and pastel pencil, white Prang color pencil, black oil pencil, and a charcoal pencil (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

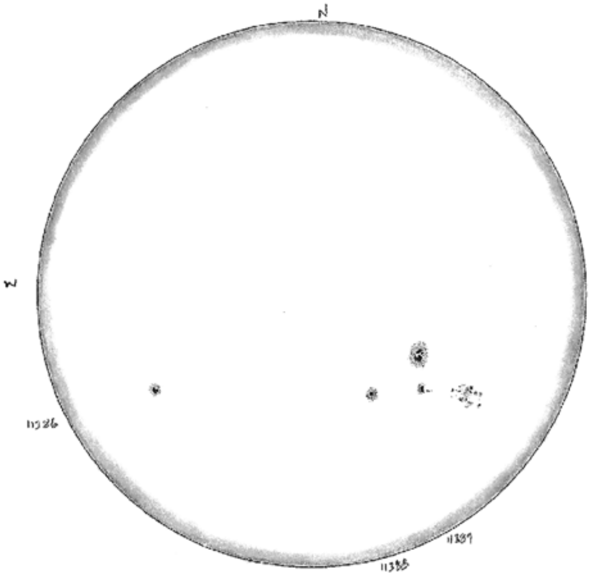


Fig. 7.18 Active regions 11386, 11388, and 11389. Refractor 102 mm f/11, Lunt Solar Systems Herschel Prism, Baader 8–24 Zoom. Full disk white light sketch on regular white copy paper and HB pencil (Courtesy of Alan Strauss, Arizona, USA)

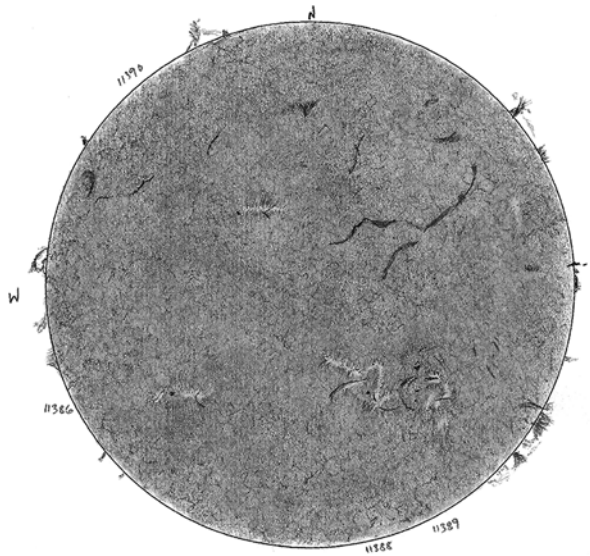


Fig. 7.19 The Sun in H-alpha, NOAA 11386, 11388, 11389, 11390—January 1, 2012. Lunt Solar Systems LS60THa Solar Telescope—pressure-tuned, Baader 8–24 zoom eyepiece. HB graphite pencil, mechanical pencil, white paper with a preprinted circle template (Courtesy of Alan Strauss, Arizona, USA)

Chapter 8

Transits

A solar transit occurs with the passage of Mercury, Venus, or a satellite across the face of the Sun as seen from Earth's vantage point. Because these events are relatively rare, it is necessary to plan well in advance if you wish to sketch them. The benefit you will reap is the wonderful opportunity to witness a transit first hand, and then come away with a unique record of your observation.

8.1 Planetary Transits

Mercury and Venus are the only two planets that pass between the Sun and Earth. They are seen as small black disks slowly drifting across the face of the Sun. A transit begins at first contact, when the planet is seen to just touch the Sun's limb. Second contact occurs at the moment when the planetary disk passes fully onto the face of the Sun, with third contact being the equivalent last moment that the planet is fully silhouetted against the solar disk. Fourth contact occurs when the final sliver of the planet's disk disappears from view off the solar limb.

Mercury

Due to the eccentricity of Mercury's orbit (0.21), its distance from the Sun varies from 46 to 70 million kilometers. Its transit events are divided into two groups, in May (33 % of the time) and November (67 % of the time). The May intervals recur every 13 and 33 years, at which time Mercury's apparent size is 1/158th the size of the Sun.

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical Astronomy Series 178, DOI 10.1007/978-1-4939-2901-6_8

The November transits recur at intervals of 7, 13, and 33 years with the planet's apparent size 1/194th that of the Sun.

NASA provides a Mercury transit catalog with key information, including the dates and contact times for events ranging over a 700-year timeline. It's titled *Seven Century Catalog of Mercury Transits: 1601 CE to 2300 CE* and can be found on their webpage at http://eclipse.gsfc.nasa.gov/transit/catalog/MercuryCatalog.html.

Venus

The transit events for Venus are also divided into two groups, in June (54.3 %) and December (45.7 %) with a recurring interval pattern of every 8 and 121.5 years, and then every 8 and 105.5 years—when a Venus transit occurs, a second one usually follows 8 years later. With an eccentricity of less than 0.01, the orbit of Venus is nearly circular.

A Venus transit catalog from NASA is also available, titled *Six Millennium Catalog of Venus Transits: 2000 BCE–4000 CE*. It can be found on their webpage at http://eclipse.gsfc.nasa.gov/transit/catalog/VenusCatalog.html.

Unless a narrowband filter is used so that the planet will be visible against the backdrop of a serendipitously positioned prominence, observations of first and fourth contact will not be possible. An aureole around the disk of Venus may be visible between first and second contact, due to sunlight refracted through the planet's atmosphere.

During the brief moments just after second contact, and also prior to third contact, a phenomenon known as the black drop effect might occur that can make the moment of contact hard to determine. This is where the disk of Venus appears to be attached to the Sun's limb by a dark thread before pulling away from, or while closely approaching, the Sun's limb. The effect, which was widely reported and sketched during the Venus transits of the 1700s and 1800s, is now thought to be due not only to Venus having an atmosphere, but also to the quality and size of the optics used and the atmospheric turbulence (seeing) in combination with solar limb darkening. How far the Sun is above the horizon at the time of ingress or egress will also affect the observation.

Ephemerides

Along with transit visibility maps and catalogs, ephemerides are essential when planning for a transit. The specific information pertaining to your observing location and equipment should be used so that the times and apparent topocentric coordinates that are displayed in the ephemeris are accurate for your observation. For example, Fig. 8.1 is an ephemeris screenshot of the *WinJUPOS—Database for Object Positions on Sun* freeware created by Grischa Hahn (http://www.grischa-hahn.homepage.t-online.de/). The program was designed for planning and analyzing solar system observations. The *Date* and *UT* time of the 2012 Venus transit was entered into the program along with the pertinent information for the observing

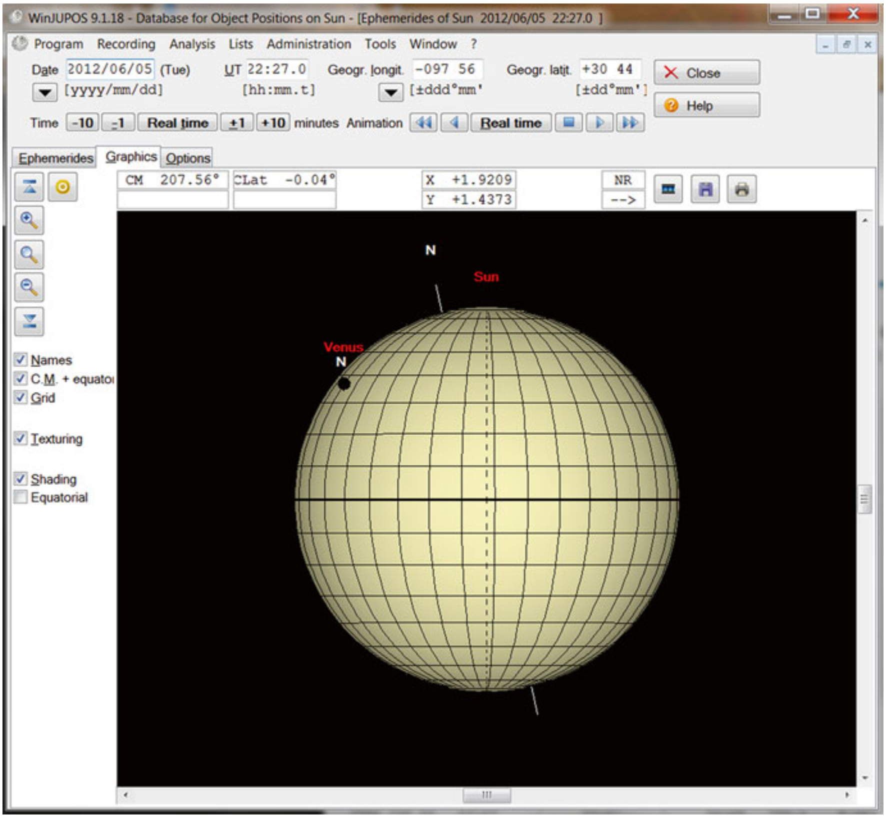


Fig. 8.1 *WinJUPOS 9.1.18—Database for Object Positions on the Sun* is freeware that was developed by Grischa Hahn for planning and analyzing solar system observations. It is a very useful tool when preparing for solar events

location. By manipulating the *Real time* values, the Venus graphic can be seen at its respective positions in relation to the Sun. Choosing any of the three tabs, *Ephemerides, Graphics,* or *Options* will provide additional information concerning the event. The program's planetary graphic can be referred to when estimating the size of the planet's disk for your sketch.

Ephemerides from various programs may be slightly off by a minute or two, so be prepared by familiarizing yourself with where the planet's ingress and egress will be located along the solar limb. The base sketch of the Sun should be completed at least 5–10 min before the transit is due to begin. Then keep a keen eye on the section of limb where the planet will make first contact to ensure that crucial phase of the transit is caught.

Although the next Venus transit isn't due to occur until the year of 2117, there will be numerous opportunities to observe a Mercury transit in the meantime. The sketching techniques provided in this section are relevant to both planets.

Warning! ALWAYS use a suitable filter when directly observing the Sun

8.1.1 Mercury Transit: White Light and Hydrogen-Alpha Whole Disk (By Sally Russell)

In 2003, I was very fortunate to observe and sketch the May 7 transit of Mercury under ideal conditions in both white light and H-alpha. I shared the experience with a good friend, the owner of the H-alpha scope, who kindly allowed me to sketch from that view. It was interesting to note that the transit lasted a couple of minutes longer in H-alpha as the chromosphere lies just above the photosphere, and hence the Sun exhibits a fractionally larger diameter in H-alpha.

Suggested Materials

- White drawing paper (Daler-Rowney heavyweight cartridge paper, 135 lbs., 220 g/m^2, size 5 ¾″ × 8 ¼″, UK size A5, was used in this example)
- B graphite pencil
- Compass
- Plastic eraser

In this example, I made overview sketches to capture the progress of the transit. The full disk schematic drawings were drawn first, and then I added dots to represent Mercury at various times as it progressed across the solar disk. See Chap. 3, Sect. 3.1 *Whole Disk,* and Chap. 5, Sect. 5.3 *Whole Disk*, for methods on sketching the Sun in white light and H-alpha, respectively.

For the White Light Sketch

Step 1

I started by drawing a 4 ½-inch diameter circle template to represent the Sun's disk. There were three small active regions visible in white light (AR348, AR349, and AR351, the latter being the most obvious) so these were lightly sketched in to act as anchor points to help while rendering Mercury's position.

Step 2

To chart the progression of the transit, the location of Mercury was sketched as a small black dot, and the time added at each position. As there was little white light activity visible that day, it was quite tricky to keep the correct orientation during the progress of the transit—small blank circles drawn alongside the early stages represent the correct placing of Mercury rather than those that were actually sketched at the second and third timings. Because the telescope was alt-az mounted, the whole field of view, including the Sun, rotated as the morning progressed. That added to the difficulty of accurately tracking Mercury's position. See Chap. 1, Sect. 1.2 *Essential Tips, Determining Disk Orientation* for further explanation, and how it changes throughout the day depending on the type of telescope and mount being used.

The first sighting of Mercury occurred at 05:15 UT just after ingress, so it was already fully onto the Sun's disk at this point. Mercury was clearly seen making a small notch on the limb at egress around 10:32 UT. This is represented in a thumbnail sketch.

Figure 8.2 shows the final white light sketch annotated with the cardinal directions and observing notes.

In contrast, the view in H-alpha was full of interest with active regions, filaments and prominences to help as anchor points. One massive prominence on the eastern limb changed and dissipated during the course of the transit, and this was also recorded in a thumbnail sketch.

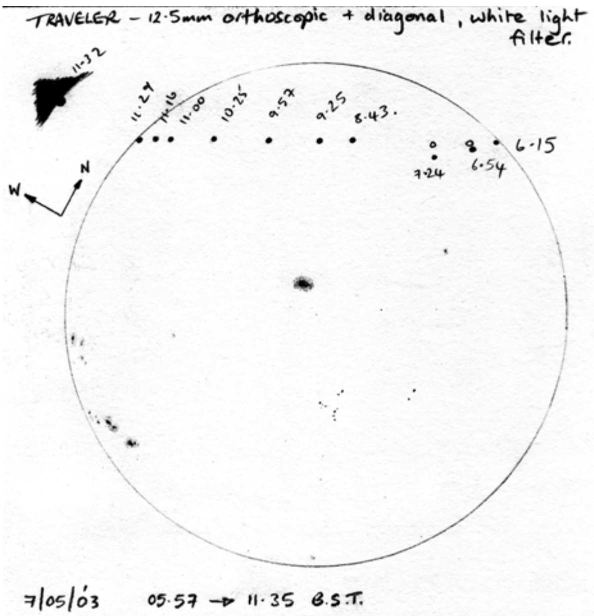


Fig. 8.2 White light view of the Mercury transit—May 7, 2003, 04:47–10:35 UT. Astro-Physics 105 mm f/6 refractor on an Alt-Az mount, Kendrick white light solar filter, 12.5 mm eyepiece, 48×. Clear, calm. Daler-Rowney heavyweight cartridge paper, B graphite pencil (By Sally Russell)

Warning! ALWAYS use a suitable filter when directly observing the Sun

For the H-Alpha Sketch

Step 3

Again, I started by drawing a 4 ½-inch diameter circle template to represent the Sun's disk. The prominences were the most obvious features that were visible so they were lightly sketched next, keeping in mind their o'clock positions when transferring the view from the eyepiece to paper. Using the prominences as anchor points, I then added schematic representations of the active region near the center of the disk and the filaments.

Step 4

As before, I sketched the positions of Mercury as a small black dot at various times throughout the transit. It was slightly easier to correctly gauge Mercury's position due to the greater amount of visible features already included in the sketch. From the times that were recorded, it can be seen that I alternated viewing between the two telescopes.

Figure 8.3 shows the final annotated H-alpha sketch, including cardinal directions.

After completing a transit sketch, it can be scanned and then processed using photo editing software. As seen in Fig. 8.4, Jeremy Perez added a black background for presentation along with the relevant details of the observation. To highlight Mercury's passage across the face of the Sun, he included call outs with labels and pointers, and then the sketch was saved under a separate file name so that both versions were retained (Fig. 8.5).

8.1.2 Venus Transit: Hydrogen-Alpha Whole Disk (By Erika Rix)

During the 2012 transit of Venus, I set up both an H-alpha filtered telescope and one for white light so that I was able to alternate the views. Two drawing boards were used so that the event could be recorded for both bandwidths. The following method explains the technique I used with the H-alpha filter.

Suggested Materials

- Black acid-free paper, 60 lb. (160 g/m^2), 8″ × 8″ or larger
- Pastel or charcoal pencils, white and black
- Colored pencils, black and white
- Hard pastel stick, white
- Bulb blower
- 6-in. circular protractor

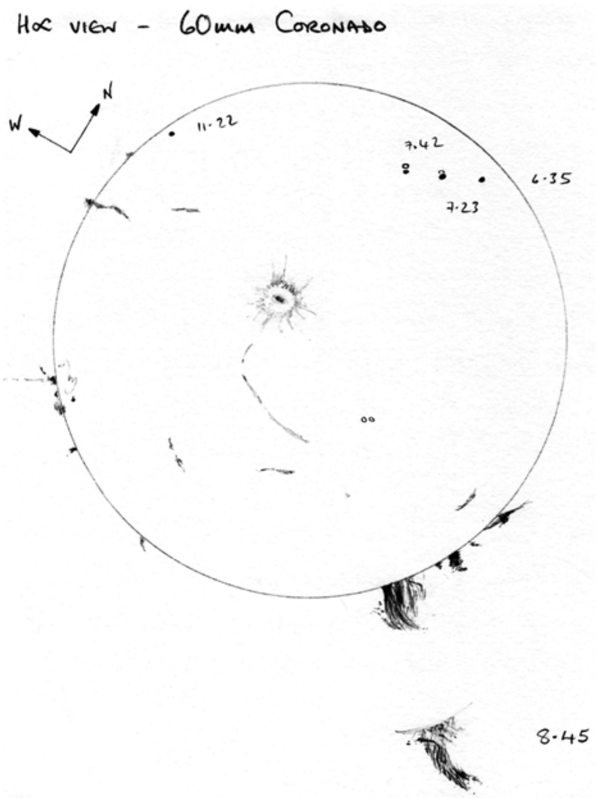


Fig. 8.3 H-alpha view of the Mercury transit—May 7, 2003, 04:47–10:35 UT. Coronado SolarMax 60 mm f/6.6 H-alpha telescope on Alt-Az mount, 12 mm eyepiece, 33×. Clear, calm. Daler-Rowney heavyweight cartridge paper, B graphite pencil (By Sally Russell)

Refer to Sect. 5.3 *Mixed Media on Black Paper (by Erika Rix)* in Chap. 5 to render a full disk sketch of the Sun using similar media. If you wish to create an animation of the event, draw two. One will be used on the field to record the positions of Venus along with their times. The other will be used to recreate the transit with photographs or scans of the sketch after the inclusion of each progression. The sketches should be completed with time to spare before the transit begins.

Step 1

Mark celestial orientation onto the paper so that if the Sun rotates in the field of view during the course of the event, you can rotate the sketch to match. Solar features that are scattered across the face of the Sun, as well as the prominences along the limb, should also be used for this purpose. During the transit, each positional marking is cross-referenced to the solar features and orientation.

Warning! ALWAYS use a suitable filter when directly observing the Sun

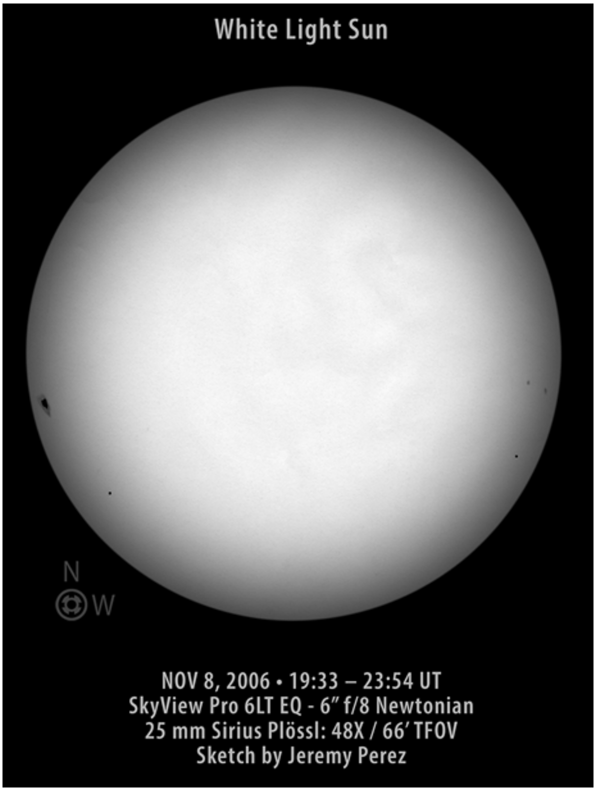


Fig. 8.4 Mercury transit in white light—November 8, 2006, 19:33–23:54UT. Orion SkyView Pro 6LT EQ f/8, 25 mm Sirius Plössl, 48×. Graphite on white paper (Courtesy of Jeremy Perez, Arizona, USA)

Ephemerides may be slightly off by a minute or two, so several minutes before first contact is expected, begin observing and have your drawing board and both pencils in hand and ready to use. Setting the alarm on your smart phone or watch 5 min before the transit is due to begin will ensure that you remain on schedule.

Step 2

You will need to determine which stages of ingress and egress you wish to include in the full disk sketch. Because one sketch is used for the entire event, you will only be able to add the planet's position either as it crosses the limb or at the moment of second contact. For the purpose of this example, I included the brief moment after first contact, and then continued after second contact.

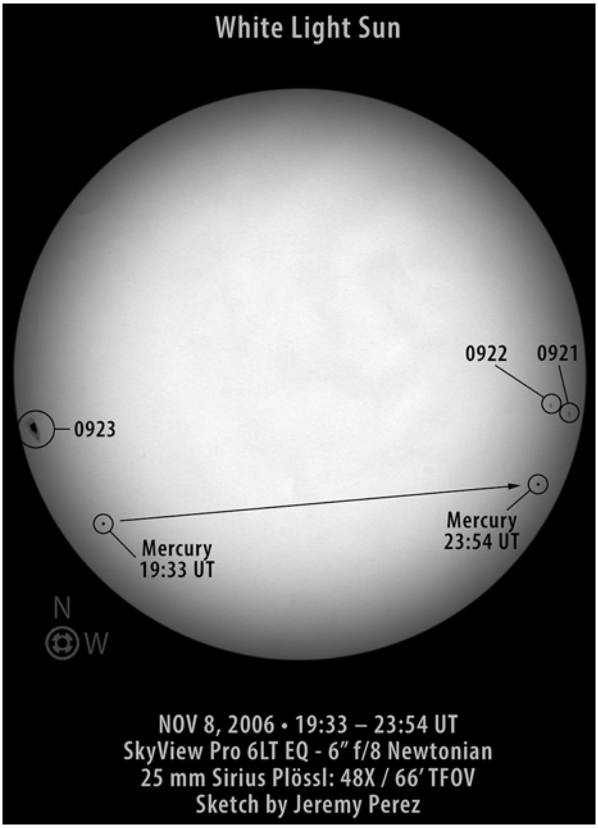


Fig. 8.5 Labels were added to the sketch to show the times and movement of Mercury as it transited the Sun on November 8, 2006 (Courtesy of Jeremy Perez, Arizona, USA)

Watch the area of the solar limb where first contact is expected. If a prominence is nearby, the planet may be seen passing in front of it so that first contact can be recorded. Otherwise, as soon as the planet is noticed, jot the time off to the side of the sketch. Then use the black pencil to create its thin indent into the limb.

If you are observing with tandem telescopes, quickly switch over to the white light filtered scope to record the planet's position onto the other sketch with a graphite pencil (see the next section, *Venus Transit—White Light Whole Disk*). Likewise, you could create a third sketch to include close-up views near the limb. Beware, though, that with the addition of each sketch, you run the risk of missing key elements of ingress and egress.

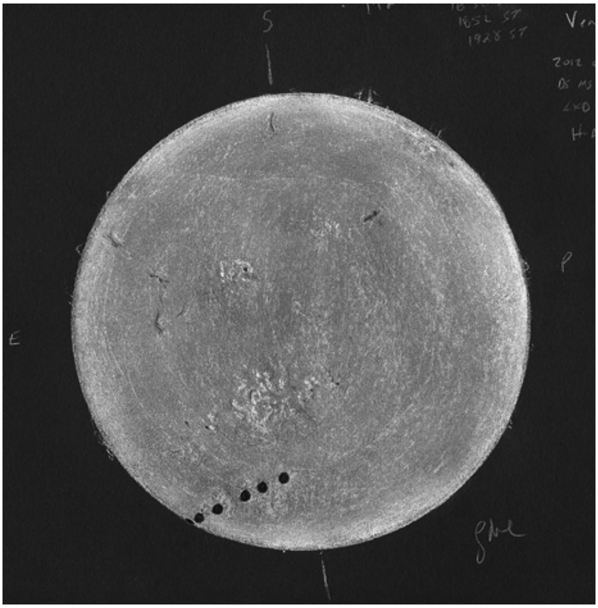


Fig. 8.6 Venus transit in H-alpha—June 5/6, 2012, 22:00–00:29 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, Baader Planetarium Hyperion 8–24 mm Mark III set at 8 mm, 50×. Wilson III–IV, 1–2/6 transparency, 30–70 % overcast with SE winds, 50 % humidity, 101 °F (38 °C). The session ended early due to clouds. Black Strathmore Artagain paper, white Conté crayon and pastel pencil, white Prang color pencil, black oil pencil, and a charcoal pencil (By Erika Rix)

Step 3

Reverting back to the H-alpha view, use the black pencil to record Venus' position just inside the limb. Record the time. The planet's size should be proportionate to nearby solar features. Again, if using two telescopes, swap back to the white light filtered view to record the next movement onto the other sketch. Continue recording the times and positions of the planet at set intervals until the event has ended.

The transit path from my observation can be seen in Fig. 8.6. The session was cut short when a large cloud moved in (and then planted itself!) to block my view of the Sun. I held out for 45 min while waiting for the cloud to move away, but the Sun set behind it in the meantime.

Because I intended to make an animation of the event, I drew two full disk sketches before the transit began, as mentioned at the beginning of this tutorial. When the transit ended, I scanned the second sketch to create an image file of the Sun before adding to the drawing. Then, using a black colored pencil, I referred to the first sketch (that I used during the event) to redraw each progressive movement of Venus onto the second one. After the addition of each black circle, the sketch was

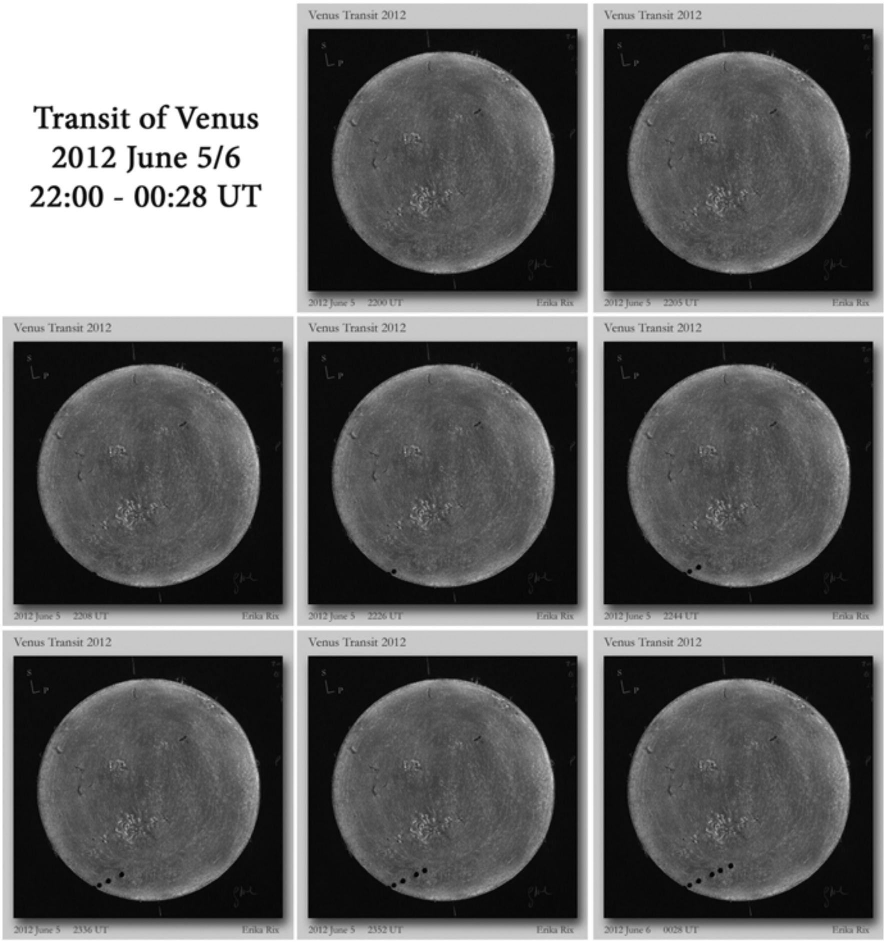


Fig. 8.7 Transit sketch sequence used to make an animation of the event (By Erika Rix)

scanned again so that by the time the sequence was complete, there were a total of eight scanned images (Fig. 8.7). These images were then stacked in Adobe Photoshop CS6 to create an animation using the *Timeline* feature that is located under the *Window* menu tab. In older versions, this feature was simply called *Animation*.

The H-alpha Venus transit animation can be viewed by visiting the PCW Memorial Observatory webpage at http://pcwobservatory.com/2012/06/07/2012-june-056-venus-transit/. For more information on the animation process, see Chap. 10.

8.1.3 Venus Transit: White Light Whole Disk (By Erika Rix)

The method used to render a white light transit event is very similar to that when viewing with a Hydrogen-alpha filter. Rather than using the same media for both, I prefer black paper for H-alpha observations to preserve my visual dark adaptation, and white paper to represent the brighter white light view. Again, if using both types of filters in tandem, alternate between them after recording each positional change during the transit.

Suggested Materials

- Transit grid template printed on white paper (Fig. A.20 in Appendix A)
- #2 graphite pencil
- Small blending stump

A grid template can prove quite useful when plotting the positional movements of a transit. Several types are provided for your use in Appendix A. Simply photocopy and enlarge them as needed. They can be placed underneath your sketch paper so that the gridlines show through, or you can sketch directly onto the grid template, as shown in Fig. 8.8.

Step 1

Determine the orientation of your eyepiece view and then rotate the grid template so that the equatorial line matches between the two. Notate the cardinal directions around the disk on your paper. Next, complete the white light sketch using any of the suggested graphite on white paper techniques found in Sect. 3.1 *Whole Disk* of Chap. 3. As you draw the features observed in the photosphere, maintain matched orientations between the eyepiece view and your grid template. The sketch should be completed at least 5–10 min prior to the expected time of first contact.

Step 2

Five minutes or more before first contact, begin watching the area of ingress along the solar limb. Actual first contact is not possible with a white light filter, but immediately after, you should be able to spot the first thin sliver of the planet's disk entering the solar limb. Jot down the time it was observed, and then use the graphite pencil to render the thin indent into the limb.

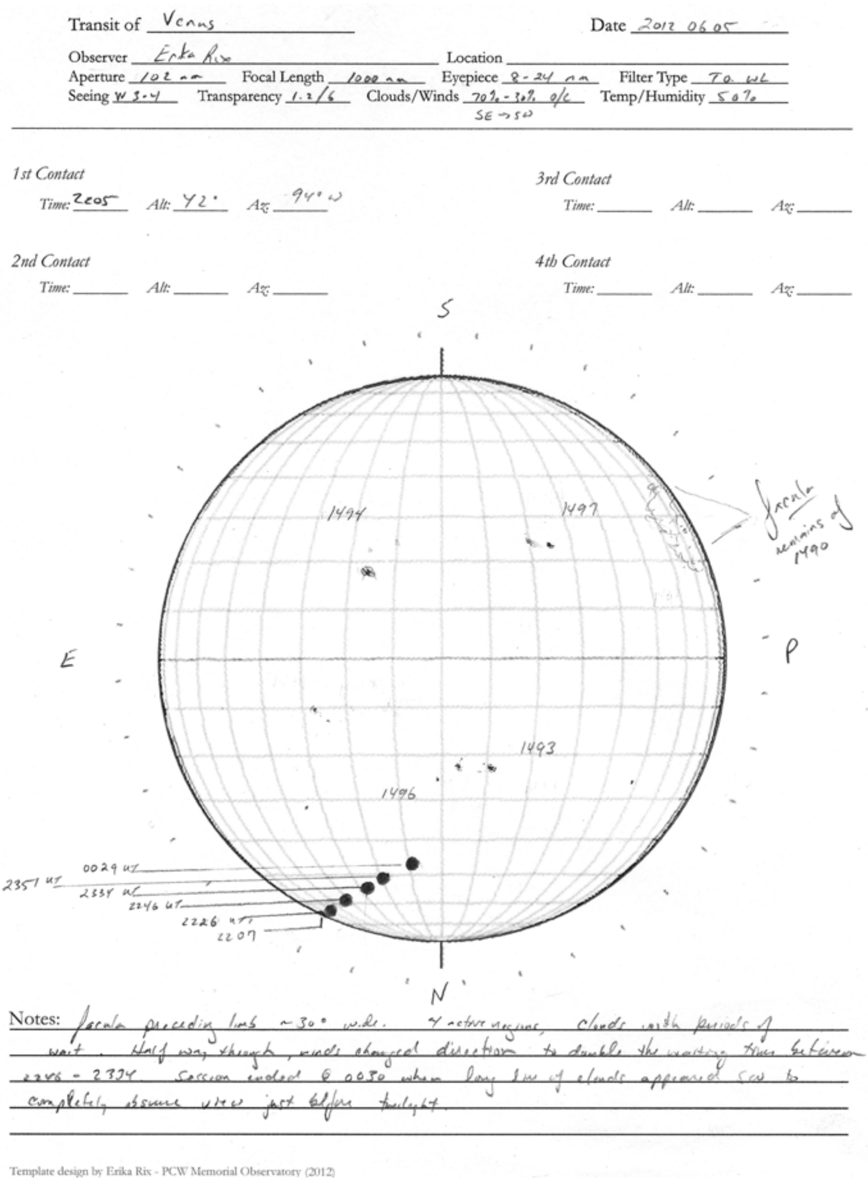


Fig. 8.8 Venus transit observation in white light—June 5/6, 2012, 22:07–00:29 UT. Celestron Omni XLT 102 mm f/9.8 refractor, LXD75, Thousand Oaks glass white light filter, Baader Planetarium Hyperion 8–24 mm Mark III. Wilson III–IV, 1–2/6 transparency, 30–70 % overcast with SE winds, 50 % humidity, 101 °F (38 °C). Transit template printed on white printer paper and #2 graphite pencil (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

Step 3

Assuming that a limb template will be used to record high magnification views of ingress (refer to the next tutorial of this chapter, *Venus Transit—White Light Limb*), the next positional plot on the full disk sketch will be at second contact or shortly after. Notate the time before adding its position. Continue at set intervals, clouds permitting, until the planet reaches the far side of the solar disk. Pay special attention to areas of interest; e.g., the planet crossing over a sunspot group.

Step 4

At third contact, add the time and plot the position to end the full disk sketch. Then switch back to the limb template to record high magnification views of egress.

Figure 8.8 shows the result from my white light observation while viewing between groups of clouds. The session was forced to an end when a large slow-moving cloud obscured the view and then hovered near the horizon until sunset.

8.1.4 Venus Transit: White Light Limb (By Erika Rix)

High magnification views of ingress or egress can be recorded with greater detail while using a solar limb template or by using hand-drawn arcs. If you wish to use a limb template, two can be found in Appendix A, Figs. A.18 and A.19. This method works particularly well in conjunction with a full disk white light sketch, which, in comparison, begins at or just after second contact and ends at or just prior to third contact.

Suggested Materials

- Limb ingress/egress template printed on white paper
- #2 graphite pencil
- A 1-in. circle template to represent the planet's disk (I used an American 25-cent coin)

Step 1

Five minutes or more before first contact, begin watching the area of ingress along the solar limb. The first sign of the transit will be a thin nip out of the solar limb just after first contact. Note the time on the sketch next, and then use the pencil and the 1-in. circle template to trace the indent of the planet just inside the arc. It can be shaded in when the event has ended.

Step 2

Next, watch closely for the aureole (ring of light) effect around Venus as it crosses the Sun's limb. If you manage to catch it, jot down the time, place the circle template in the appropriate spot on the limb template, and then use the pencil to lightly trace all the way around it. Remove the circle template so that you can add shading to the outer edge of the planet's disk (that hasn't yet crossed over the Sun's limb). Hold the pencil at a very shallow angle while lightly shading, and create the ring of light by leaving a very thin gap of untouched paper around the planet's outer edge.

Step 3

Just as the planet has fully crossed over the solar limb, use the circle template to create the disk at second contact.

Step 4

Shortly after second contact, Venus may appear to be pulling part of the Sun's edge with it. This is known as the black drop effect. Again, if you are able to see this phenomenon, record the time and then trace around the 1-in. circle template to create the planet's disk. Remove the circle template, and then lightly render the smudged pulling effect with the pencil. Blend if needed.

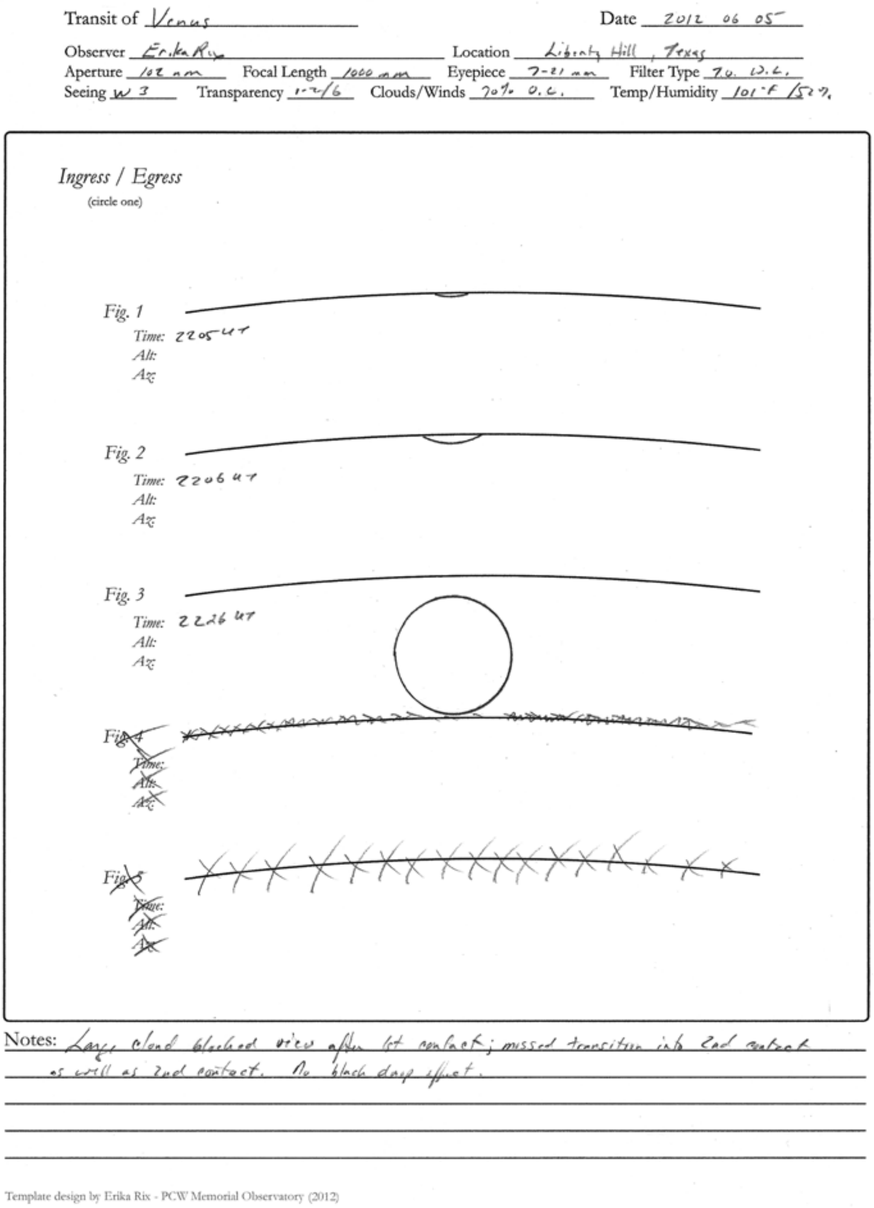
The clouds from my Texas USA location prohibited me from catching the exciting phases of ingress, which were the aureole, second contact, and the black drop effect. I did, however, manage to witness the moment just after the first and second contacts. Figure 8.9 shows the sketch sequence immediately after ingress. Later that night, when the event was over, I used the graphite pencil to fill in the outlines of the planet's disk, and then smoothened them with a blending stump (Fig. 8.10).

Kim Hay observed the 2012 Venus transit from Canada, also with both the white light and H-alpha filters in tandem. Her drawings were rendered from the H-alpha view. The set in Fig. 8.11 includes the moment just after first contact and at second contact. She recorded the time the planet crossed halfway over the limb, and also the time at the ¾ crossing. Due to cloudy sky conditions, she was unable to witness either an aureole or the black drop effect (Figs. 8.12 and 8.13).

Sally Russell had complete success from her location in England during the 2004 transit of Venus. The sequence during ingress is shown in Fig. 8.14.

8.1.5 Venus Transit: White Light Whole Disk Digital Coloring (Technique of Jean Barbeau)

Image manipulation software can be utilized to add digital coloring to a sketch once it has been scanned or photographed. A black background and labeling can then be added to create an aesthetically pleasing presentation of the drawing for framing or sharing with others.



Transit of Venus Date 2012 06 05

Observer Erika Rix Location Liberty Hill, Texas

Aperture 102 mm Focal Length 1000 mm Eyepiece 7-21 mm Filter Type 70. W.L.

Seeing W 3 Transparency 1-2/6 Clouds/Winds 70% O.C. Temp/Humidity 101 °F / 52%

Ingress / Egress
(circle one)

Fig. 1
Time: 2205 UT
Alt:
Az:

Fig. 2
Time: 2206 UT
Alt:
Az:

Fig. 3
Time: 2226 UT
Alt:
Az:

~~*Fig. 4*~~
~~*Time:*~~
~~*Alt:*~~
~~*Az:*~~

~~*Fig. 5*~~
~~*Time:*~~
~~*Alt:*~~
~~*Az:*~~

Notes: Large cloud blocked view after 1st contact; missed transition into 2nd contact as well as 2nd contact. No black drop effect.

Template design by Erika Rix - PCW Memorial Observatory (2012)

Fig. 8.9 Outline drawings of Venus during ingress while transiting the Sun. (By Erika Rix)

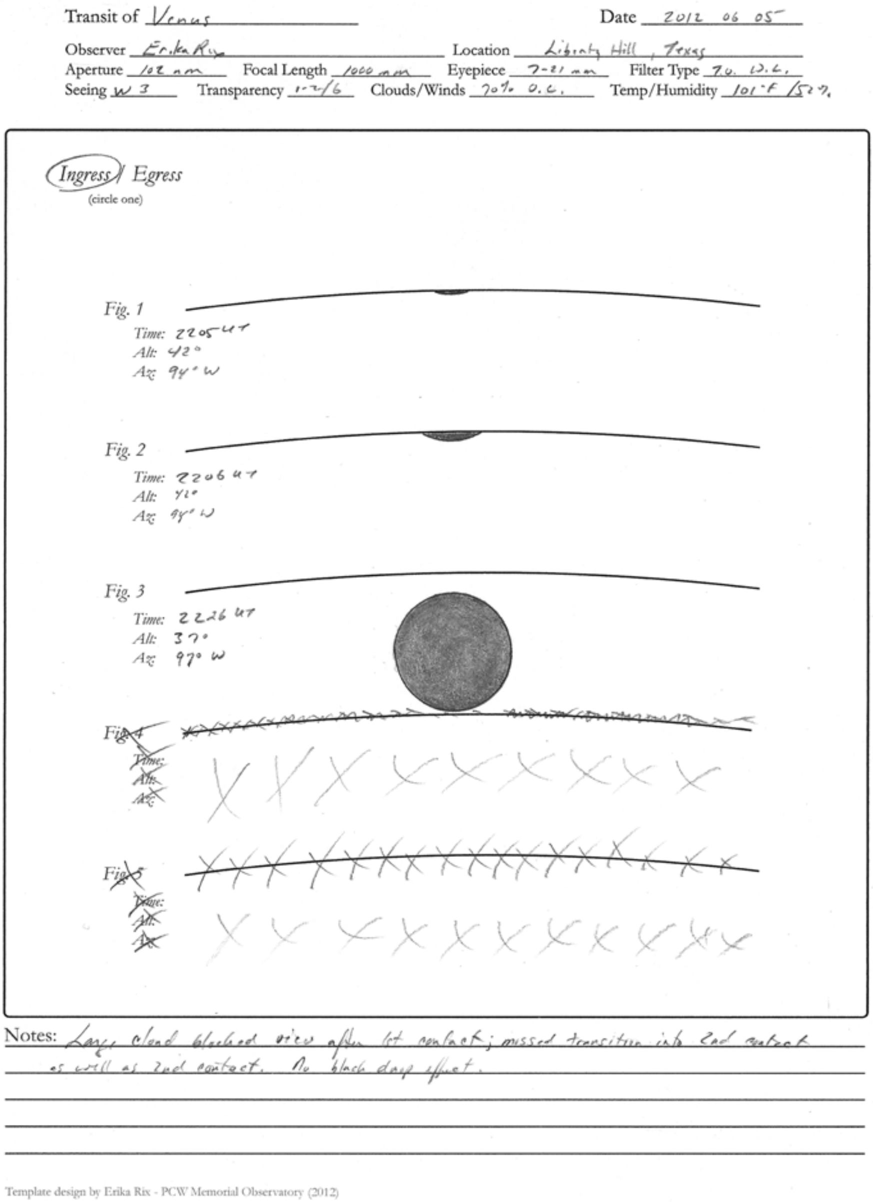


Fig. 8.10 Ingress progression limb drawings of the Venus transit—June 5/6, 2012. Celestron Omni XLT 102 mm f/9.8 refractor, LXD75, Thousand Oaks glass white light filter, Zhumell 7–21 mm eyepiece. Wilson III, 1–2/6 transparency, 70 % overcast, 52 % humidity, 101 °F (38 °C). The session ended early due to clouds. Transit Ingress/Egress template printed on white printer paper and #2 graphite pencil (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

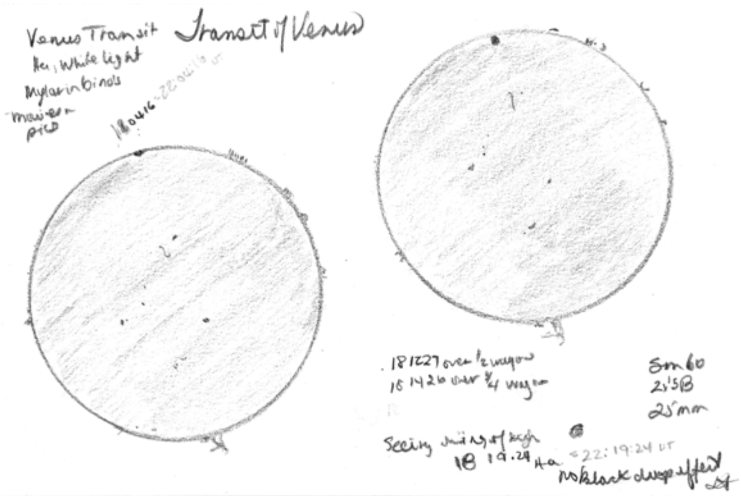


Fig. 8.11 Venus transit in H-alpha just after first contact and at second contact—June 5/6, 2012, 22:04 UT and 22:19 UT. Coronado H-alpha SolarMax 60 mm, 25 mm eyepiece, 2× Barlow, 32×. Clouds. Graphite on white paper (By Kim Hay)

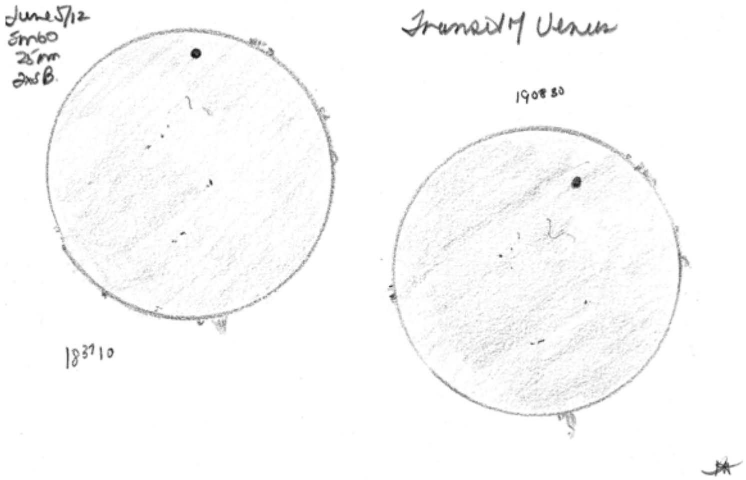


Fig. 8.12 Venus transit in H-alpha—June 5, 2012, 22:37 UT and 23:08 UT. Coronado H-alpha SolarMax 60 mm, 25 mm eyepiece, 2× Barlow, 32×. Clouds. Graphite on white paper (By Kim Hay)

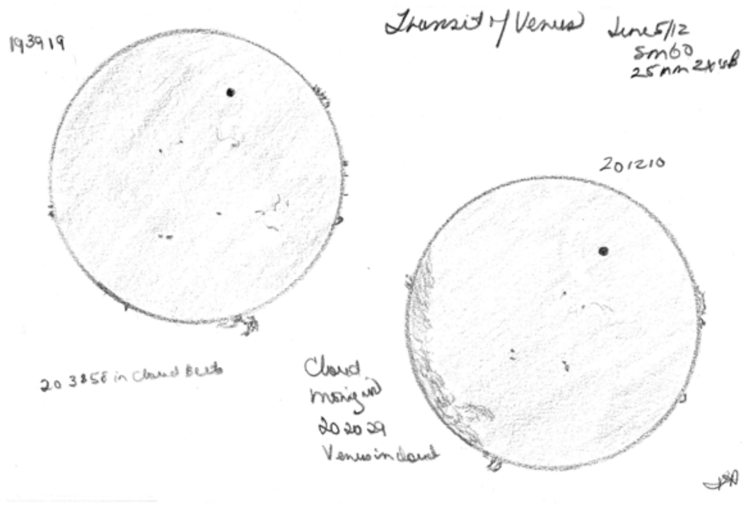


Fig. 8.13 Venus transit in H-alpha—June 5/6, 2012, 23:39 UT and 00:12 UT. Coronado H-alpha SolarMax 60 mm, 25 mm eyepiece, 2× Barlow, 32×. Clouds. Graphite on white paper (By Kim Hay)

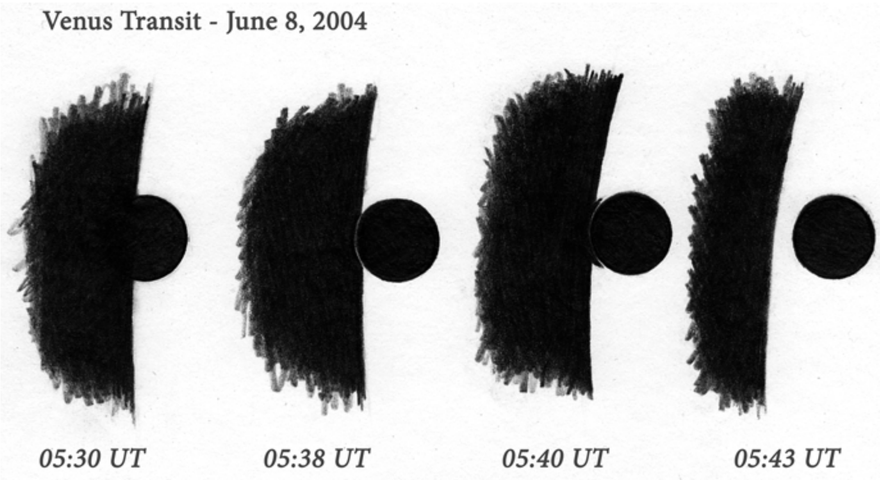


Fig. 8.14 Venus transit ingress sequence with the black drop effect at 05:40 UT—June 8, 2004, 05:30–05:43 UT. Astro-Physics 105 mm f/6 refractor on a driven mount, Kendrick white light solar filter. Graphite on white cartridge paper (By Sally Russell)

Warning! ALWAYS use a suitable filter when directly observing the Sun

Suggested Materials

- Sheet of white, acid-free drawing paper
- HB graphite pencil
- 2HB (#2) graphite pencil
- Compass
- GIMP freeware (or similar image manipulation software)

Step 1

Prepare the sketch media at least two hours before the transit begins. Use the compass fitted with a 2HB pencil to create a 4-in. to 6-in. diameter disk outline of the Sun onto your paper. The sunspots are drawn within the disk outline first so that they can be used as position markers during the transit. Plot the umbrae with the HB pencil, and then use the 2HB to render the penumbrae.

> *Tip*
>
> Use lower magnification when marking the positions of the sunspots on your paper. The power can then be increased to add the finer details of the sunspot groups.

Step 2

Begin watching the Sun steadily several minutes before the transit is due to begin. Once Venus is observed crossing in front of the solar limb, mark the time and then use the flat eraser end of an HB pencil, darkened with another pencil, to "print" the planet in place on your sketch. If necessary, touch up the planet's disk directly with the HB pencil while maintaining its circular shape (Fig. 8.15).

Step 3

Scan and save your sketch. Next, open the image in GIMP (or the image manipulation software of your choice).

Step 4

Click on the *Ellipse Selection Tool* in the *Toolbox*. A new menu selection will pop up. Click in the tick box next to *Fixed*, and then select *Aspect ratio* from the drop down box so that the selection tool remains circular. Use the selection tool to isolate the solar disk with your cursor.

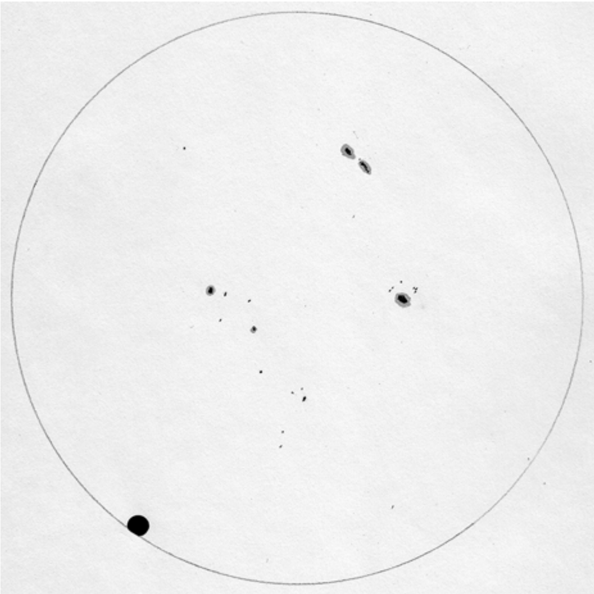


Fig. 8.15 Venus transit prior to second contact—June 5, 2012, 22:17 UT. Newtonian 130 mm f/7, EQ3 mount, Baader AstroSolar Safety Film mounted on a cardboard frame, 25×. HB graphite pencils on white Canson sketch paper (Courtesy of Jean Barbeau, Montreal, Canada)

Step 5

On the top menu bar, click on *Select* and then *Invert* to select the area outside of the solar disk. Choose a black foreground color and then click on the *Bucket Fill Tool*. Tick the *Fill Whole Selection* radio button. Next, click in the selected area outside of the disk so that it becomes black.

Step 6

Click *Select* once again from the top menu bar, and then chose *Invert* to select the solar disk. Next, click on *Colors* from the top menu bar and choose *Brightness-Contrast*. Adjust both settings with the slide bars so that the solar disk becomes light gray in color. Press *OK*. Still under the *Colors* tab, select *Color Balance* and adjust the settings to change the shading of the disk to light yellow-orange. Click *OK*.

Step 7

Limb darkening can be achieved with the 2HB pencil and blending, or, alternatively, you could use the *Dodge / Burn Tool* that is located within the *Toolbox*. Click on the radio button next to the *Burn* option. Then, adjust the *Brush, Opacity,* and

Scale settings to your preference through trial and error. Hold the left click button down on your mouse while producing the soft limb darkening effect within the solar disk.

Step 8

From the top menu bar, click *Tools, Transform Tools, Flip* and/or *Rotate* to change the orientation of the image.

Step 9

Click the *Text Tool* and a lighter foreground color in order to add text to the image that is relevant to your observation. Go to *File* and then *Save As* to save the image to your computer's hard drive (Fig. 8.16).

8.1.6 Venus Transit: Aureole and the Whole Disk in Hydrogen-Alpha (Technique of Michael Rosolina)

The technique used by Michael Rosolina includes a limb sketch to capture the aureole and a second sketch to record the position of the planet as viewed against the face of the Sun. The field sketches are then redrawn after the event to create final versions.

Suggested Materials

- White acid-free sketch paper, two sheets, 60 lb., 9″ × 12″
- Black acid-free sketch paper, one sheet, 60 lb., 9″ × 12″
- Limb ingress/egress template printed on white paper (Fig. A.18 in Appendix A)
- 1-in. circle template to represent the planet's disk along the solar limb
- 1/8-in. circle template to represent the planet's disk within the solar disk
- 4-in. circle template to represent the solar disk
- 2B graphite pencil
- Colored pencils, white, orange, red and black
- Pastel (or charcoal) pencils, white and black
- Pastel stick, white
- Blending stump
- Kneadable eraser

Fig. 8.16 Venus transit prior to second contact—June 5, 2012, 22:17 UT. The graphite sketch was processed in GIMP 2.6 to produce digital disk coloring and presentation (Courtesy of Jean Barbeau, Montreal, Canada)

Tip

Plastic see-through circle templates are available through most art suppliers. A small template will generally have 40–80 circle cutouts ranging from 1/32″ to 1-1/4″ diameters.

Prepare the templates in advance. Trace a 4-in. circle on a sheet of white acid free sketch paper, and print the limb ingress/egress template on ordinary printer paper. Both will be used for field drawings and for adding notes on which to base the final drawings.

Warning! ALWAYS use a suitable filter when directly observing the Sun

Drawing the Aureole

Step 1

Ingress from first to second contact lasts approximately 18 min. Within that time span, Venus and the section of limb it crosses will need to be studied closely for signs of the bright arc around the planet's disk. Once it is observed, note the UT time, and then use the 1-in. circle template and the 2B graphite pencil to create Venus' disk on one of the preprinted arcs from the limb ingress/egress template.

Step 2

The pencil is then used to shade the area around the disk and also along the inside edge of the arc that represents the solar limb. Smoothen the shading with a blending stump.

Step 3

Knead and form the eraser so that it has a thin edge, and then use it to remove graphite from around the limb of Venus to render the appearance of the aureole as seen in Fig. 8.17 (next to Fig. 4 on the template). Disregard the circles along the arcs above and below the drawing of Venus. Those were from trial and error in determining the template size to depict Venus.

Drawing Venus' Position During Transit

Step 4

Once Venus moves completely in front of the solar disk, switch to the prepared sketch paper that has the 4-in. disk circle drawn onto it. Roughly draw the positions of a few prominences with the 2B pencil to use as positional markers. The same pencil will be used through the following two steps.

Step 5

Record the time, and then draw around the 1/8-in. circle template to represent Venus' position on the Sun.

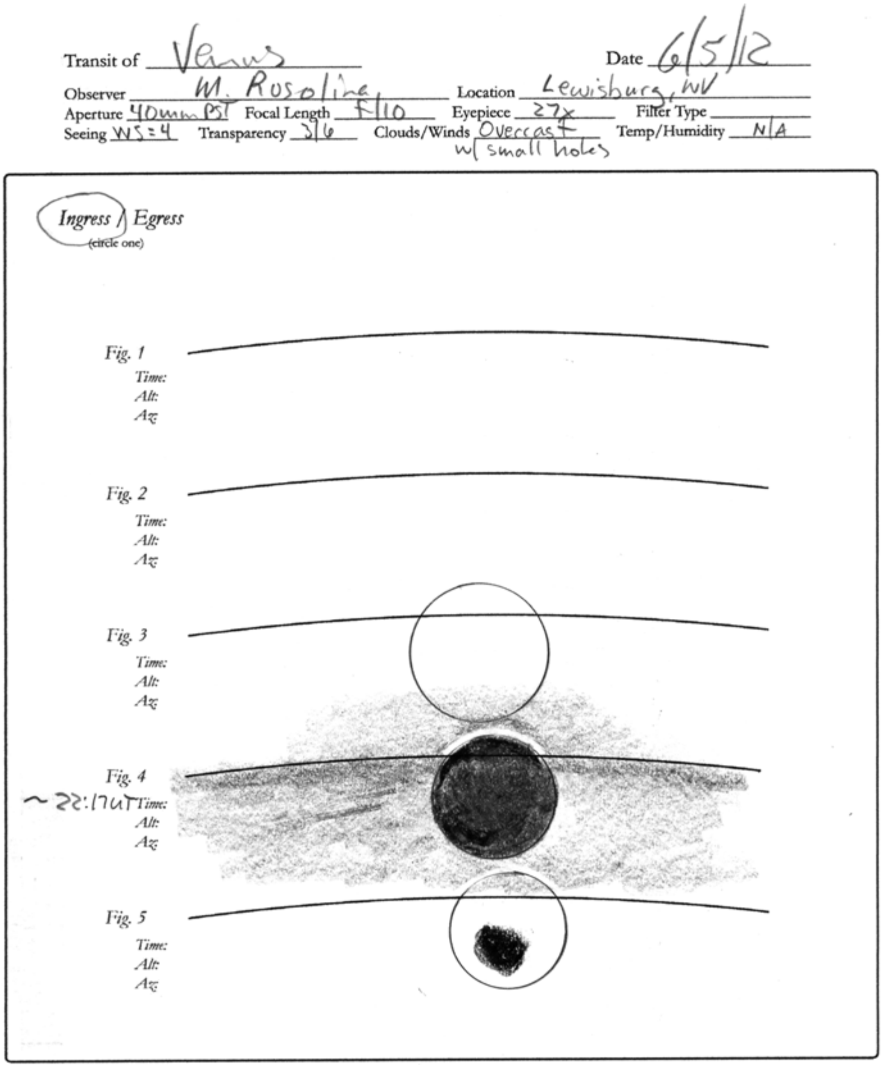


Fig. 8.17 Aureole around Venus between first and second contacts—June 5, 2012, 22:17 UT. Coronado H-alpha PST f/10, 27×. Wilson IV, transparency 3/6, 90 % overcast. Field sketch using a 2B graphite pencil on white paper using a limb ingress/egress template (Courtesy of Michael Rosolina, West Virginia, USA)

Step 6

Add the sunspot groups and complete the prominence drawings to conclude the full disk field sketch (Fig. 8.18).

Warning! ALWAYS use a suitable filter when directly observing the Sun

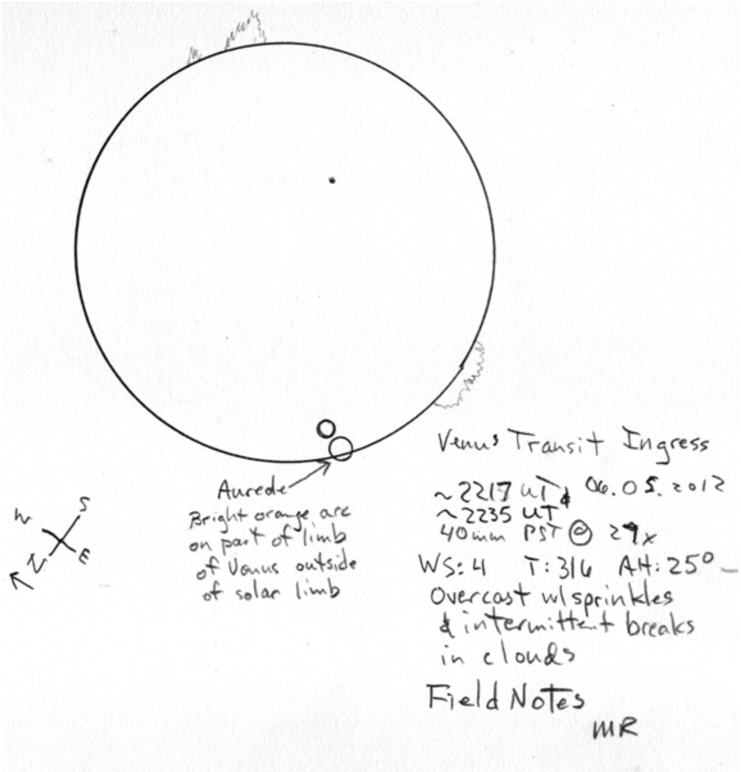


Fig. 8.18 Venus transit ingress—June 5, 2012, 22:17–22:35 UT. Coronado H-alpha PST f/10, 27×. Wilson IV, transparency 3/6, overcast and sprinkles with intermittent cloud breaks. Field sketch using a 2B graphite pencil on white Strathmore Artagain paper (Courtesy of Michael Rosolina, West Virginia, USA)

Final Version of Aureole Drawing

Step 7

In one continuous movement, use the 2B pencil to recreate the curvature of the solar limb on the white acid-free sketch paper. Place the 1-in. circle template in the correct position on the sketched limb and trace around it to create Venus' disk.

Step 8

Finish the sketch by colorizing both the limb and Venus with the colored pencils, similar to the drawing in Fig. 8.19. The orange pencil is used to reproduce the aureole.

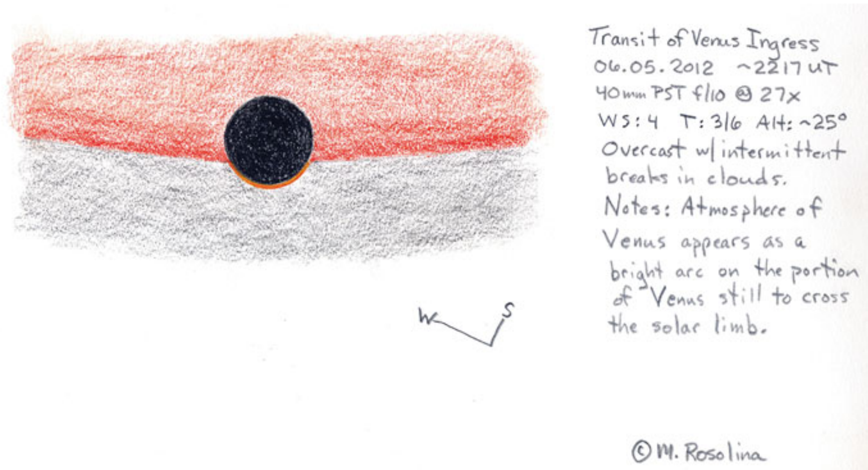


Fig. 8.19 Finished drawing of aureole around Venus based on the field sketch. Koh-I-Noor Hardtmuth colored pencils on white paper (Courtesy of Michael Rosolina, West Virginia, USA)

Final Version of Venus' Position During Transit

Step 9

Use the white colored pencil and the 4-in. template to draw the solar disk on the black paper. Hold the pastel stick flat on its side and fill in the disk. Start just inside the circle's edge and rotate the paper as you work all the way around it before continuing toward the middle of the disk. Blend slightly with your fingertips as a blending stump may remove too much of the pastel layer.

Step 10

The white pastel pencil is used next to render the brightest structures of the prominences, followed by the white colored pencil for the faintest areas. Switch to the black pastel pencil to add the sunspots. If plages are observed, use the white pastel pencil to render them.

Step 11

The black pastel pencil is then used with the 1/8-in. circle template to draw the outline of Venus in its correct position within the solar disk. Fill in the planet's disk with the same black pencil. Add relevant notes and orientation to complete the sketch (Fig. 8.20).

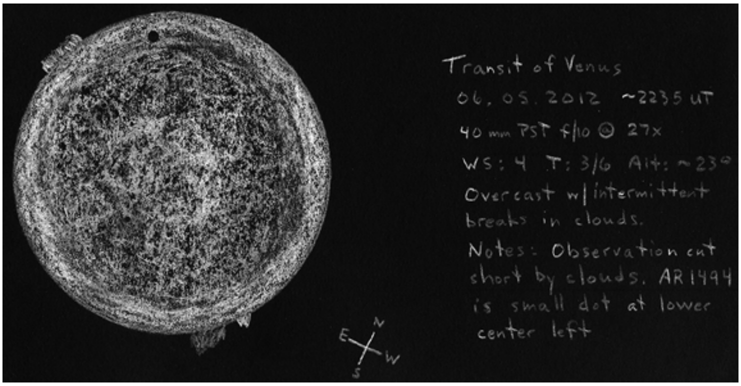


Fig. 8.20 Finished drawing of Venus transiting the Sun based on the field sketch. Black Strathmore Artagain paper, white Conté crayon and pastel pencil, Derwent watercolor pencil, Derwent Graphitint pencil, and a black charcoal pencil (Courtesy of Michael Rosolina, West Virginia, USA)

The digital illustration displayed in Fig. 8.21 was also based on a field drawing and provides another method of recording Venus as it crosses the Sun's limb. Each stage of ingress is clearly represented, from moments just after first contact, to the development of the aureole, and then through to the black drop effect and the next moment as Venus begins its passage across the face of the Sun.

8.2 Satellite Transits

International Space Station (ISS) transits of the Sun are a real treat to witness. The ISS crosses the solar disk in approximately one second for an earth bound observer. Consequently the solar disk should be fully sketched 5–10 min prior to the transit so that the Sun's features can be used as references when recording the satellite's passage.

Preparation is essential in order to capture a satellite transit, so plan well in advance. Several websites, as well as smartphone and tablet applications, are available to help you determine when and where the next ISS transit will occur near your location. Three excellent sources are Heavens-Above, CalSky and GoSatWatch. Heavens-Above is a popular website for tracking satellites, but you will need to compare the observing data for the ISS to that of the Sun to determine transit dates and times.

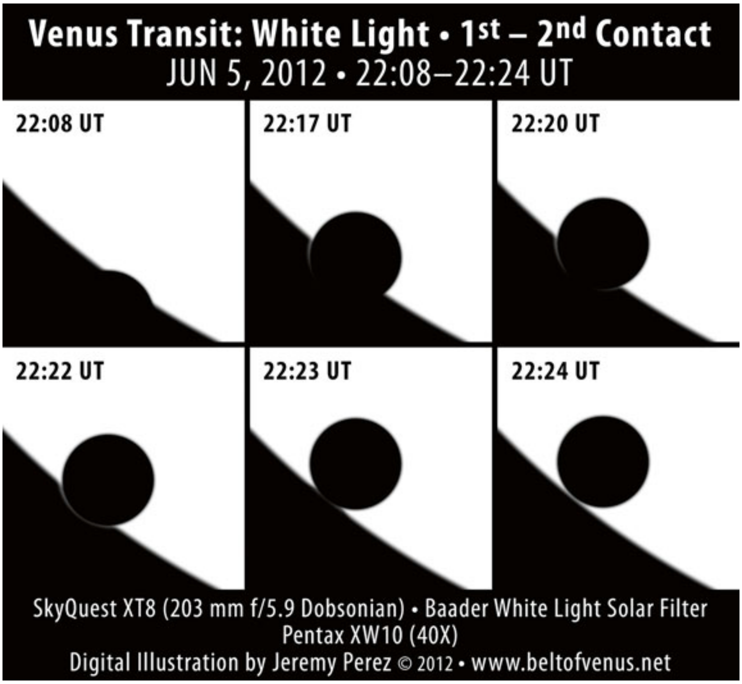


Fig. 8.21 First and second contacts of the Venus transit—June 5, 2012, 22:08–22:24 UT. SkyQuest XT8 Dobsonian f/5.9, Baader white light solar filter, Pentax XW10, 40×. Digital illustration based on a field sketch (Courtesy of Jeremy Perez, Arizona, USA)

CalSky

Arnold Barmettler founded CalSky in 1991. It is a website that offers planning tools and a means to consult scientists and astronomical organizations regarding questions of a celestial nature. Click on *Intro* to set up an account and enter your user site demographics. Then go to *Satellites, Sat-Library* to select which man-made satellite you wish to observe. If you type ISS where it asks for the satellite name or number and then click *Go!*, the program will list every satellite that has "ISS" as part of the name. Scroll down to the ISS information box. To the right of it, select *Transit Centerline*. Adjust the parameters to show the ISS transit path within those parameters. Alternatively, you could choose *Satellites within Interval* at the top page menu to broaden the parameters or to browse for other satellites. Alerts may also be set up so that CalSky can email you with upcoming satellite events. http://www.calsky.com/.

GoSatWatch

This handy application, by GoSoftWorks, is available to purchase for real-time satellite tracking on your iPhone, iPad or iPod touch. It uses multiple orbital data sets from NASA to predict satellite locations. Users can customize the settings such as specific satellites, locations, and alerts. The overhead sky track view is particularity useful within 10–15 min of transit when timing is critical to end the solar sketch and prepare for the observation itself. http://www.gosoftworks.com/GoSatWatch/GoSatWatch.html.

Heavens-Above

Developed and maintained by Chris Peat, Heavens-Above GmbH offers satellite trajectories set against the backdrop of detailed star charts as seen when looking up, and also in orbital view. To use, set the configuration of your observing location, and then choose from the *Satellites* options. For example, 10-day predictions of ISS passes will show the dates, magnitude, times and alt-az positions (start, highest point, and end), and the pass type. http://www.heavens-above.com/.

8.2.1 ISS Transit: White Light Whole Disk (Technique of Alan Strauss)

Although a satellite transit can be viewed in H-alpha or CaK, the clean backdrop of the white light Sun was chosen for this example for an optimal view of the ISS. As with any transient event, begin observing through the eyepiece several minutes before it is due to begin. Either your watch or the ephemeris could be slightly off.

Suggested Materials

- Solar observing form printed on white paper
- HB graphite pencil

Step 1

Using the HB pencil, complete the white light sketch using any of the suggested graphite on white paper techniques found in Sect. 3.1 *Whole Disk* of Chap. 3. The sketch should be completed at least 10 min prior to the transit.

Step 2

When the sketch is finished, refer to the live tracking application if you have it installed on your tablet or smartphone. Have your sketch and pencil ready and begin continuously observing the Sun within a few minutes before the transit is due to occur.

> *Tip*
>
> To catch the ingress, familiarize yourself with the predicted track of the ISS and where its entry should occur in relation to the orientation of the Sun. Doing so will also help you track its line of passage.

Step 3

When the transit begins, try to commit to memory the path that the ISS takes across the solar disk by using the Sun's orientation and active regions as positional markers. Even though its path will be straight during its short transit, the ISS may have a yaw such that it's not actually "pointed" in the direction it is traveling. Look at its shape and relative size compared to that day's sunspots. If the solar disk is blank, use the size of the Sun itself as a comparison. The apparent shape of the ISS (both the main structure and the solar array panels) will vary based on the viewing angle.

Immediately after the transit, lightly mark the positions of ingress and egress near the edge of the solar disk. Next, draw the ISS the best you can from memory, then add lines on either side of it to depict the direction of movement and transit path. Add relevant notes from your observation to conclude the sketch (Fig. 8.22).

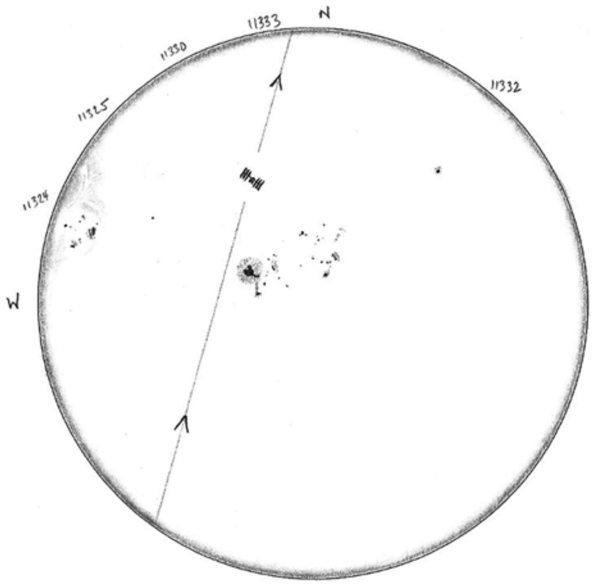


Fig. 8.22 ISS transit—October 28, 2011, 20:39 UT. Refractor 102 mm f/11 equipped with a Lunt Solar Systems Herschel Prism, Baader Planetarium Hyperion 8–24 mm Mark III. HB graphite pencil on white printer paper (Courtesy of Alan Strauss, Arizona, USA)

Chapter 9

Eclipses

The Sun offers dramatic views with each observation, but little compares to a solar eclipse when the new Moon passes directly between the Sun and Earth. Annular and partial eclipses are a sight to behold—but totality is the grandest of all (Fig. 9.1).

Planning and preparation are essential for success while sketching these fast-paced events. Determine where you plan to observe, months or even years in advance, so that travel arrangements can be made for you and your equipment.

Closer to the date, check your gear and watch for updates on the weather. Familiarize yourself with each phase of the eclipse and jot down the times they will occur as well as how long they will last. During this time, you should prepare your sketch kit. Include extra of the medium you plan to use and draw circle templates on the paper in advance to save time the day of the event. Visit the observing location to choose a spot with low horizons and unobstructed views.

Tip

One or two days before the eclipse, decide how far apart time wise you would like your sketches to be. White light sketches are usually less detailed without the filaments, plage, and prominences that are seen through a narrowband filter, and therefore faster to draw. Plan accordingly.

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical Astronomy Series 178, DOI 10.1007/978-1-4939-2901-6_9

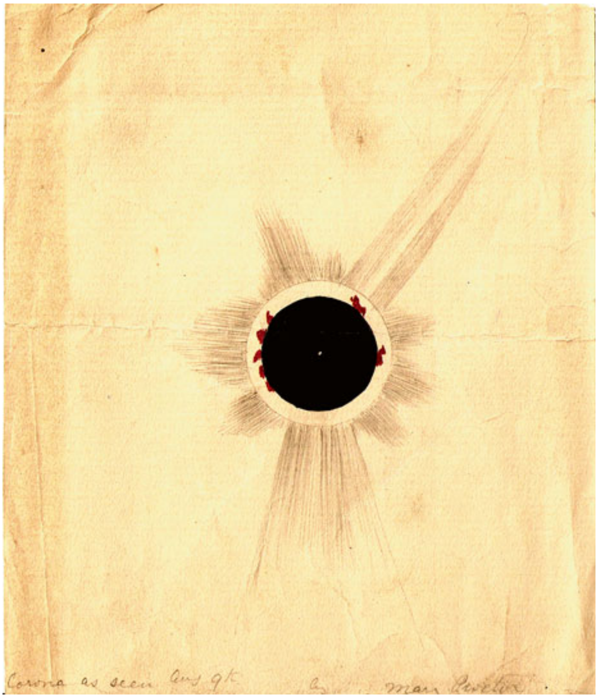


Fig. 9.1 August 9, 1896, solar eclipse drawing by Mary Proctor (1862–1957) using a compass, pencil, and a pen with red and black ink on paper. This sketch depicts totality during a solar eclipse viewed onboard a ship anchored near Bodø, Norway. Proctor prepared the image by first inscribing the *circle* for the occulted solar disk using a compass and pencil. The disk may have been colored in *black* next, or possibly even prior to the event. The coronal streamers were then drawn, followed by the solar prominences, which were painted in watercolor directly without under drawing in pencil. The *black* watercolor overlays the pencil; the *red* watercolor overlays the *black* (Image courtesy of the Royal Astronomical Society of Canada)

Finally, on the day of the eclipse, arrive at the observing site early enough to assemble your equipment, align the telescopes, and situate your workspace for easy access. All elements should be in place well before the eclipse begins.

9.1 Total Solar Eclipse

9.1.1 Total Eclipse Sequence (Technique of Serge Vieillard)

Serge Vieillard observed the November 2012 total solar eclipse with his astronomy club, Magnitude 78, on the path's central line north of Cairns, Australia. The choice of location was based on meteorological statistics to maximize their chances of success.

There are several phases of an eclipse, so consider using more than one type of telescope during its course. For instance, a wide-field refractor fitted with a white light filter could be used to document the partial phases leading up to, and following, totality. The filter would then be removed only during the initial brief moments of totality to record the full tenuous extension of the corona.

For the remaining moments of totality, a second telescope of longer focal length and higher power could be employed to reveal the delicate details of the solar limb. These include prominences, spicules, and more depth within the coronal extensions.

Keep in mind, though, that the viewed orientation between the two telescopes may not be the same. Identify their differences beforehand so that you'll be prepared during the eclipse.

The sketch kit should be minimal, so choose reliable materials that you have mastered and feel comfortable with. The media listed for this tutorial provide a successful combination to rapidly capture the event. By using graphite on white paper near totality, a negative sketch is produced. This means that the darker the applied graphite, the brighter the feature when digitally inverted. A green color pencil is used for prominences because it turns magenta after inversion.

Tip

Practice sketching solar eclipses using photos or video recordings made publicly available on the Internet. This will develop a sense of the timing and the speed required to record the event progression, and also the complexity of the details you can expect to observe versus what you can hope to document. This exercise should be repeated many times until you achieve satisfactory results and will be valuable preparation for those transient moments of totality.

Stick to what works best for you. The day of the event is not the time to improvise with equipment or techniques.

Suggested Materials

- White sketch paper, 75 1b. (200 g/m^2), several sheets pre-drawn with 2-in. and 4-in. diameter circle templates
- HB graphite pencils, two or three, sharpened
- Green color pencil
- Eraser, plastic or rubber
- Clipboard(s)

Step 1

Partial phases leading to totality are unique and can be quite stunning. Although you'll want to keep track of the time, they can drawn at a more leisurely pace and provide a more thorough account of the entire event.

With a proper solar filter in place, use a graphite pencil to record each phase onto the pre-drawn set of 2-in. diameter circle templates. Each eclipse notch and any sunspots should be included as well as rendering the effects that atmospheric turbulence may have along the solar limb. Prominences and other chromospheric features should be added if using a narrowband solar filter during your observation. As seen in Fig. 9.2, the first phase drawing included the beautiful view of the sunrise partial eclipse behind a cloud band lying just above the horizon.

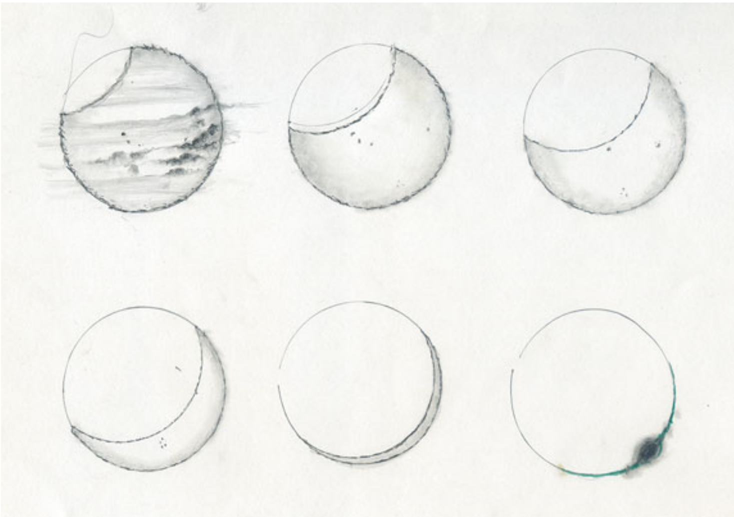


Fig. 9.2 Total eclipse—November 13, 2012, near Cairns, Australia. Sketch sequence of the partial phases leading to totality using a fully opened polyamide filter and 2-in. diameter circle templates (Courtesy of Serge Vieillard, with the permission of Axilone, publisher of the book *ASTRODESSIN, Observation and dessin en astronomie*)

Warning!

When sketching with an unfiltered telescope, it is of paramount importance that all precautions are taken to avoid the intense rays of the photosphere. Blindness or severe eye damage can occur when totality is just beginning or ending, especially if the timing is not known precisely. This is difficult because it takes complete understanding and judgment as to when the solar intensity drops to a point, or does not exceed a point, when your eyes are in peril. After totality, immediately cap all unfiltered scopes to avoid accidental eye damage.

Step 2

Remove the solar filter just moments before second contact. Meanwhile, enjoy the last magenta grains of Baily's Beads (drawn in green) and the Diamond Ring (drawn with graphite).

Step 3

As totality begins, switch to the paper that has the pre-drawn 4-in. diameter circle template. Because totality often lasts only a very brief 2 min or so, maximize the observing time at the eyepiece and commit the view to memory. Identify each detail, its position on the solar limb, shape, texture, size, and brightness. Observe the Sun's regions in sequential order—the eastern solar limb, the polar regions, and then the western limb just before the Sun reappears. Remember that the appearance of the chromosphere and lower corona depends on the proximity of the Sun behind the lunar limb.

Pay special attention to the polar regions for the faint filamentary tendrils of the corona. Due to the complexity and subtlety of the corona, divide your time spent with each telescope during the brief observing window. Start with the wide field telescope for the initial view before switching to the high-powered telescope for the finer details.

Only a quick outline sketch is created during the actual observation of totality. Your eyes become more adapted to the darker view over time, so the additions of the furthest coronal extensions are reserved for the end.

Step 4

Immediately after totality, cap the telescope, and then use the graphite pencil to incorporate the details of your observation into the sketch outline while they are still fresh in your memory. This step should take no longer than 10–15 min and

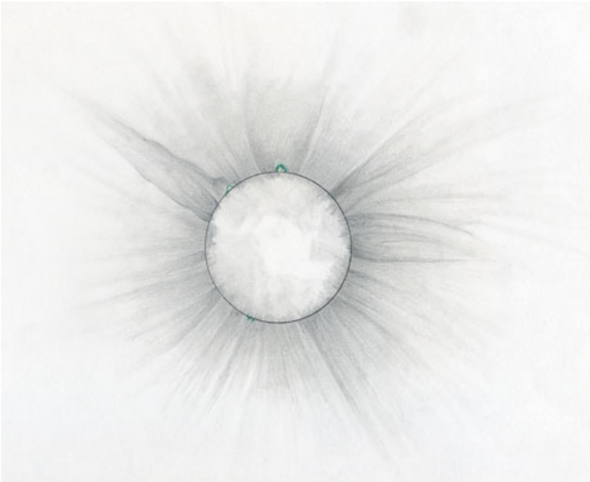


Fig. 9.3 Total eclipse—November 13, 2012, near Cairns, Australia. This sketch was created seconds after totality while the filamentary details were still fresh in memory. An 80 mm refractor was used during the first 90 s of totality, followed by 15 s with a 16-in. reflector and 22 mm TeleVue Nagler eyepiece to capture structure within the lower corona. HB graphite pencils, green color pencil, white paper with a 4-in. diameter circle template (Courtesy of Serge Vieillard, with the permission of Axilone, publisher of the book *ASTRODESSIN, Observation and dessin en astronomie*)

requires a high level of concentration to recall and render the vivid details of the observation from memory before they fade. Remember to use the green color pencil to depict the prominences (Fig. 9.3).

Tip

During totality, observation and memory should guide the hand rapidly with intent on capturing the fleeting details, so the least amount of close inspection or correction of the sketch maximizes the precious observing time. If an errant stroke is noted, correct it after the event, when time is no longer an element.

Step 5

The completed field sketches can now be scanned or photographed. Using image-editing software, stray markings and smudges are removed and the negative drawings can be inverted to positive format and colorized.

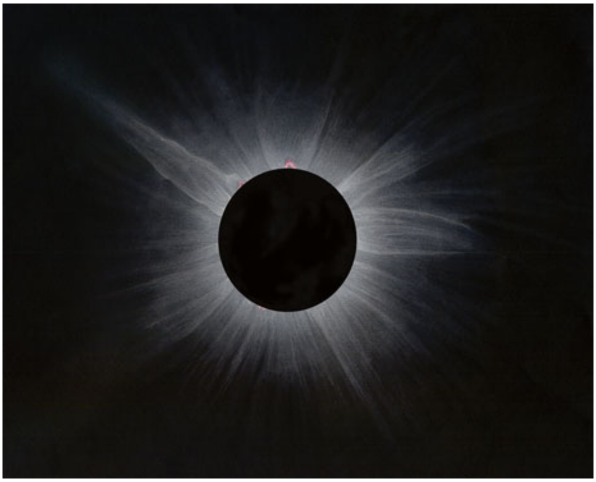


Fig. 9.4 Total eclipse—November 13, 2012, near Cairns, Australia. Totality after the sketch was scanned and processed with photo-editing software (Courtesy of Serge Vieillard, with the permission of Axilone, publisher of the book *ASTRODESSIN, Observation and dessin en astronomie*)

Figure 9.4 shows the inverted scanned sketch of totality. The final colorized versions are digitally combined to create a beautiful montage, as shown in Fig. 9.5.

9.2 Partial Solar Eclipse

9.2.1 Partial Eclipse Sequence (By Erika Rix)

One method of recording a partial solar eclipse is to complete a full drawing before starting another, as demonstrated with Serge Vieillard's total eclipse technique. Another is to use the same base sketch for the entire event. This method is particularly useful if you plan to record the progression of the eclipse in smaller increments. During periods of high solar activity, a single Hydrogen-alpha full disk sketch would take too long to draw, not to mention several in a row for an eclipse sequence.

Normally, a minimal sketch kit should be used for this type of event. But because only one base drawing is produced for this technique, there is no reason why you should forgo your preferred media. My typical sketch kit for rendering the chromosphere in the H-alpha wavelength is listed under *Suggested Materials.*

During the progression sequence, you can either draw the arc of the Moon's limb freehand or with a circular template. The diameter of the template should be proportionate to the apparent diameter of the Moon's silhouette in front of the Sun.

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 9.5 Total eclipse—November 13, 2012, near Cairns, Australia. Montage of the processed sketches (Courtesy of Serge Vieillard, with the permission of Axilone, publisher of the book *ASTRODESSIN, Observation and dessin en astronomie*)

Suggested Materials

- Black drawing paper suited for soft pastels, 60 lb. (160 g/m^2), several sheets
- Charcoal or pastel stick, black and white
- Charcoal or pastel pencil, black and white
- White color or watercolor pencil
- Black oil-based color pencil
- 6-in. circular protractor
- Vinyl eraser pencil, sharpened with a craft knife
- Drawing board
- Camera and tripod to photograph each phase on your base sketch

Once you arrive at the observing location, set up your camera and tripod. When photographing your sketch sequence, the camera and paper will need to squarely face each other so that the photographed solar disk remains circular rather than elliptical. My tripod head can be adjusted so that the camera faces the ground. I place my drawing board on a step stool underneath it when taking photos of my sketches.

Step 1

An hour or more before the eclipse begins, create a full disk sketch of the Sun. Refer to Chap. 5—*Whole Disk, Mixed Media on Black Paper (by Erika Rix)* to review the H-alpha technique that uses the same suggested materials (except for the black pastel stick) listed in this section. Otherwise, use the media and technique of your choice.

If your camera is equipped with an image monitor, take a photo of your sketch and then review it with the play back button. Check the focus, the exposure, and that the solar disk is circular. Make any necessary adjustments before proceeding to the next step.

Step 2

Notice in Fig. 9.6 that four lines are placed outside of the solar disk. These represent the orientation as seen through a Coronado Maxscope on a German equatorial mount. East is at the lower left; north is at the lower right. Using the four points of

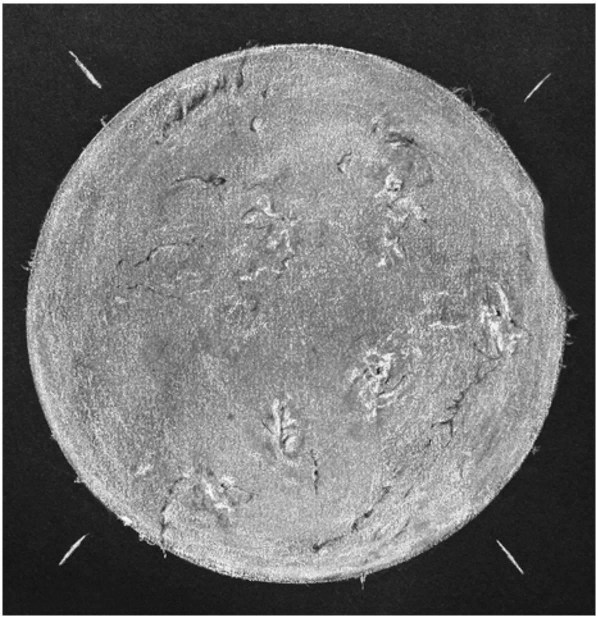


Fig. 9.6 First contact was recorded with a black charcoal pencil (By Erika Rix)

orientation along with the added solar features provides references when marking the Moon's movements onto the drawing. Mark your orientation view on the sketch.

Once first contact occurs, note the time outside of the sketch area. Then use a black charcoal pencil to create an indent on the disk to indicate its location. Pay particular attention to where it falls within nearby prominences or other solar features.

Take a photo of the sketch (or two or three if you use auto focus). Work quickly to stay on schedule. My sequences were 5 min apart. That meant that as soon as I took the photo, I went straight back to the eyepiece to record the next progression.

Step 3

The Moon had advanced far enough across the Sun that it was necessary to use the flat edge of a charcoal stick to draw it rather than the pencil. Lay the stick on its side, and with one fluid movement, create the black arc. Again, cross-reference its position with nearby prominences and solar disk features.

If the shade of your charcoal doesn't match closely with the black paper, as seen in Fig. 9.7, blend for a smooth transition. If desired, you can adjust the blending further with photo editing software when the event is over.

Note the time and take a photo.

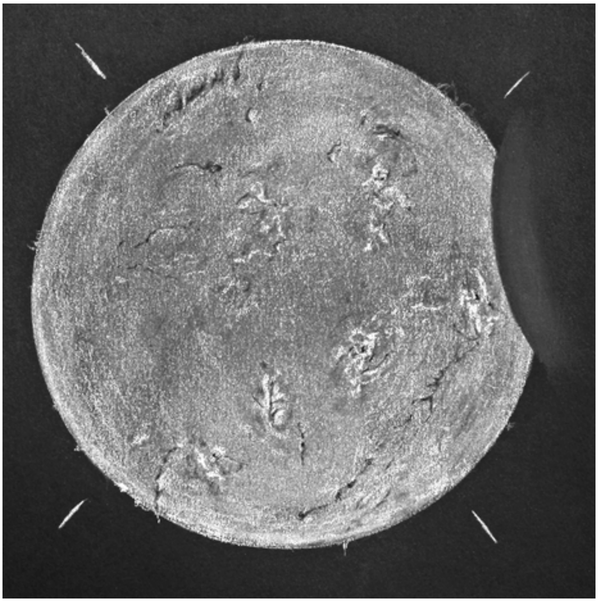


Fig. 9.7 The same base sketch is used for the duration of the eclipse. A stick of black pastel was used to draw the phases and then blended (By Erika Rix)

Step 4

Repeat *Step 3* until the eclipse ends, or the Sun dips below the horizon. The view becomes darker nearer sunset. To translate that effect into your sketch, use a tissue or your fingertips to lightly dab and brush away excess white pastel from the solar disk in your sketch. Alternatively, a stick of charcoal could lightly be rubbed into the disk to darken it. Try not to smear the solar features while doing so.

Step 5

The photographs can be processed in photo editing software by cropping and arranging them into a compilation. Figure 9.8 is the final sequence using only one sketch as the base for the entire event.

Draw two

For a slightly different approach, draw two full disk sketches before the eclipse starts. One is used during the event; the other is used to recreate it (Fig. 9.9).

A 6-in. circular protractor was used as a solar disk template for both drawings. The same protractor was used with a black oil-based pencil to outline the Moon's movements during the eclipse. In hindsight, I should have used a smaller template. During this particular eclipse, the Moon was near apogee and had an angular size of 0.49°. The Sun's angular size, by comparison, is 0.53°.

The date, the start time, and the orientation were noted first. Then in 5-min intervals, the subsequent times and positional arcs were drawn on the disk (Fig. 9.10).

When the session ended, I created a smaller circular template to represent the Moon using a piece of heavy black drawing paper. My error was not calculating the correctly scaled size for the Moon. I underestimated it, but next time, I'll be better prepared!

Placing both sketches side by side, the eclipse sketch was used as a reference while recreating the event using the second sketch with the black lunar template. With each 5-min progression interval, the lunar template was placed on top of the second drawing in its corresponding position. A photograph was taken of it before advancing the template to the next interval (Fig. 9.11).

Once the photo series was completed, the images were processed in Adobe Photoshop and presented as a montage (Fig. 9.12).

Each sketching session is a learning experience. I wanted to capture an H-alpha view of this eclipse due to the high level of solar activity that day. This meant experimenting with a few techniques that allowed me to both record the chromospheric details *and* accurately plot the eclipse progression.

Figures 9.13 and 9.14 provide examples of other techniques and media used to capture partial eclipses.

Warning! ALWAYS use a suitable filter when directly observing the Sun

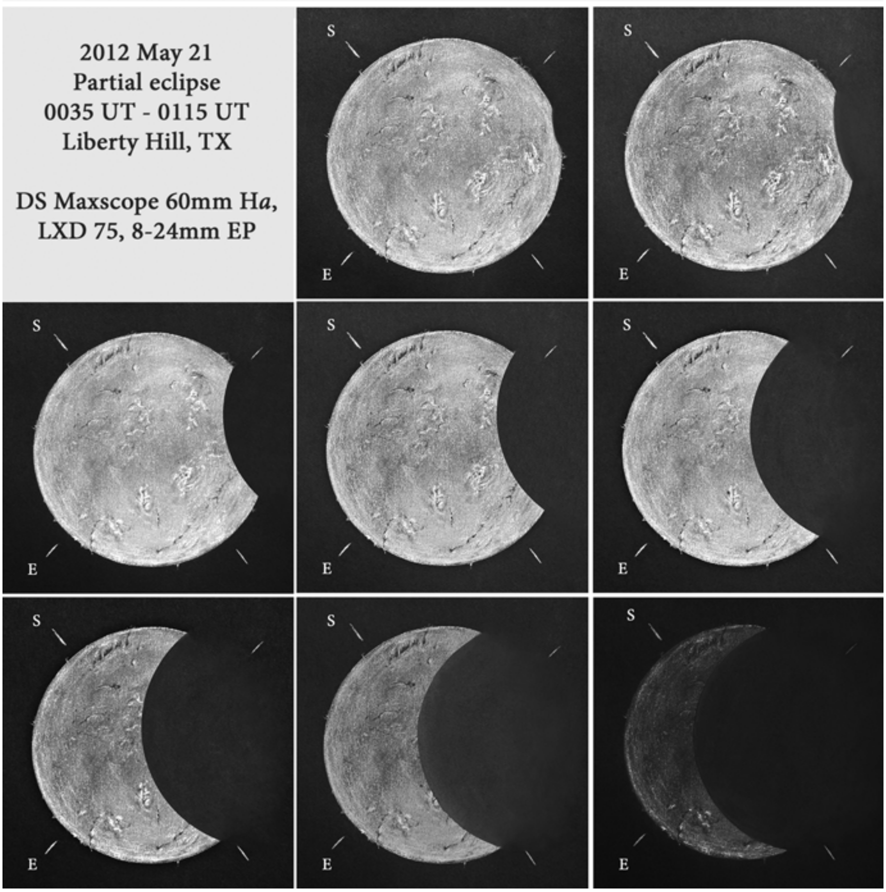


Fig. 9.8 Partial eclipse and active regions 1478, 1479, 1482, 1483, 1484, and 1486—May 21, 2012, 00:35–01:15 UT, near Liberty Hill, Texas. Observed through an internally double-stacked Coronado Maxscope 60 mm H-alpha telescope mounted on an LXD75. A single base sketch was created so that the Moon's progression could be recorded in stages by photographing the evolving sketch (By Erika Rix)

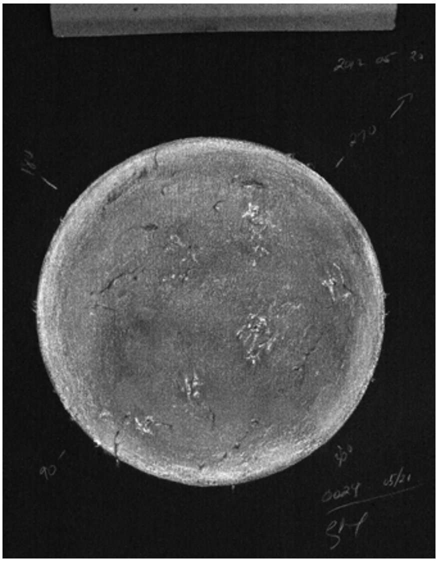


Fig. 9.9 Base sketch of the Moon near apogee prior to first contact (By Erika Rix)

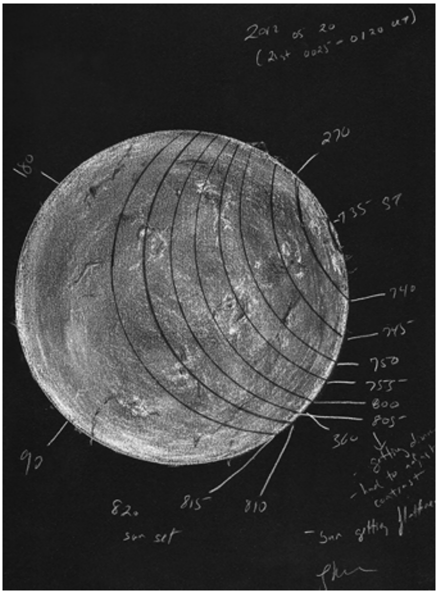


Fig. 9.10 Time and positional markings were recorded onto the sketch during the eclipse (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

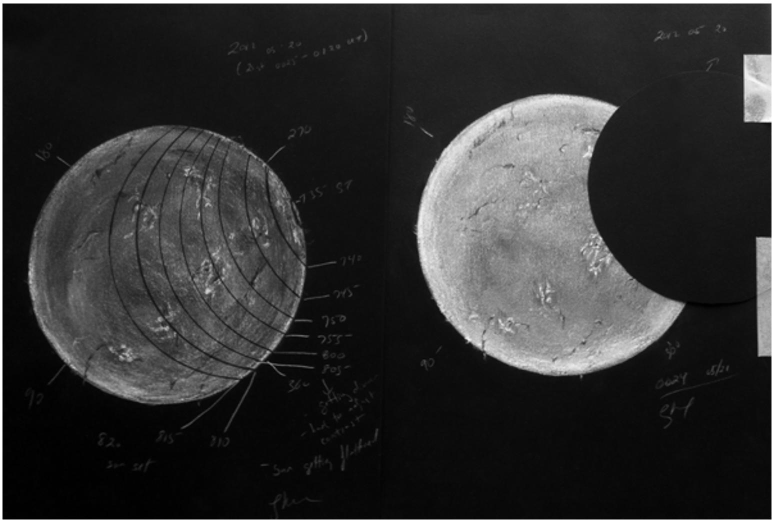


Fig. 9.11 Both sketches were drawn at the eyepiece just prior to first contact. The drawing on the *left* was used to mark the times and positions of Moon's movements in 5-min increments. A Moon template was then used with the drawing on the *right* to recreate the event with a series of photographs (By Erika Rix)

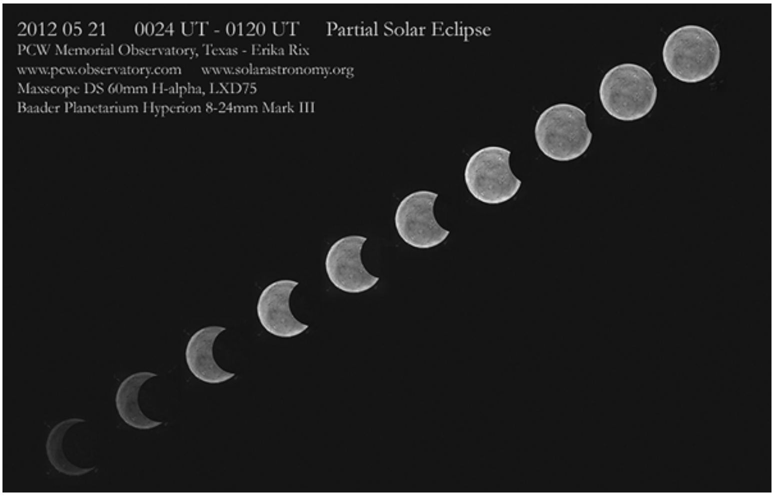


Fig. 9.12 This montage was created using two sketches, one to mark the times and positions of the eclipse progression, the other to recreate the eclipse sequence after the event ended. Partial eclipse—May 21, 2012, 00:24–01:20 UT, near Liberty Hill, Texas. Observed through an internally double-stacked Coronado Maxscope 60 mm H-alpha telescope mounted on an LXD75 (By Erika Rix)

Fig. 9.13 May 28, 1900, solar eclipse drawing by A. E. Weatherbe (1890–1940) as seen from Foote's Bay, Muskoka, Ontario. The medium was pen and ink on birch bark. Wood is a particularly unforgiving medium as it does not permit easy correction. However, ink on bark makes for an attractive, unique presentation (Image courtesy of the Royal Astronomical Society of Canada)

Fig. 9.14 Partial eclipse—August 1, 2008, 10:00 UT. Observed in H-alpha using TeleVue Pronto refractor fitted with a Coronado SM40/BF10. Watercolor pencil on *black* Canford paper (By Sally Russell)

Warning! ALWAYS use a suitable filter when directly observing the Sun

Chapter 10

Animations

Due to the Sun's dynamic nature, it is in a constant state of flux. Active regions exhibit morphological changes as they slowly traverse across the solar disk, yet prominences can develop and decay during the course of a single observing session. Transient events, such as solar flares, can take place in a matter of minutes.

When a sequence of solar sketches is made over several minutes, hours, or even days, it is possible to show how the Sun's features evolve with time. If more than one filter type is used throughout the sequence, their contrasting views can be showcased by combining sketches. For example, a series of sketches could begin with a zoomed-in view of a prominence eruption or an active region flare in Hydrogen-alpha, and then the progression of that region throughout its course could be followed in white light.

As if solar sketching isn't exciting enough, the sketch sequences can be assembled and brought to life through animation! This chapter provides an introduction to common animation techniques. Follow the step-by-step processes, and you will soon be able to create your own with ease.

10.1 MakeAGif

MakeAGif is a free web-based application in which an animation GIF can be made in three easy steps. Once it is created, the GIF is readily available on the MakeAGif site with an option to download it directly to your computer. Registration is not required, although there are perks if you do. They include having access to your own gallery and the ability to delete a file without sending a request to the site administrators.

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical Astronomy Series 178, DOI 10.1007/978-1-4939-2901-6_10

The only caveat of the application is that the images cannot be positioned or manipulated separately as with more advanced programs. You can, however, adjust the size of the stacked images by cropping or stretching them to the smallest or largest image of the set. You can also customize the pixel dimensions (http://makeagif.com/).

10.1.1 The Three Easy Steps of MakeAGif (By Erika Rix)

Step 1

In the area marked *Pictures to Gif Maker*, click on *add pictures*. Select the images you wish to animate. Click *open*.

Step 2

Scroll down to *Select the order you want the pictures to appear in*, and then rearrange them with your cursor. Press *continue*.

Step 3

Under *Customize your gif and animate*, select from the following options:

Animation Speed	Hover your cursor over the tab to choose a speed.
Resize Your Images	The images can be resized or cropped as a set.
Choose a Category	Select which category the GIF is most suited for.
Gif Details	Name the GIF and include tags.
Rating	The GIF can either be public or private, and suitable for all ages or 18+ only.

And lastly, click on *create your gif*.

10.1.2 Active Region Two-Day Comparison (By Erika Rix, Sketches By Sally Russell)

GIFs can be made with as little as two highly-detailed drawings of active regions. It's easier to understand how the magnetic field activity moves through those regions when the two drawings alternate over each other during an animation.

Figure 10.1 is of AR 756 on May 1, 2005, from 14:20–15:30 UT. The following day from 10:05–11:15 UT, the active region was sketched again to record its

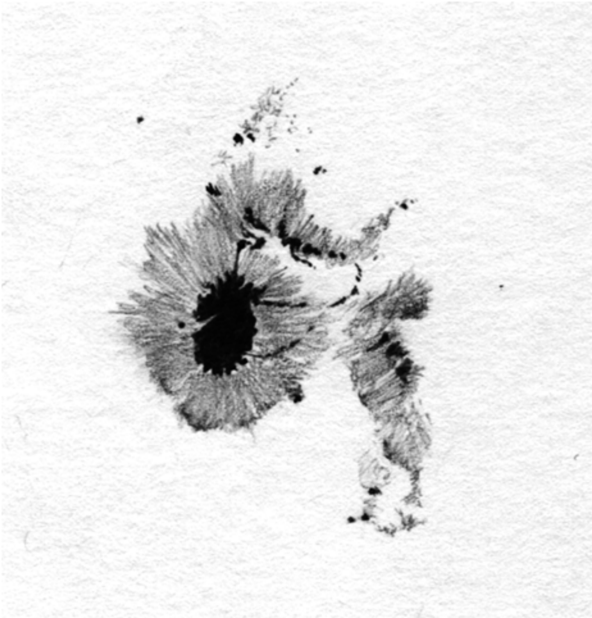


Fig. 10.1 Active region 756—May 1, 2005, 14:20–15:30 UT. 105 mm f/6 refractor fitted with a Kendrick solar filter, 9 mm eyepiece and Barlow, 130×. Graphite on white paper. (By Sally Russell)

changes, as seen in Fig. 10.2. The same equipment configuration and sketch media were used during both observations for comparable results. Refer to Chap. 3—*White Light Filters*, Sect. 3.2 *Active Regions, Graphite (by Sally Russell)* for step-by-step instructions on the sketching technique that was used.

Step 1

Because the sketches could not be positioned or rotated manually within the MakeAGif application, I used image-editing software to determine if they aligned well with each other. To do this, the images were stacked by duplicating one onto the other to create two layers, one of each sketch. The opacity of the top layer was reduced so that the bottom layer could be viewed at the same time.

Step 2

I slightly rotated the top sketch, and then positioned it over the lower one until the largest umbrae of both images were centered and the penumbrae aligned well. The opacity of the top layer was set back to 100%.

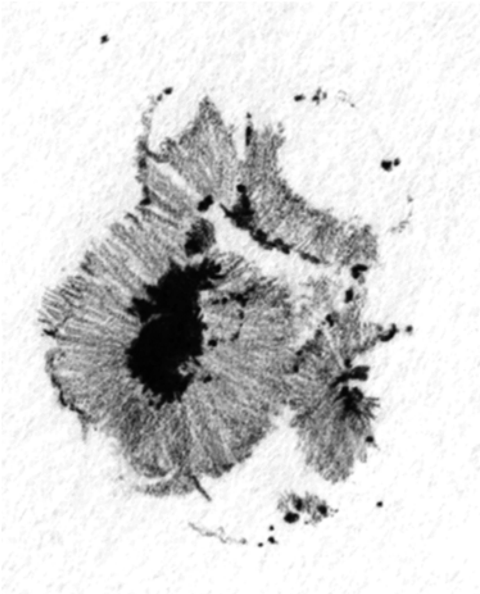


Fig. 10.2 Active region 756—May 2, 2005, 10:05–11:15 UT. 105 mm f/6 refractor fitted with a Kendrick solar filter, 9 mm eyepiece and Barlow, 130×. Graphite on white paper. (By Sally Russell)

Step 3

Next, the pair were cropped as one unit, and then separated to produce two images that were suitable for a smooth animation. See Sect. 10.2 *Adobe Photoshop* in this chapter for detailed information on preparing sketches for animation.

The original two sketches were nearly in perfect alignment, so little adjustment was necessary. When planning for your GIF, keep in mind that the drawings will need to be similar in size and position for a smooth animation. It may help to place one sketch under the other to use as a guide, or hold both sketches side by side when rendering the new observation.

Step 4

Following the three easy steps of MakeAGif, the animation was created and can be viewed at http://makeagif.com/i/Qo1M2d.

10.1.3 *Whole Disk White Light and Hydrogen-Alpha Comparison (By Erika Rix)*

Comparing the white light and H-alpha views provides us with a better understanding of the magnetic network and how it permeates the Sun's atmospheric layers. Any combination of filters would work for this technique.

Step 1

A 6-inch circular protractor was used to draw the solar disk for both observations so that minimal alignment adjustments would be needed for the animation (Figs. 10.3 and 10.4). The images were scanned and stacked in Adobe Photoshop CS6. So that the underlying layer could be seen, the opacity of the top layer was reduced, which then enabled me to align the active regions by rotating the top image.

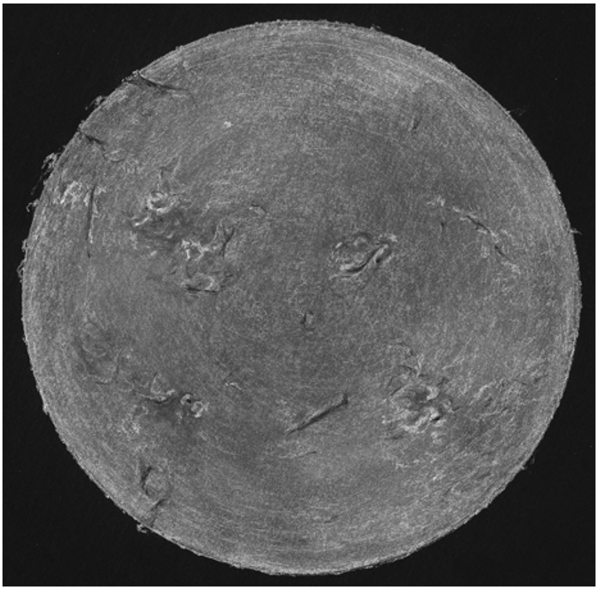


Fig. 10.3 The Sun in H-alpha—November 14, 2012, 1430 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75, Baader Planetarium Hyperion 8-24 mm Mark III, 50×. Black Strathmore Artagain paper, white Conté crayon and pastel pencil, white Prang pencil, black oil pencil, and black charcoal pencil. (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

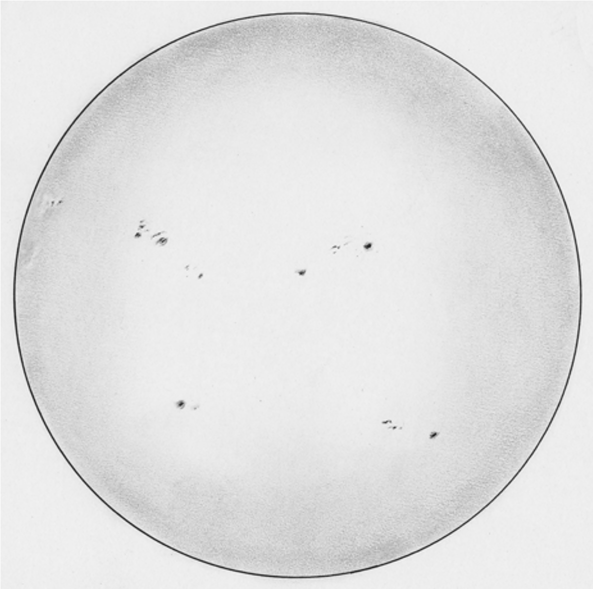


Fig. 10.4 The Sun in white light—November 14, 2012, 13:22 UT. Celestron Omni XLT 102 mm f/9.8 refractor, LXD75, Thousand Oaks glass white light filter, Baader Planetarium Hyperion 8-24 mm Mark III, 83×. White card stock, black Faber-Castell PITT artist pen S, charcoal pencil, and black oil-based pencil. (By Erika Rix)

Step 2

The stacked images were cropped before changing the opacity back to 100%, and then separated once more to be saved as JPEG image files. See Sect. 10.2 *Adobe Photoshop* in this chapter for detailed information on preparing sketches for animation.

Step 3

An additional JPEG was created by duplicating the image of the white light sketch into a new destination document. Text was added for the date and active regions labels (Fig. 10.5).

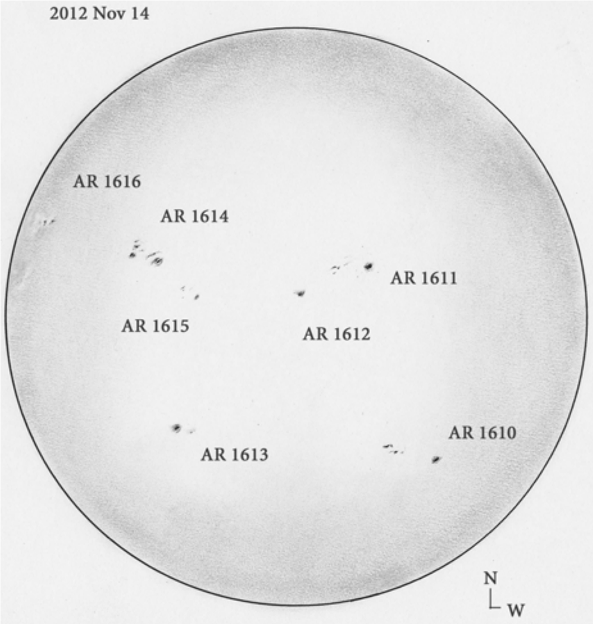


Fig. 10.5 A labeled version of the white light sketch is used as the third image for the GIF. (By Erika Rix)

Step 4

After using the three easy steps of MakeAGif, the animation of the filter comparison was created and can be viewed at http://makeagif.com/i/oZyE8v.

10.2 Adobe Photoshop

Adobe Systems Incorporated is one of the leading developers of digital imaging and photo editing software. Photoshop allows raster images to be edited and composed in multiple layers, which makes it perfect for preparing scanned sketches for animations. Adobe has several products to choose from depending on your needs. Adobe Photoshop CS6 was used to demonstrate the techniques provided in this section (http://www.photoshop.com).

10.2.1 Tracking Active Regions (by Erika Rix)

The morphological changes of sunspots that occur over an extended period of time can easily be seen when sequences of daily full-disk active region drawings are produced and then animated. Refer to Chap. 3—*White Light Filters*, Sect. 3.1 *Whole Disk, Daily Sunspot Tracking (by Erika Rix)* for step-by-step instructions on how to produce this type of sketch sequence.

Figure 10.6 is one of the unprocessed sketches taken from a 17-day sequence that was drawn October 14 through October 30, 2014. A 6-in. circular protractor was used to create the solar disk for each sketch. Limb darkening and faculae were purposely omitted during the sketching process, which allowed the disk to remain uncluttered so as not to detract from the changes that were occurring within the sunspot groups.

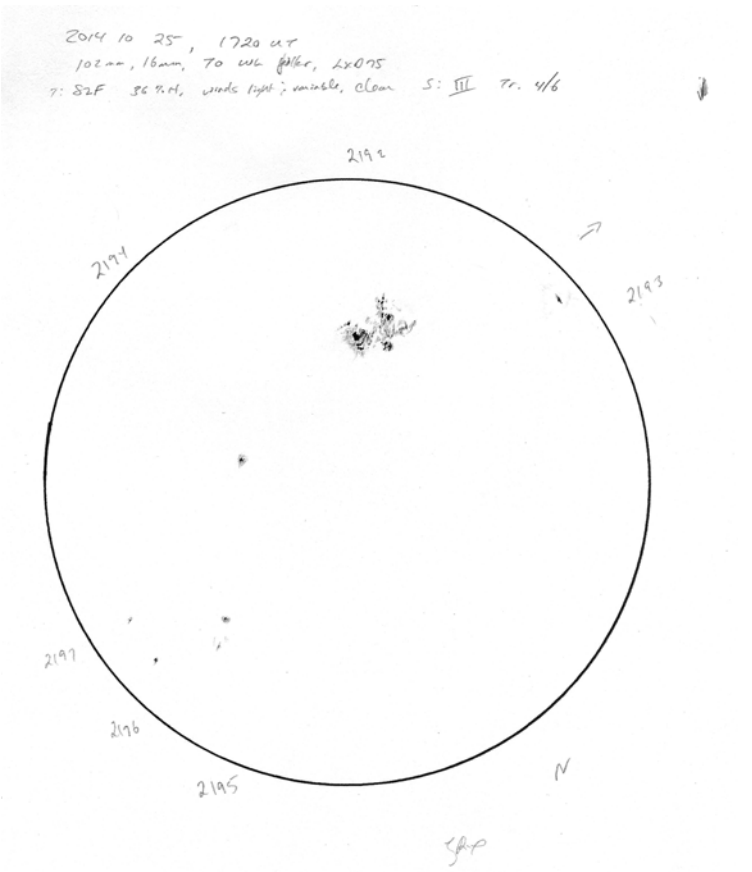


Fig. 10.6 Full disk sketch before processing with Adobe Photoshop CS6. (By Erika Rix)

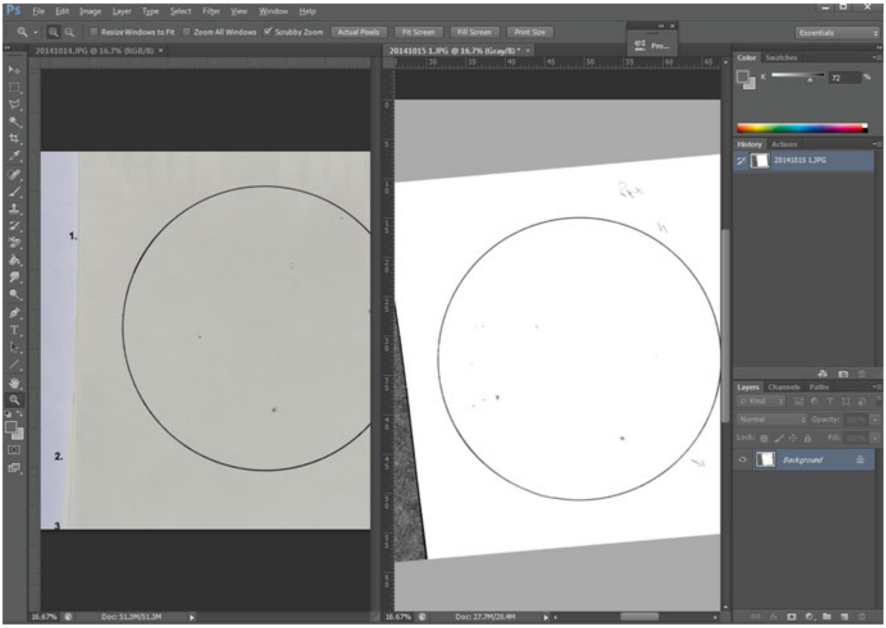


Fig. 10.7 Use a side-by-side arrangement to match the contrast and brightness levels of both images. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

Preparing the Sketches

Step 1

After scanning and saving the sketches to your computer, open the earliest two drawings in Photoshop. At the top menu bar, click on *Window, Arrange,* and then *2-up Vertical* so that the sketches can be viewed side by side (Fig. 10.7).

Step 2

Adjust the two sketches so that they are similar in brightness and contrast. Use the cursor to click the tab above the sketch, and then select *Image, Adjustments, Exposure* to adjust the exposure, offset or gamma-correction settings. If preferred, *Levels* or *Curves* may be used.

Next, stack the two images by clicking on the tab above the second sketch and then selecting *Layer, Duplicate Layer* to rename and add it to the first document destination (20141014.JPG in Fig. 10.8). The second sketch will now show as a stacked layer within the image of the first sketch. Select *Window, Arrange,* and then *Consolidate to One Tab* so that the screen reverts back to one view.

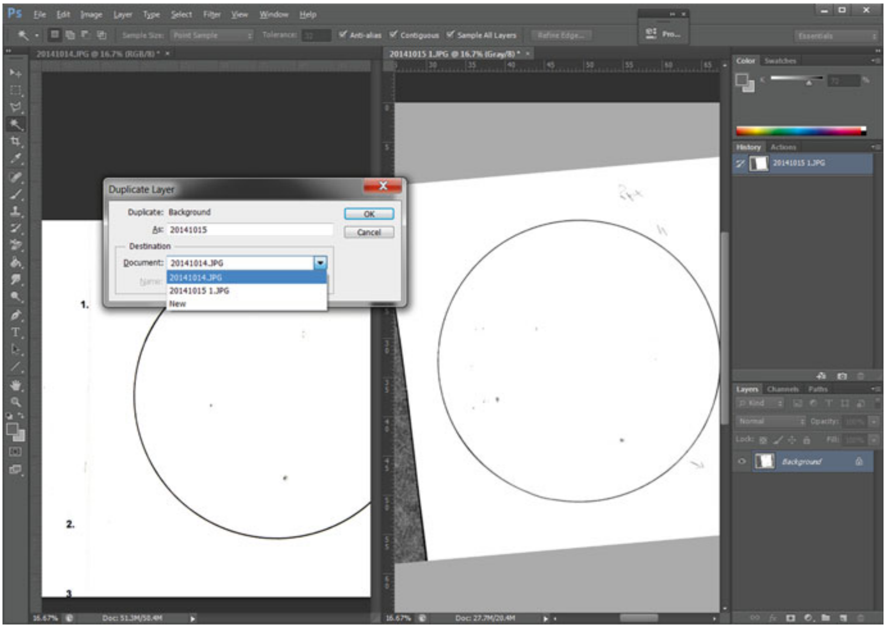


Fig. 10.8 Duplicate the image layers to produce a stack of images in one destination file. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

Step 3

Click on the tab above the first sketch (that now includes the second one), and then click on the new layer that is located within the *Layers* dialog box. Adjust its opacity so that the underlying layer can also be seen (Fig. 10.9). Use the *Move tool* to position the images over each other so that both circles are aligned. Then select *Edit, Transform, Rotate*. Move your cursor to one corner of the selection area (the outer box) to rotate the top layer until the orientation matches between the two. The sunspots should show a progression from one image to the next. Leave the opacity reduced for now.

Step 4

Save the file as a PSD so that the layers will remain separate for future use. Repeat the process described in steps 1 through 3 with each sketch in succession, until all of the sketches have been aligned and stacked within the image file. Remember to save your work regularly.

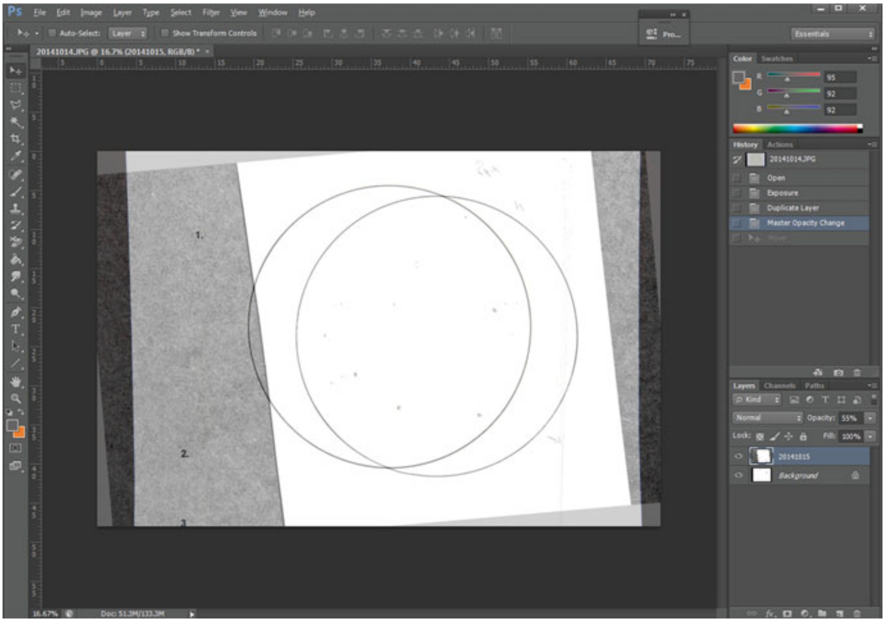


Fig. 10.9 Lowering the opacity of the top layer is necessary while aligning the images. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

Step 5

In the *Layers* dialog box, highlight all of the image layers by holding down the *Ctrl* button on your keyboard and using the cursor to click on each layer. Next, select *Image, Image rotation* to flip or rotate the layers for standard solar orientation—north is up; west is to the right.

Use the *Crop Tool* to crop the stacked images using the *1 × 1 (Square)* ratio option that is located under the top menu bar. Click on the *Move Tool* to complete the cropping process (Fig. 10.10).

Step 6

In the *Layers* dialog box, highlight the background layer (which is the first sketch in the sequence) and then create a new layer within that same destination document. The name of the new layer should represent the date of the first sketch. Since the first sketch in my sequence was from October 15, 2014, I named that layer 20141015 (yyyymmdd). Use your cursor to drag the new layer so that it comes next after the background in the layer sequence. Likewise, make sure that all the layers are in chronological order from bottom to top. If not, rearrange them before progressing to the next step.

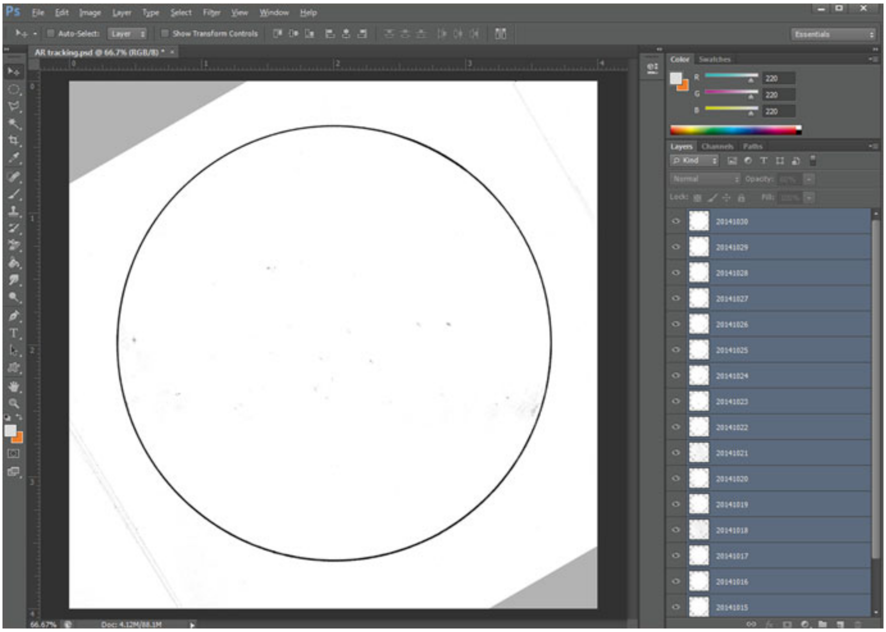


Fig. 10.10 The stacked images can be cropped and resized as a unit. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

Step 7

Un-tick the radio button for each layer with the exception of the background, which will remain visible. Highlight that layer and then select the *Elliptical Marquee Tool* with a *Fixed Ratio* style.

To create a uniform, solid black outline of the solar disk, create a circular selection area just inside the existing outline. Go to *Select, Select Inverse* and right click outside of the solar disk. Click on *Fill*. Select the color for your background and press *OK* (Fig. 10.11). Inverse the selection again, and fill the center of the disk by using the *Eyedropper Tool* to pick up the original color of the solar disk. Then right click within the circle to create a black disk outline by selecting *Stroke,* and then choosing from the thickness and position options.

Step 8

Un-tick the background layer to hide it. Click on the next layer, and also the box next to it, so that it becomes visible. The *Elliptical Marquee Tool* should still be active with the solar disk in its selection area. If not, create a new selection area just

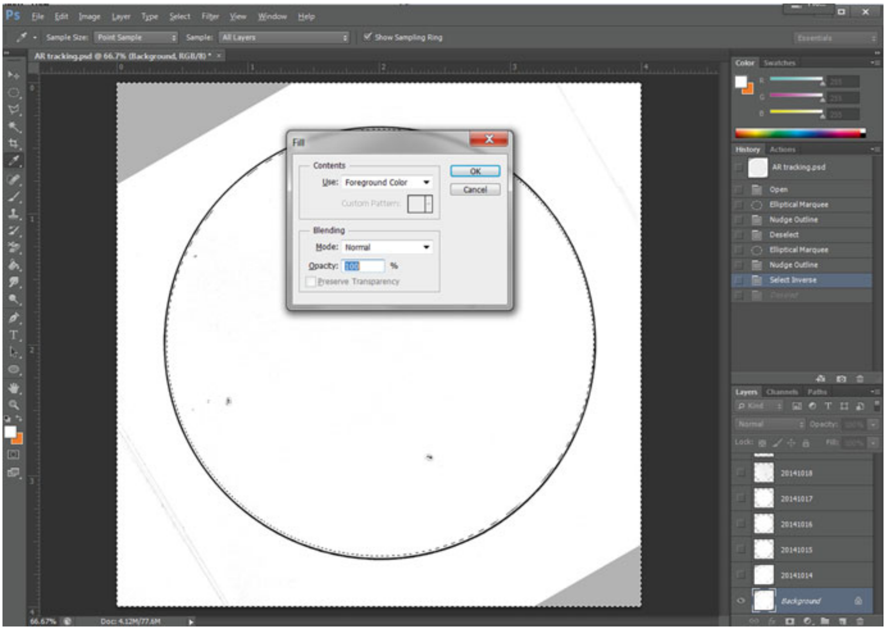


Fig. 10.11 A solid white background is produced while using a layer mask. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

inside the black outline of the disk. Click on the *Add layer mask* icon below the *Layers* dialog box. The area outside of the solar disk will become transparent. Change the opacity back to 100%, and then repeat the process for each subsequent layer (Fig. 10.12).

Step 9

Starting at the earliest date layer, use the *Horizontal Type Tool* to begin adding the dates onto each sketch. Use your cursor to form the text box outside of the disk area. Select from the font options at the top of the screen. After the text has been added, reposition the text layer under the sketch date layer (in the *Layers* dialog box) that it's associated with.

While the text layer is still highlighted, create a duplicate layer from it, and then rename the new text layer with the next consecutive date. Reposition the text layer under its associated sketch date layer. When the layers are duplicated, their positions remain unchanged within the image file. This provides a clean transition during animation. Un-tick all the layers so that only the newest one is visible. Use the cursor to click within the text box, and then type in the correct date.

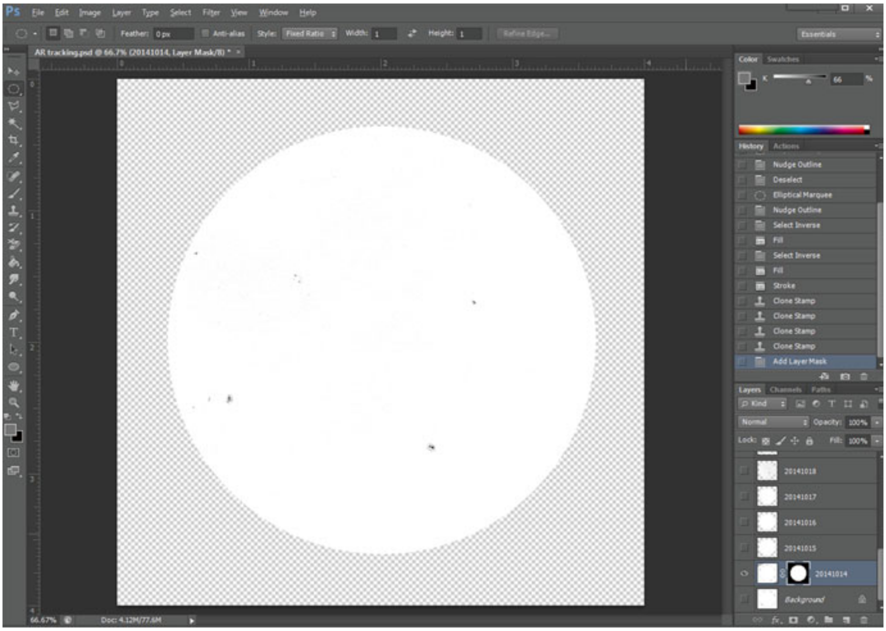


Fig. 10.12 A mask is used with each sketch layer to remove the area surrounding the disk. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

Repeat this step until the date text layers accompany each sketch layer that they are associated with.

Step 10

Scroll back down to the first text date layer and its associated sketch layer. Tick the boxes next to them so that both layers become visible. While pressing the *Ctrl* button on your keyboard, use the cursor to highlight the layers, then right click and select *Merge Layers*. The layers will become one. Continue in this manner until all text date/sketch layer pairs are merged (Fig. 10.13).

When both the merged text date/sketch layer and the background are made visible, the layers are stacked to produce one view.

Step 11

To prepare for the animation, it was necessary to reduce the file size to one that was more manageable for sharing online. The set of layers was cropped and resized to 6.25″ by 6.25″ at 72 dpi.

A final layer was added as a title page (Fig. 10.14).

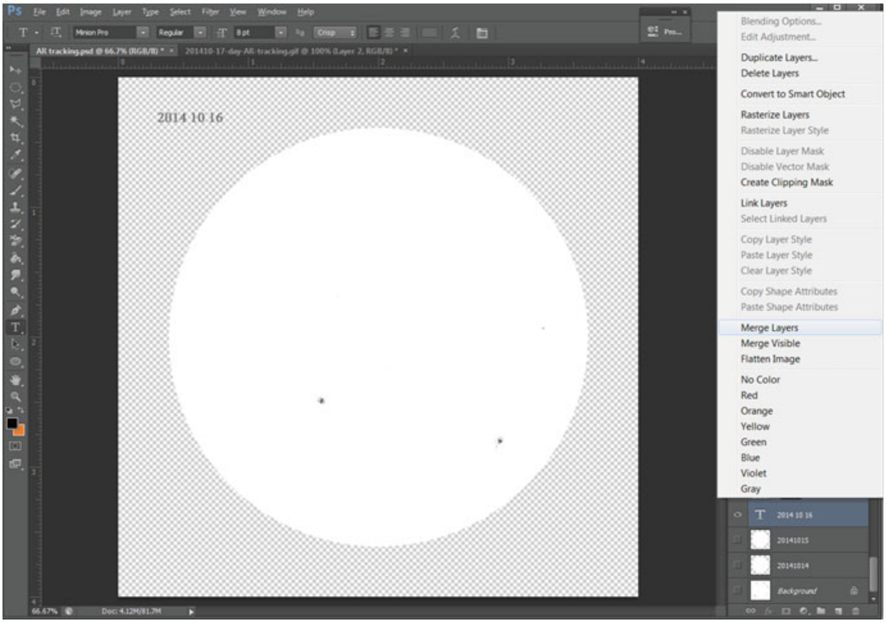


Fig. 10.13 Text is added to each layer with its associated date. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

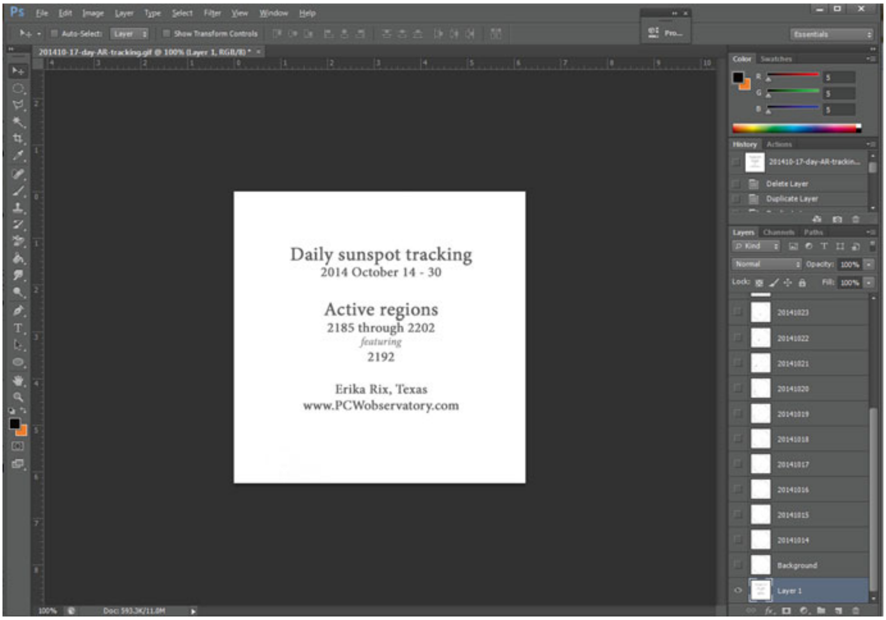


Fig. 10.14 A title page can be created for the animation. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

Warning! ALWAYS use a suitable filter when directly observing the Sun

Creating the Animation

Step 12

On the menu bar, select *Window* and then *Timeline* (called *Animation* in earlier versions of Photoshop). An animation strip will appear at the bottom of the screen. Click *Create Frame Animation* so that the first frame will appear along the strip. In the *Layers* dialog box, the only visible layer should be the title page. Un-tick all the other layers so that the title page appears as the first frame.

Step 13

Below the animation strip, click on the *Duplicates selected frames* icon to create the next frame. In the *Layers* dialog box, un-tick the title page and then tick the background layer and the first date layer of the sequence. The second frame now displays the solar sketch from the first tracking date. Again, create the next animation frame, only this time, leave the background layer visible as you un-tick the first sketch in the sequence, and then tick the second one so that it appears in the animation frame. Continue in this manner until all of the date layers have been added to the animation strip (Fig. 10.15).

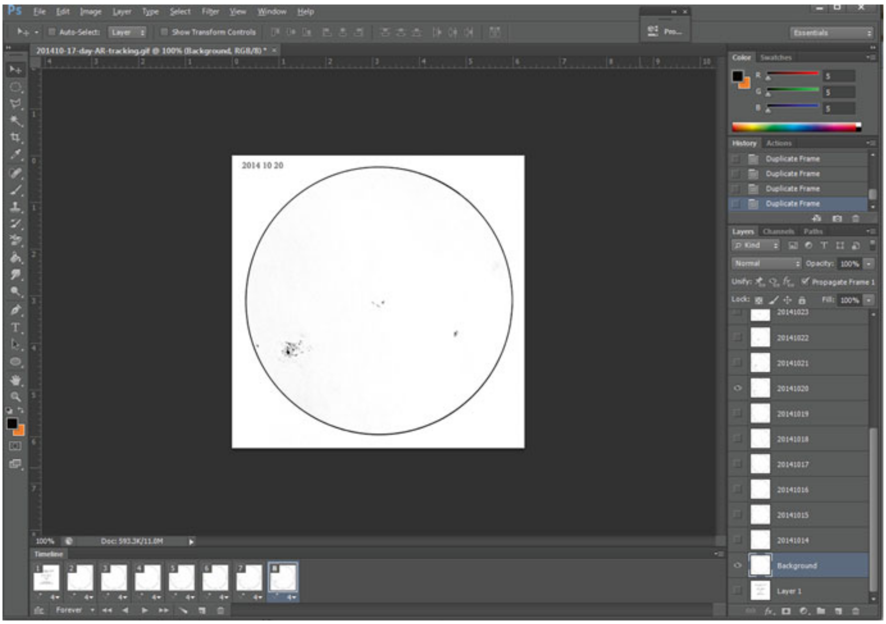


Fig. 10.15 A Timeline (animation) strip is opened in a new window to add frames for the animation. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

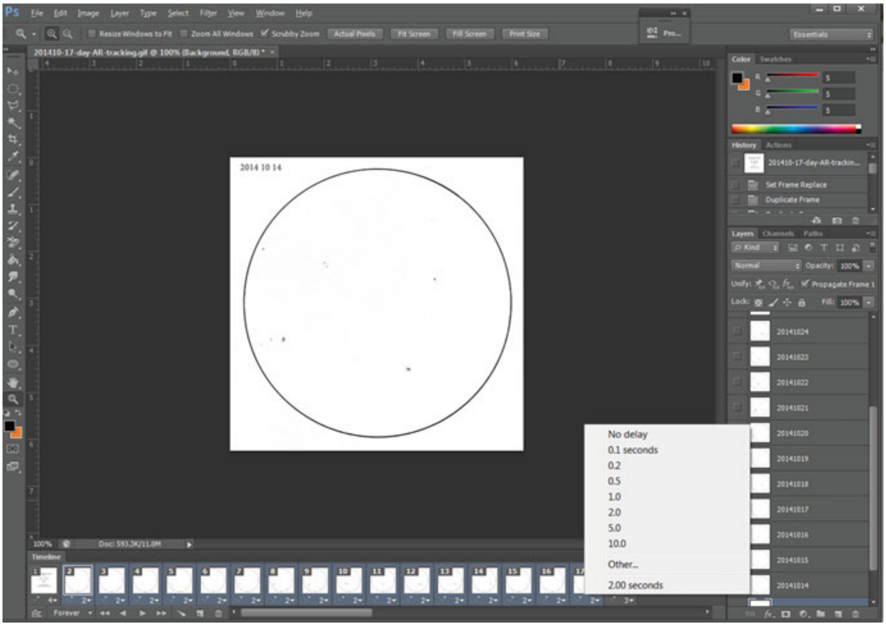


Fig. 10.16 Frame time delays are adjusted to a speed that permits a slower animation so that the evolution of the active regions can be studied. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

Step 14

The time delay can be adjusted by clicking on the dropdown box below each animation frame. The first frame is generally delayed longer so that the title page can be read (4 s should be ample time). Then, hold down the *Shift* button on your keyboard, and select the second and the next-to-last frames on the strip with your cursor. Both of those frames, and all of the ones in between, will become highlighted. This allows you to click on the dropdown box to adjust the time delay for all of them at the same time (2-s delays were chosen in this example) (Fig. 10.16). For the last frame, I usually set the delay somewhere in between so that it provides a pause to indicate the end of the sequence (3 s was used).

Step 15

Beneath the animation strip is another dropdown box to set the loop count (*Forever* was used for this animation). Click the run button at the bottom of the strip to view the animation. Make adjustments to the frames or settings if needed.

Step 16

To save the animation, select *File, Save for Web*, and then click on the dropdown box beneath *Preset* to select *GIF*. Press *Save*. To view the animation used for this tutorial, please visit the PCW Memorial Observatory webpage, https://pcwobservatory.files.wordpress.com/2015/02/201410-tracking-active-regions.gif.

The full set of sketches for the daily active region sequence is shown in Figs. 10.17, 10.18, and 10.19.

10.2.2 Erupting Prominence Sequence (By Erika Rix)

An erupting prominence is often caught when a brightened plume extending from the Sun's limb catches your eye. Then, a few minutes later, its size and shape noticeably changes. You must be willing to lay aside your current sketch in order to capture the event with a series of drawings, often rendered only 3–5 min apart!

Figure 10.20 is a photographed copy of the sketch sequence that was created during an observation of an eruptive prominence on the western limb. After quickly drawing the limb arc with a pastel stick, a pastel pencil was used to draw the brightest sections of the structure followed by a white color pencil for its faintest areas. The drawings were at 13- and 3-min intervals for the first two sketches, and then at 5-min intervals for the remainder. Refer to Chap. 5—*Hydrogen-Alpha Filters,* Sect. 5.2 *Prominences and Filaments* for techniques that are used to draw prominences.

The same animation steps provided in the previous tutorial, *Tracking Active Regions*, are used to create a GIF for the erupting prominence sequence. So this section will focus on sketch preparation.

Step 1

Open the sketch sequence in Photoshop. Rather than separating each sketch by cutting and pasting them into new documents, you can simply create duplicated layers of the entire image and stack them within the existing document. There were nine sketches in this example, so the image was duplicated nine times. I wanted the original layer to remain as a background so that it could be manipulated, if needed, without affecting the sketch.

Right click on the background layer in the *Layers* dialog box, and then click *Duplicate layer*. Rename it as the time of the first sketch. The *Destination* will be the same document. Repeat in this manner until all the sketches have their own layer. Save as a PSD so that the layers will remain separate for future use, and remember to save your work regularly (Fig. 10.21).

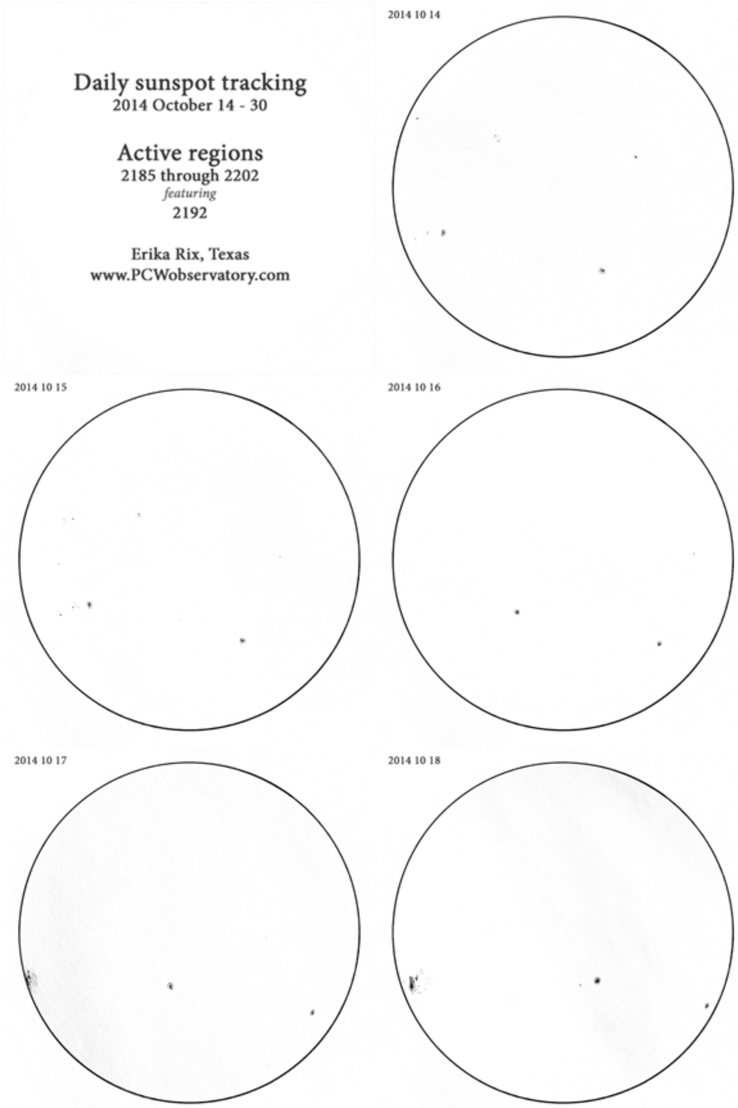


Fig. 10.17 Daily whole-disk drawings to track sunspots—October 14–18, 2014. Celestron Omni XLT 102 mm f/9.8 refractor, LXD75, homemade Sun Funnel followed by a Thousand Oaks glass white light filter, Baader Planetarium Hyperion 8-24 mm Mark III set at 16 mm, 63×. WH Smith white cartridge paper (135 gsm), Faber-Castell black S artist pen, 0.5 mm mechanical pencil, blending stump, 6-in. circle template. (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

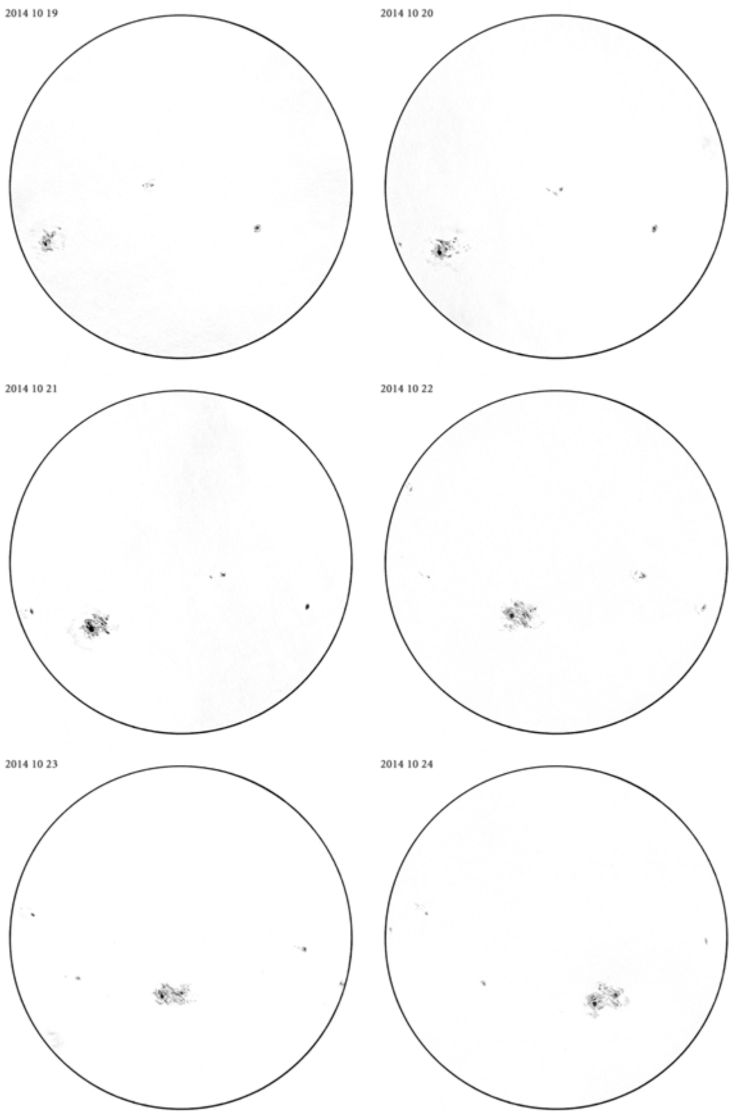


Fig. 10.18 Daily whole-disk drawings to track sunspots—October 19–24, 2014. (By Erika Rix)

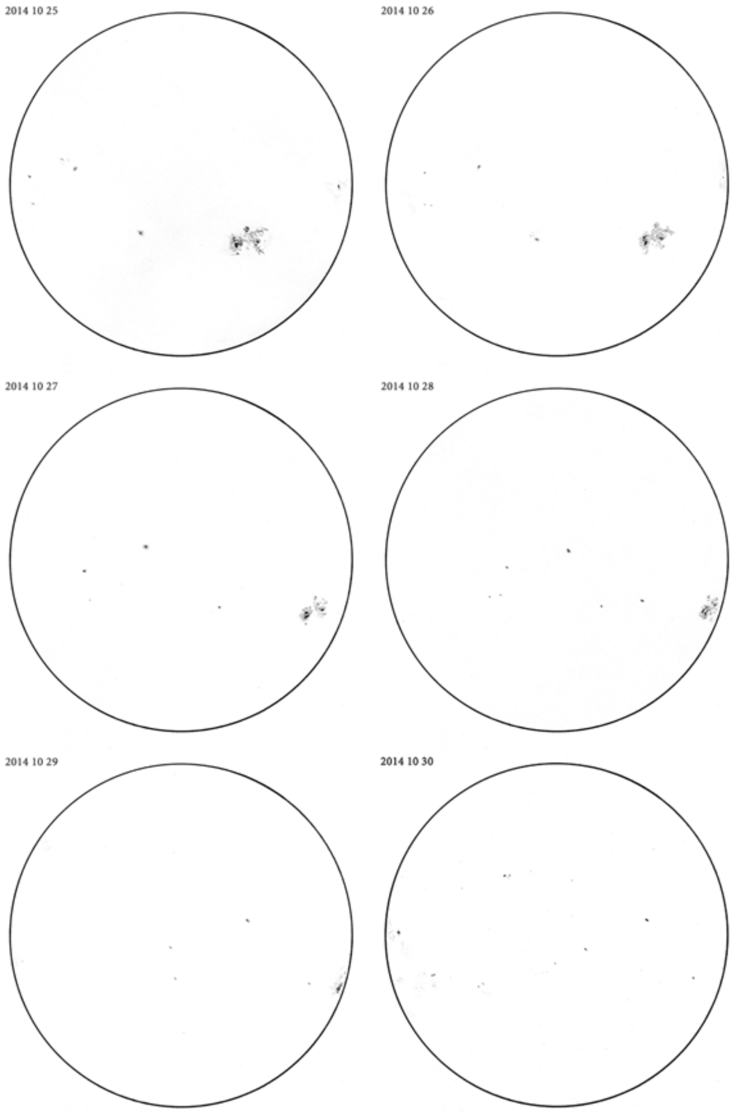


Fig. 10.19 Daily whole-disk drawings to track sunspots—October 25–30, 2014. (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

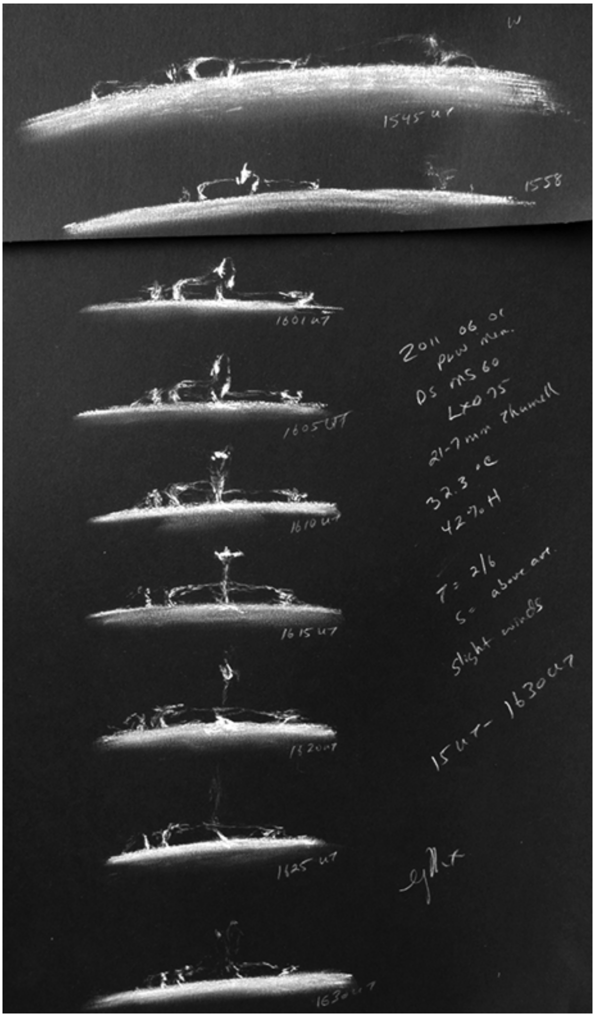


Fig. 10.20 Photographed sketch sequence of an erupting prominence before processing in Adobe Photoshop. June 1, 2011, 15:45–16:30 UT. Internally double-stacked Coronado Maxscope 60 mm H-alpha telescope, 400 FL, LXD75. 21-7 mm Zhumell zoom eyepiece. Light winds, Wilson IV, 2/6 transparency, 90°F (32°C), 42 % humidity. White Conté crayon and pastel pencil, white Prang watercolor pencil, black Strathmore Artagain paper. (By Erika Rix)

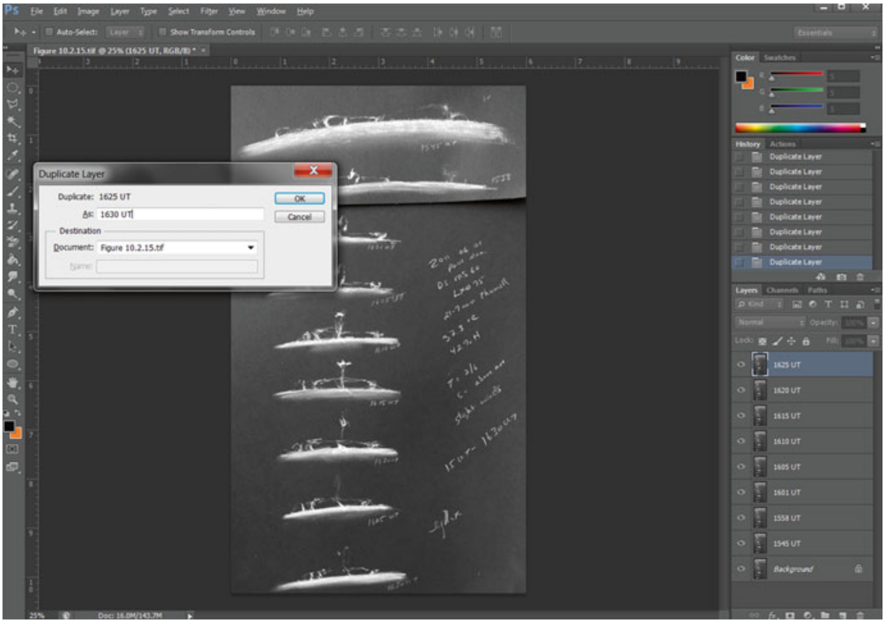


Fig. 10.21 The original image file can be duplicated within itself as separate layers. The sketches can be stacked and then cropped after alignment. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

Step 2

Highlight the earliest time layer and tick its visibility box. Select *View, Show, Grid* so that gridlines are visible to help you align the sketches. Next, select *Edit, Transform, Rotate* to move and rotate the highlighted layer so that the first sketch in the sequence is even with the horizontal gridlines and the brightest sections line up vertically (Fig. 10.22).

Step 3

Highlight and make visible the next layer in the sequence. Adjust its opacity to approximately 50 % so that the layer beneath it is visible. Then rotate and position it so that the second sketch of the sequence from the top layer is aligned over the first sketch from the bottom layer. Align several of the brightest areas near the limb. The sketches can be resized through *Transform* if needed. Click *Apply*. Set the opacity back to 100 % before un-ticking the box to make the top layer invisible once more. Click on the next layer and repeat in this manner until all the sketches are aligned with the first sketch from the bottom layer (Fig. 10.23).

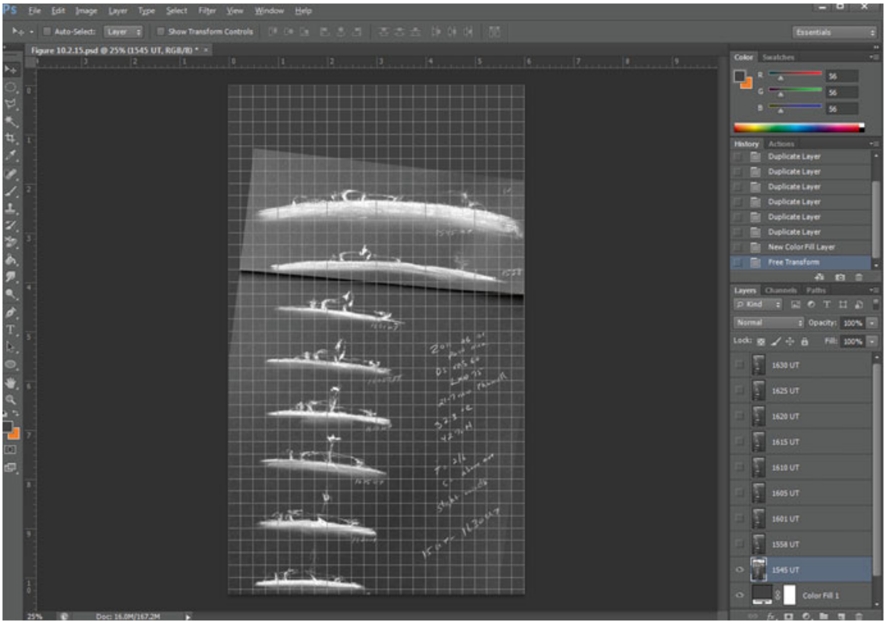


Fig. 10.22 A grid reference is used while rotating and positioning the first sketch in the sequence. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

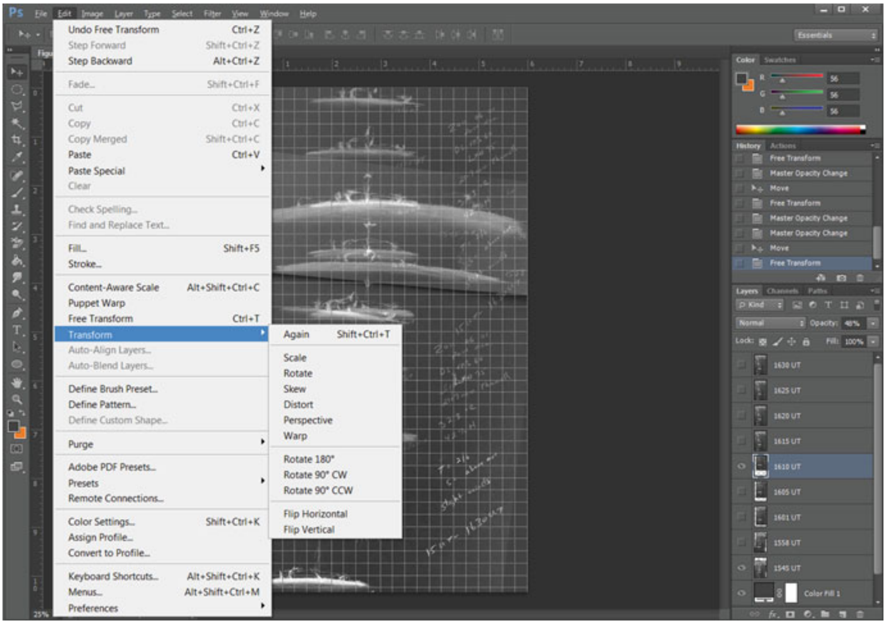


Fig. 10.23 Each sketch layer is positioned in succession over the first sketch in the sequence. The opacity is lowered so that the underlying sketch is visible during alignment. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

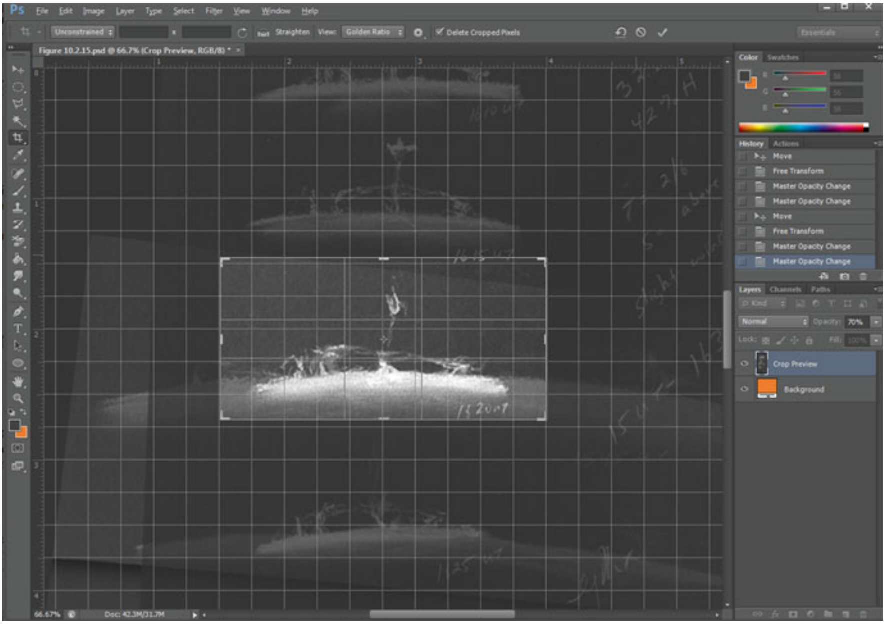


Fig. 10.24 Zoom the stacked layers during the cropping process. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

Step 4

When all the sketches are aligned and set back to 100 % opacity, highlight one of the layers that displays the tallest prominence. Make it visible along with the background and first sketch layer. Use the *Zoom Tool* to increase the magnification. Select the *Crop* tool so that your curser can be used to closely crop the stacked prominences. Use the tallest prominence as a guide for the height (Fig. 10.24).

Step 5

Select each layer individually to remove stray markings. The stacked prominence sketches were then resized for the animation. I also decided to discard the background layer (Fig. 10.25).

Step 6

For presentation, a title page can be created (as a new document) with enough room to include an animated time sequence for the eruption. To do this, select *File, New,* and then name the new document. Set the *Width, Height,* and *Resolution* parameters

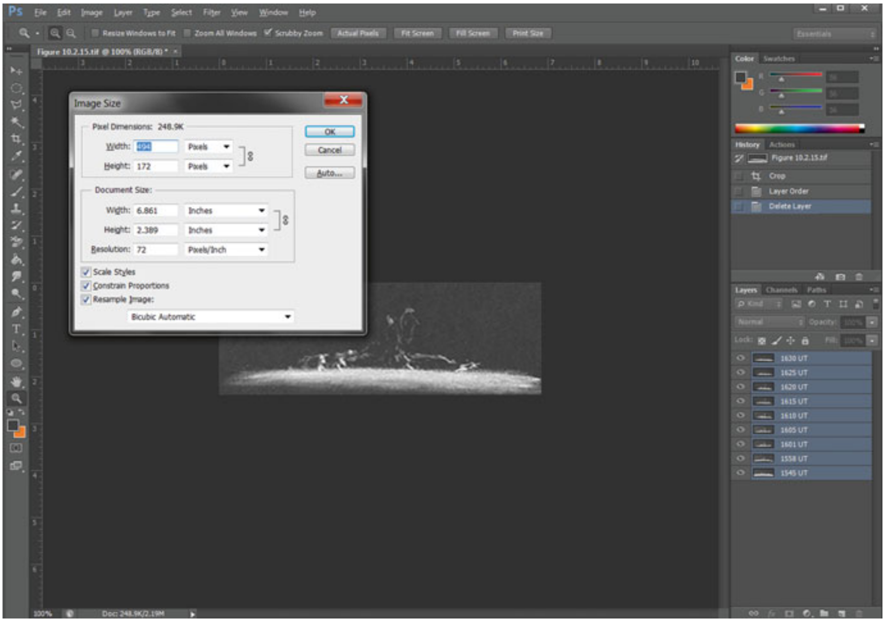


Fig. 10.25 The cropped image is adjusted to a manageable size for animation. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

to be slightly larger than that of the stacked prominence sketches. The *Background Contents* is set to a light gray color. Click on the *Horizontal Type Tool* to create the text within the title page.

Return to the set of prominence sketches to highlight their layers in the *Layers* dialog box, and then duplicate them into the title page document. Use the *Move Tool* to reposition them so that enough room is left in the area below to include the times of each sketch. Make sure the text from the title page doesn't extend into that area. If it does, highlight the title page and reduce the text size.

Step 7

Click on the first sketch layer and select *Layer, Layer Style,* and *Drop Shadow*. Adjust the *Structure* settings to produce an opaque shadow around the layer. Do this for each sketch in the sequence.

Step 8

Next, begin adding the times of each sketch. Click on the *Horizontal Type Tool* and use your cursor to form the text box in the lower right hand corner of the title page.

Select from the font options at the top of the screen. After the time text has been added, reposition the text layer under the sketch layer (in the *Layers* dialog box) that it is associated with.

While the text layer is still highlighted, duplicate it, and then rename the new layer with the next consecutive time. Reposition the new time layer under its associated sketch layer. When the layers are duplicated, their positions remain unchanged, which provide a clean transition during animation. Un-tick all the other layers so that only the newest one is visible. And lastly, use the cursor to click within the text box to change the time.

Repeat this step until the time layers accompany all the sketch layers that they are associated with.

Step 9

Scroll back to the first pair of time and sketch layers and tick the boxes next to them so that they become visible. While pressing the *Ctrl* button on your keyboard, highlight both layers by clicking on them with the cursor. Right click and select *Merge Layers*. The layers will become one. Continue in this manner until all time/sketch pairs are merged (Fig. 10.26).

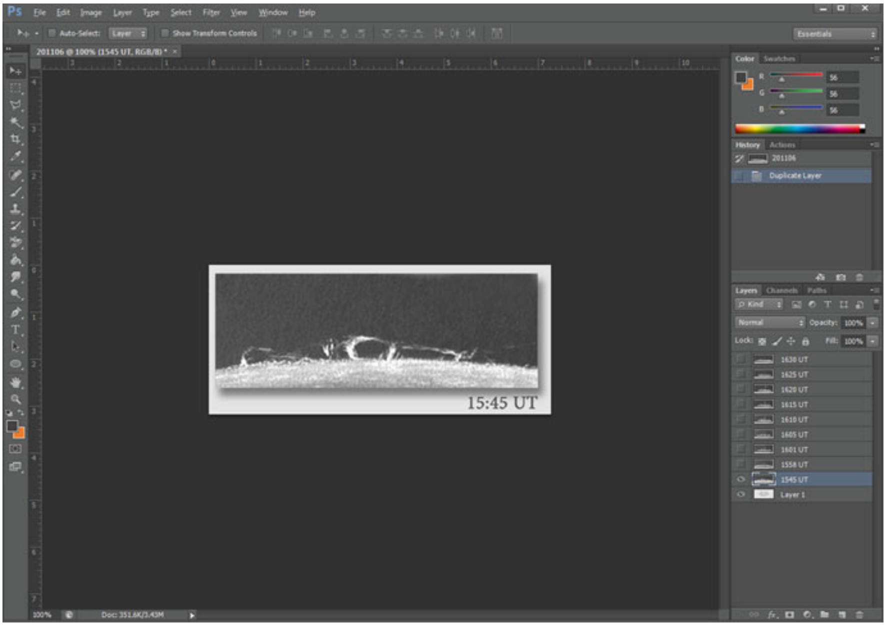


Fig. 10.26 A title page is created in a larger size, and the sketch sequence layers are duplicated into its image file. Shading and text are added for presentation. (Adobe product screenshot reprinted with permission from Adobe Systems Incorporated)

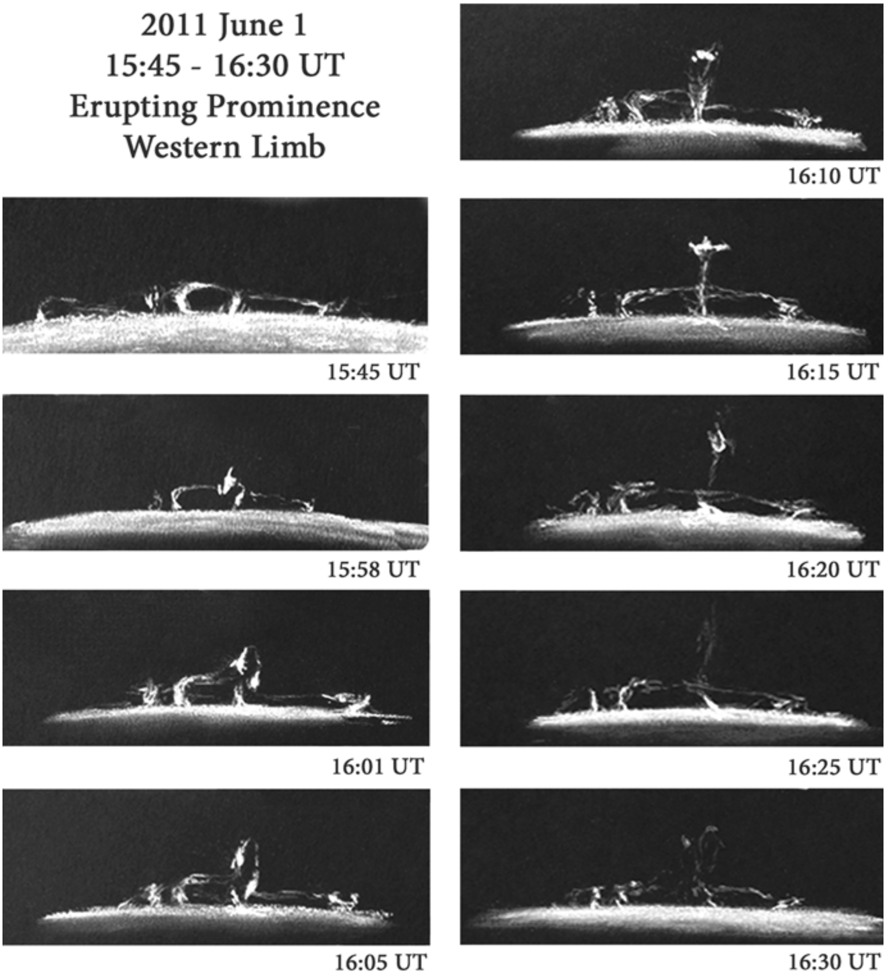


Fig. 10.27 The processed sketches that are created in the animation process can be presented as a montage for side-by-side comparisons of the structural changes that occurred during the eruption. (By Erika Rix)

Step 10

Refer to the *Creating the animation* section in the previous tutorial to animate your prominence sequence. A compilation of the prepared sequence is shown in Fig. 10.27, and the animation is available at the PCW Memorial Observatory webpage, https://pcwobservatory.files.wordpress.com/2011/06/201106.gif.

10.3 GIMP

GIMP (GNU Image Manipulation Program) is a terrific freeware program for photo retouching, image composition, and image authoring. The developers also included a thorough online user manual that makes using it a breeze. GIMP 2.6 was used to demonstrate the techniques provided in this section (http://www.gimp.org/).

10.3.1 Prominence Sequence (By Erika Rix, Sketches By Sally Russell)

Quiescent prominences appear to meander and float above the lowest layers of the Sun's atmosphere. Often times, while peering at them through an eyepiece, they may not seem to move at all. But once you begin sketching them, you start to appreciate just how much they can change in a very short period of time, as seen with the sketch sequence in Figs. 10.28 and 10.29. Refer to Chap. 5—*Hydrogen-Alpha Filters,* Sect. 5.2 *Prominences and Filaments* for techniques that are used to draw prominences.

Step 1

Open the files of the scanned sketches in GIMP. The *Toolbox* utility window will already be located on the main screen. Go to *Windows*, *Dockable Dialogs* to add the *Layers* and the *Undo* (history) dialog windows for easy access.

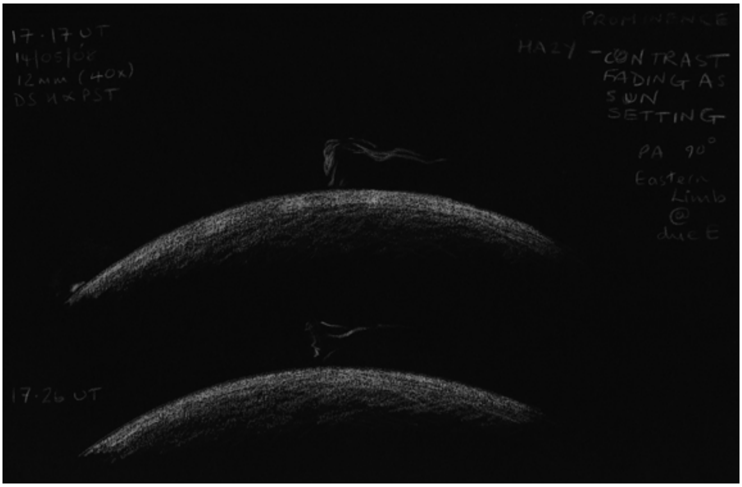


Fig. 10.28 Prominence sequence 90° PA—May 14, 2008, 17:17–17:26 UT. Coronado H-alpha PST with additional 40 mm filter to double stack, Alt-Az mount, 8-24 mm zoom eyepiece at 12 mm, 40×. White watercolor pencil on black paper. (By Sally Russell)

Warning! ALWAYS use a suitable filter when directly observing the Sun

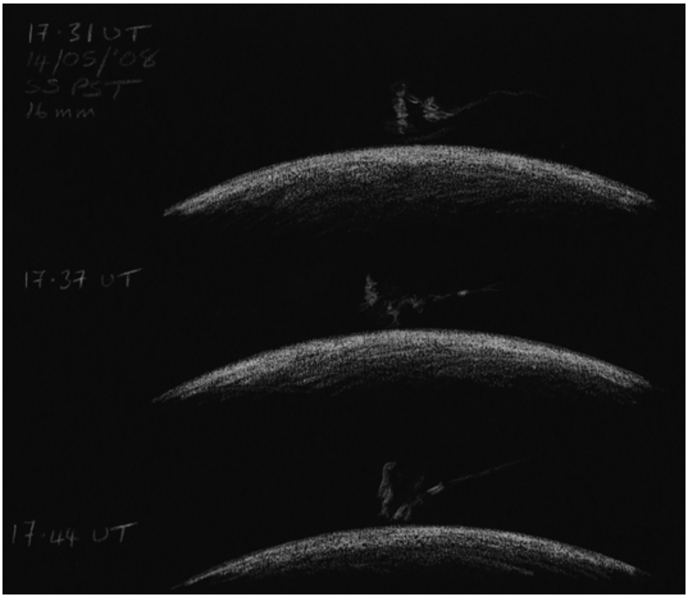


Fig. 10.29 Prominence sequence 90° PA – May 14, 2008, 17:31–17:44 UT. Coronado H-alpha PST with additional 40mm filter to double stack, Alt-Az mount, 8-24 mm zoom eyepiece at 12 mm, 40×. White watercolor pencil on black paper. (By Sally Russell)

Step 2

Use the *Rectangle Select Tool* from the *Toolbox* to outline the area surrounding the second sketch of the sequence (Fig. 10.30). Go to *Edit, Copy* to add the selection to the clipboard. Then go to *Edit, Paste as, New Layer* (Fig. 10.31). Both layers can be renamed with their associated sketch times. To do this, double click on their existing names so that new ones can be typed over them, and then press *Enter*.

Step 3

Select the second sketch layer in the *Layers* dialog box. Next, use the *Move Tool* from the *Toolbox* to position it over the first sketch of the bottom layer. Decrease *Opacity* so that the first sketch from the bottom layer can be seen through the second one above it. Both the first sketch and the checkered image grid can be used as references during alignment. Try to match up the brightest portions of the prominence and the arc of the limb (Fig. 10.32).

If further layer manipulation is needed, there are several paths to adjust its size and rotation. One is through *Tools, Transform Tools* and then use any of the listed options to adjust the layer. To check the alignment, tick and un-tick the visibility

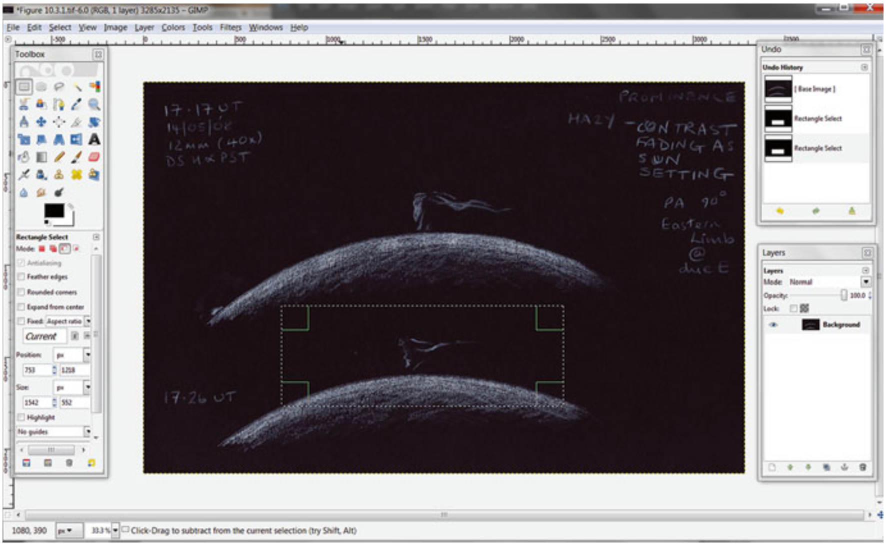


Fig. 10.30 Select the area around the second sketch of the sequence so that it can be copied. (GIMP product screenshot reprinted with permission from the GIMP Documentation Team)

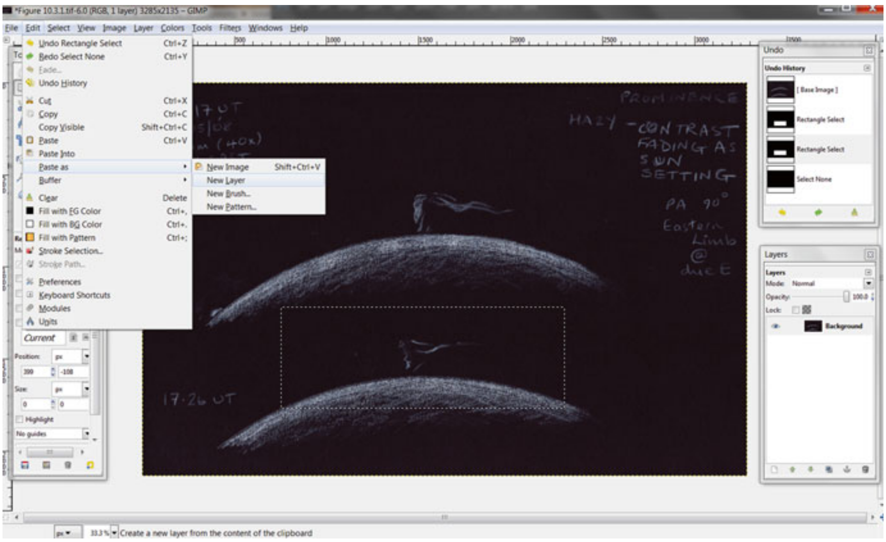


Fig. 10.31 Select *Edit, Paste as, New Layer* to stack the second sketch as an additional layer. (GIMP product screenshot reprinted with permission from the GIMP Documentation Team)

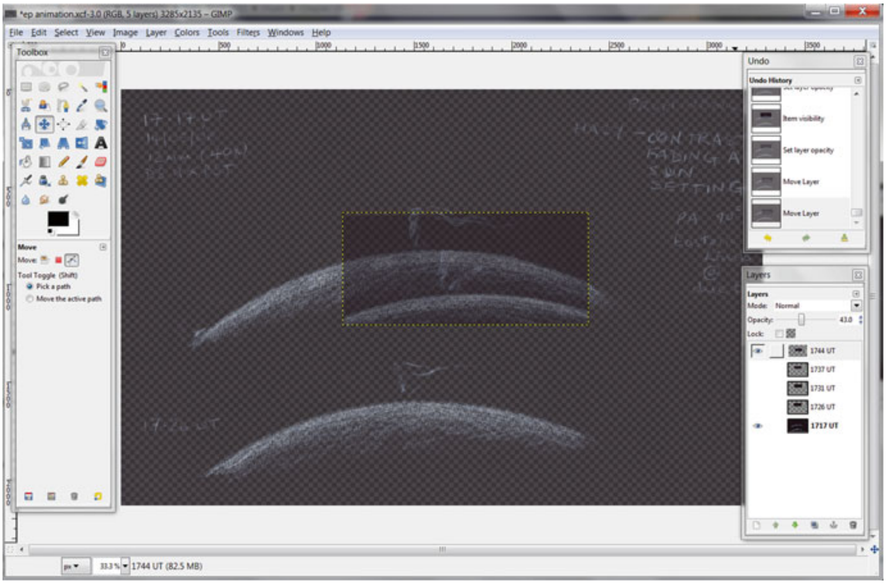


Fig. 10.32 With the opacity decreased so that both layers can be seen, use the *Move Tool* to position the new layer. (GIMP product screenshot reprinted with permission from the GIMP Documentation Team)

radio button next to the second sketch layer for quick comparisons between it and the first sketch layer beneath it. Once alignment is achieved, change its opacity back to 100 %, and un-tick its radio button so that it becomes invisible once more (Fig. 10.33).

Continue in this manner until each sketch in the sequence is layered above the first. In the *Layers* dialog box, drag the layers to reposition them in successive order.

Step 4

Select *Crop Tool* from the *Toolbox*. Use your cursor to drag the selection area around the stacked sketches. Press *Enter* on your keyboard to crop.

Step 5

Create a title page by duplicating one of the layers and then repositioning it as the first layer. Select and rename it. To view the title page, all the other layers will need to be invisible. Select a light gray foreground color from the *Toolbox*, and then click

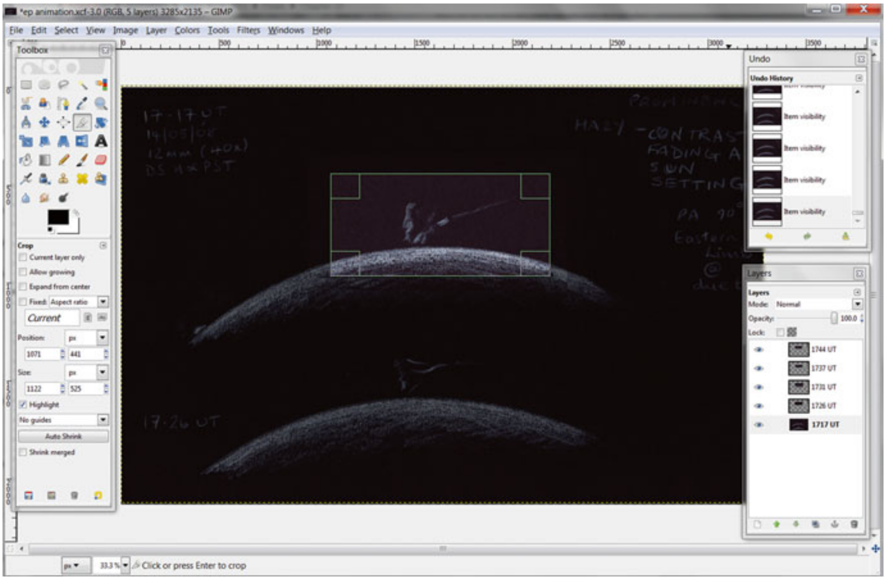


Fig. 10.33 Change the opacity back to 100 % and ensure that the layers are in successive order. (GIMP product screenshot reprinted with permission from the GIMP Documentation Team)

on *Bucket Fill Tool, Affected Area,* and then *Fill whole selection*. Click anywhere in the image of the title page to fill it with gray color.

Next, select the *Text Tool*. A *GIMP Text Editor* box will appear on the screen. Type the title information inside the box, and then click on *Close*. Adjust the color, font, size, and positioning of the text within the *Text* window of the *Toolbox* (Fig. 10.34).

Tick the radio buttons next to the text and title layers so that they are both visible. Then go to *Image, Merge Visible Layers* to select *Clipped to bottom layer* and *Merge*.

Step 6

To prepare for the animation, set the frame rate by double-clicking on the name of each layer in turn. Add a space after the existing name and type (XXXms)—XXX is the number of milliseconds that the frame will last. After testing several frame rates, I settled for 5000 ms for the title page frame, 600 ms for the middle frames, and 1000 ms for a slightly delayed end frame. Press *Enter* on your keyboard after renaming each layer (Fig. 10.35).

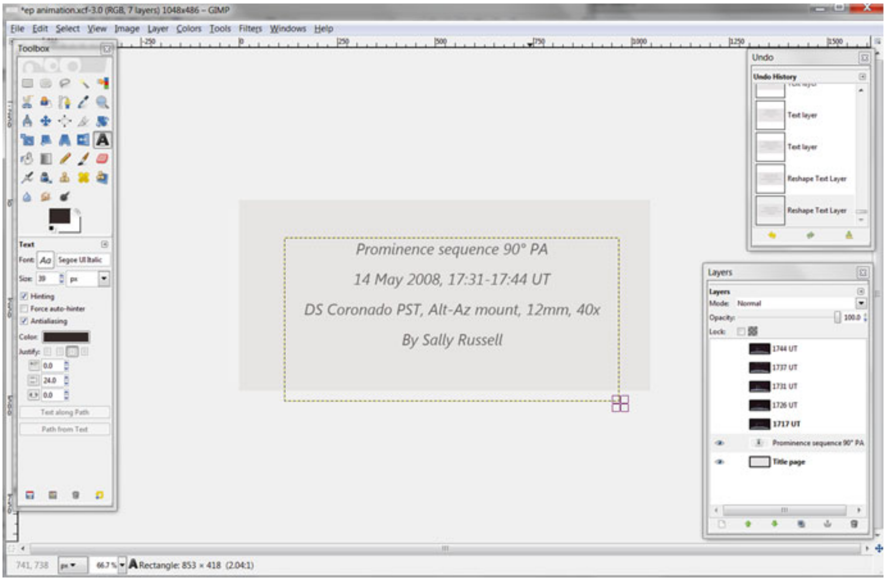


Fig. 10.34 Adjust font color and size by selection from the options that are located in the *Text* window of the *Toolbox*. (GIMP product screenshot reprinted with permission from the GIMP Documentation Team)

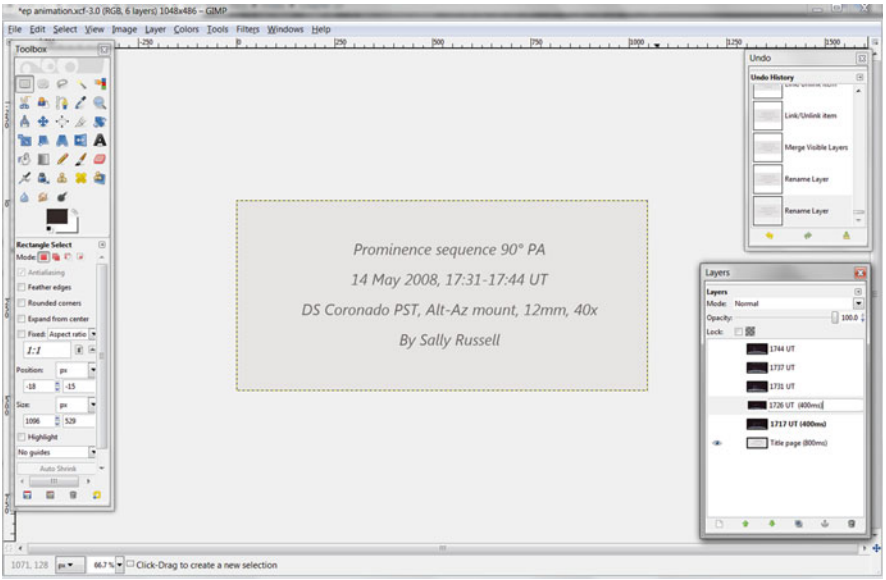


Fig. 10.35 Add a space after the existing layer name and type the number in milliseconds (XXX ms) preferred for the frame rate. (GIMP product screenshot reprinted with permission from the GIMP Documentation Team)

Step 7

Make each layer visible and then select *Filters, Animation, Playback* and then *Play* to review the animation. Make any necessary changes to the layers if needed, and then review the animation again.

Step 8

Select *Filters* and then *Optimize (for GIF)*. This feature reduces the image size when it is saved as a GIF. The new image file that appears will need to be converted to indexed colors. Use *Image, Mode,* and *Indexed* so that the *Indexed Color Conversion* dialog box appears (Fig. 10.36). Try to use as few colors as possible to avoid dithering (graphically creating the illusion of more colors). Because this prominence sequence was rendered in black and white, I chose the black and white 1-bit palette and then clicked *Convert*.

Step 9

Save the new image file as a GIF (Fig. 10.37). A pop up menu box will appear, tick the radio button for *Save as Animation*. Click *Export* (Fig. 10.38).

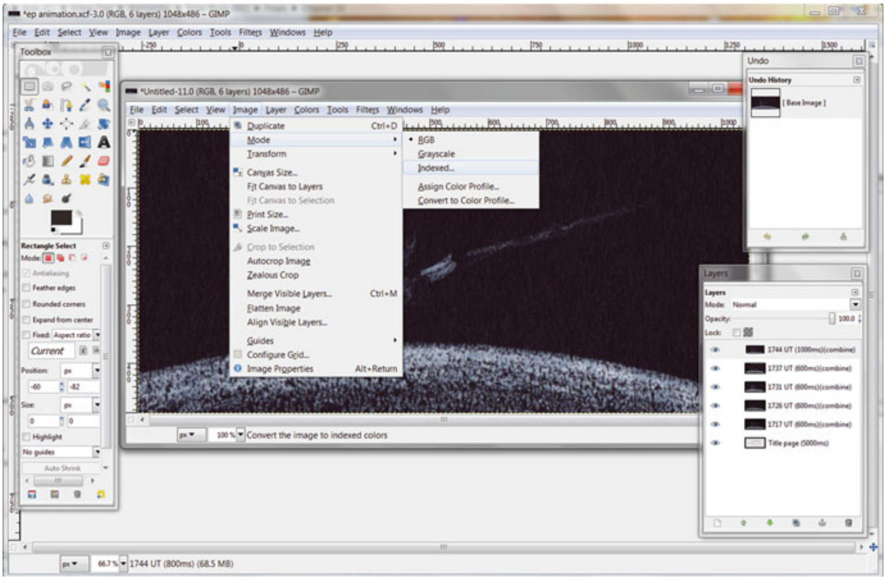


Fig. 10.36 The new image file that appears will need to be converted to indexed colors. (GIMP product screenshot reprinted with permission from the GIMP Documentation Team)

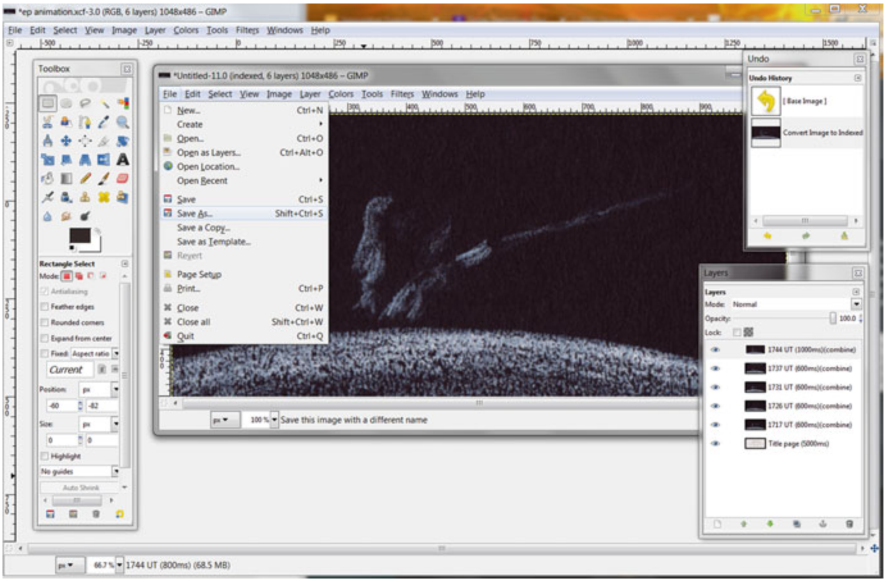


Fig. 10.37 Save the new image as a GIF by selecting *File* and then *Save As*. (GIMP product screenshot reprinted with permission from the GIMP Documentation Team)

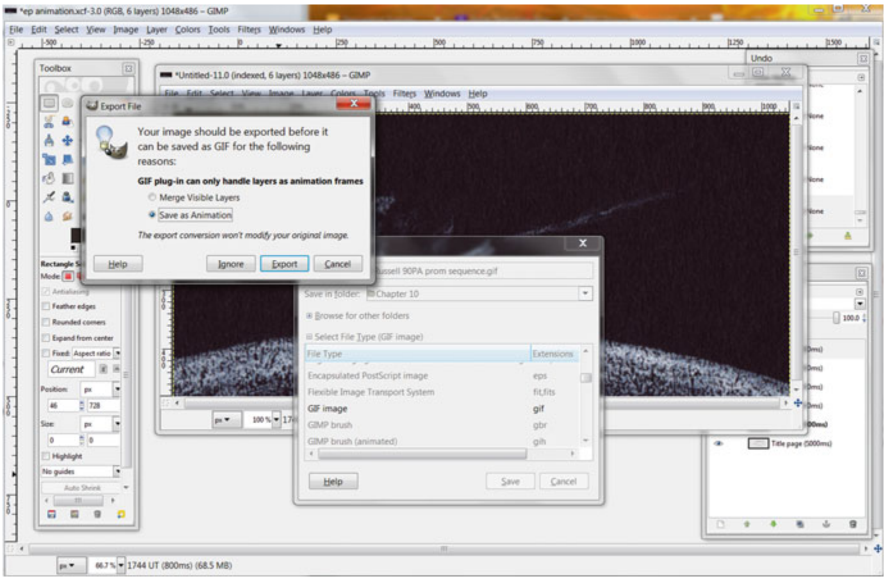


Fig. 10.38 Save the file as an animation and then export it. (GIMP product screenshot reprinted with permission from the GIMP Documentation Team)

Step 10

A new menu box will appear with GIF options. Because the frame rate was adjusted in *Step 6*, un-tick the *Use delay entered above for all frames* and set the *Delay between frames where unspecified*: to zero. Press *Save*. The animation process is complete (Fig. 10.39).

See Fig. 10.40 to view a full compilation of the prominence sequence that was used for this tutorial. The animation is available at the PCW Memorial Observatory webpage, https://pcwobservatory.files.wordpress.com/2015/04/srussell-90pa-prom-sequence1.gif.

See Chap. 8—*Transits, Venus Transit—Hydrogen-Alpha Whole Disk (by Erika Rix)* for another example of solar animation.

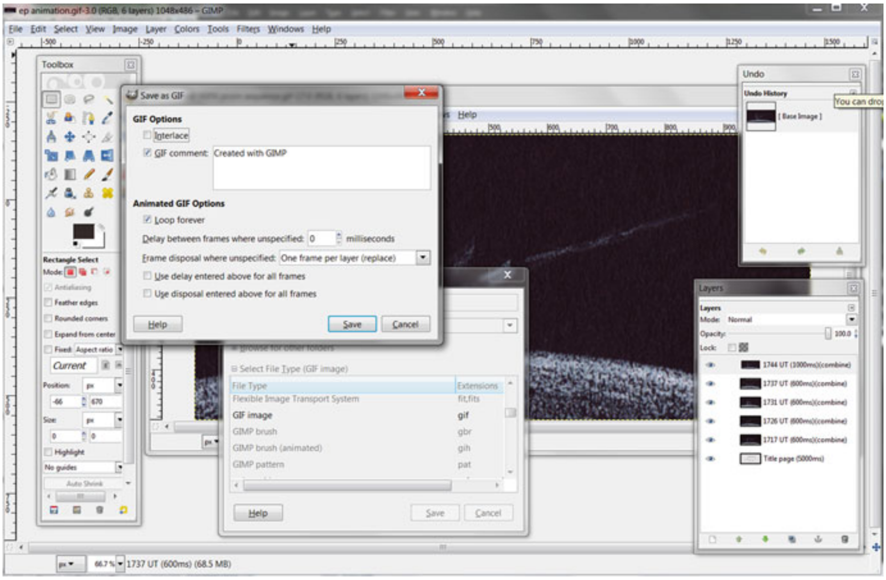


Fig. 10.39 Be sure to set the frame delay to zero and un-tick the *Use delay* option if you have already set up the frame delay times within each layer. (GIMP product screenshot reprinted with permission from the GIMP Documentation Team)

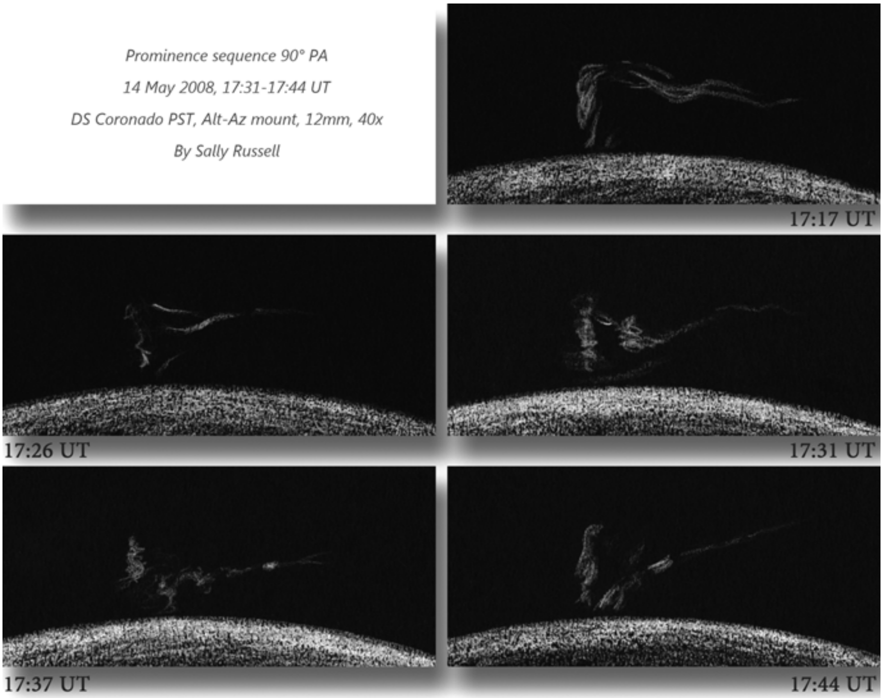


Fig. 10.40 Montage of the prominence sequence that was used for the animation. (By Sally Russell)

Chapter 11

Ideas for Outreach

Most kids thrive with hands-on activities. The more enjoyable their experiences are during an outreach event, the more enthusiastically they'll want to learn. Along with your solar telescope, make sure to pack fun projects for them to do while waiting for their turns at the eyepiece.

Handing out solar glasses creates waves of excitement without fail. Other reliable items include solar-powered robots, solar balloons, and ultraviolet changing beads with ample string to make necklaces. But because children are creative by nature, you might consider adding art to the mix. Having them render their observations consequently teaches them *how to observe* the Sun and have a great time in the process! (Fig. 11.1).

11.1 Hands-On Solar Activities

11.1.1 Action Sun: Let's Bring the Sun to Earth (Technique of Deirdre Kelleghan)

All children are artists. The problem is how to remain an artist once we grow up.

Pablo Picasso

Action Sun is a science activity that educates children about our nearest star through art. Created and developed by Deirdre Kelleghan, an artist and educator from Ireland, the workshop is aimed toward igniting interest and excitement for solar astronomy. Children are encouraged to use creative methods to study, which in turn provides a richer learning experience for them (Fig. 11.2).

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical Astronomy Series 178, DOI 10.1007/978-1-4939-2901-6_11

Fig. 11.1 Solar outreach (By Erika Rix)

Fig. 11.2 *Action Sun* created by children from the Stargazer's Astronomy Club at St Cronan's National School. (Courtesy of Deirdre Kelleghan, Wicklow, Ireland)

This outdoor activity allows groups of children to participate in building a large solar disk to represent the photosphere and chromosphere of the Sun (Figs. 11.3 and 11.4). Real-time solar information is used from NASA's Solar Dynamics Observatory, or if the sky is clear, the children use visual observations from a solar telescope. Solar features including sunspots, filaments, and prominences are added to the Action Sun disk.

The educational material is provided through the generous support and funding of organizations such as NASA's Goddard Space Flight Center, Dublin City of Science 2012, Discover Science and Engineering Science Week, Dunsink Observatory, and the Royal Dublin Society Science Live Bursary. To see more of her innovative workshops and the exciting work she does, please visit her website, *Dee Kelleghan*, http://www.deirdrekelleghan.net/ (Fig. 11.5).

Fig. 11.3 Student Sean Stanley adding to the *Action Sun* during National Drawing Day 2012 at Kilkenny Castle, Ireland. (Courtesy of Deirdre Kelleghan, Wicklow, Ireland)

Fig. 11.4 Student Sam Ferrie along-side Deirdre Kelleghan during the National Drawing Day 2012 at Kilkenny Castle, Ireland. (Courtesy of Deirdre Kelleghan, Wicklow, Ireland)

Fig. 11.5 Astronomers attending Solarfest at Dunsink Observatory ‘warmed’ their hands with the *Action Sun*. (Courtesy of Deirdre Kelleghan, Wicklow, Ireland)

11.1.2 Sunspotter and Sun Funnel (By Erika Rix)

As described in Chap. 4—*Solar Projection*, using a Sunspotter or a Sun Funnel permits groups of people to simultaneously observe and sketch the Sun in white light. In terms of safety, both are especially useful around children.

Young astronomer Emily Krzywonski and her mother, Tara, joined me during a solar outreach event. At the time, Emily had recently learned how to sketch the Sun while using the Sunspotter and was keen to share her knowledge with other children.

Several stations were set up for the group. Inside, they learned more about the Sun and solar safety. Outside, they were given solar glasses and a demonstration on ultraviolet light using UV beads, a cowboy hat, and sunscreen lotion as props. Other activities included a solar-powered robot dog, a pocket spectroscope, a necklace-making area with the UV beads, observing with a Hydrogen-alpha solar telescope, and Emily's Sunspotter sketching activity.

If you would like to add sketching to your next outreach event, choose kid-friendly materials and a simplified sketching technique. With a group of very young children, the idea is for them to enjoy the experience and have fun while learning, rather than to make it so complicated and time consuming that they lose interest.

Suggested Materials

- White paper, several sheets at least 5″ by 7″
- Rulers, to draw straight lines
- Child-safe protractor compass to create circle templates
- Pencils, whichever type the children would enjoy using
- Erasers, any variety

The amounts of material needed depend on the estimated group size. Bring plenty to spare.

Step 1

Before the children arrive, prepare the sketching station. The Sunspotter and art materials should be set up on a table. If the table legs are adjustable, they should be set at a suitable height for the age group.

Step 2

With the children gathered around in small groups of 2–4 at a time, demonstrate how to create a 3¼-in. circle template on the paper using the protractor compass and pencil. The children should be encouraged to prepare their own paper for the activity (Fig. 11.6).

Fig. 11.6 Young solar astronomer, Emily Krzywonski, teaches other children to how to draw sunspots using the Sunspotter telescope. (Courtesy of Tara Krzywonski, Texas, USA)

Step 3

If you are with a young group, have one of the children place his or her paper directly on the viewing platform and adjust its positioning so that the Sun's projected image is centered within the circle template (Fig. 11.7). Have the child point out the projected sunspots and then trace them on the paper with a pencil. You will need to make small alignment adjustments to keep the image centered while the child draws.

Tip

Hazy sky conditions hinder the views and could make it difficult to see sunspots on the projection platform.

If the age group is older, it will be worth preparing a circle template to be placed on the viewing platform before the kids arrive. Use the ruler to create crosshairs within the circle. The lines will be used as a grid reference.

Then, with the kids gathered around in larger groups of 3–5, demonstrate to them how to make their own circle template, with or without the crosshairs. They should be encouraged to observe the sunspot in the projected image on the viewing platform, and then draw what they see on their own sketch paper.

Fig. 11.7 The sunspots can either be traced onto the projected image or drawn on a separate sheet of paper next to the telescope. (Courtesy of Tara Krzywonski, Texas, USA)

Step 4

As each sketch is completed, have the kids write down their names, the date, and anything they would like to record from their observations. Explain how they can compare their sketch to daily images from Internet sites like NASA's Solar Dynamics Observatory (http://sdo.gsfc.nasa.gov/). Their sketch can be taken home as a keepsake of the outreach event (Fig. 11.8).

The Sun Funnel can also be used for sketching at outreach events (Fig. 11.9). Rather than placing a piece of paper over the funnel, have enough clipboards on hand for the kids to attach their sketches to. The drawings should be sketched free hand rather than traced.

Warning!

Always supervise the use of projection equipment. Before allowing the children near the telescope, explain to them what they are permitted and not permitted to do. Do not allow them to touch or grasp the Sun Funnel during the observing session. Doing so runs the risk of the funnel being jarred or pulled out of the eyepiece holder, which could lead to someone looking directly at the Sun, possibly causing permanent eye damage or blindness.

Fig. 11.8 Children draw their own observations of the Sun and have a keepsake from the experience to take home. (Courtesy of Tara Krzywonski, Texas, USA)

Fig. 11.9 Solar outreach for an older group of young astronomers using a telescope fitted with a Sun Funnel and a dedicated H-alpha solar telescope. Encourage hands-on activities during these events – drawing observations, solar powered robots, solar balloons, UV beads, and many more! (By Erika Rix)

11.1.3 Spectroscopy (By Erika Rix)

The visible portion of the electromagnetic spectrum represents only a small range of its wavelengths (Fig. 11.10). This narrow band of sunlight is known as visible radiation, and its range of wavelengths is collectively called white light (all visible light). Wavelengths are in nanometer (nm) units with the K spectral line of ionized calcium (CaK), 393.4 nm, at the bottom of the visual range. At the top is the A-line of molecular oxygen in our air, 759.4 nm. The colors of the spectrum range from violet (bottom) through blue, green, yellow, orange, and red (top) (Fig. 11.11).

When studying visible spectra, dark absorption lines may be seen with sharp wavelength resolution. They depict light absorption from atoms or ions in the Sun, and the wavelengths of these dark gaps can be used to identify its molecular composition.

Warning! ALWAYS use a suitable filter when directly observing the Sun

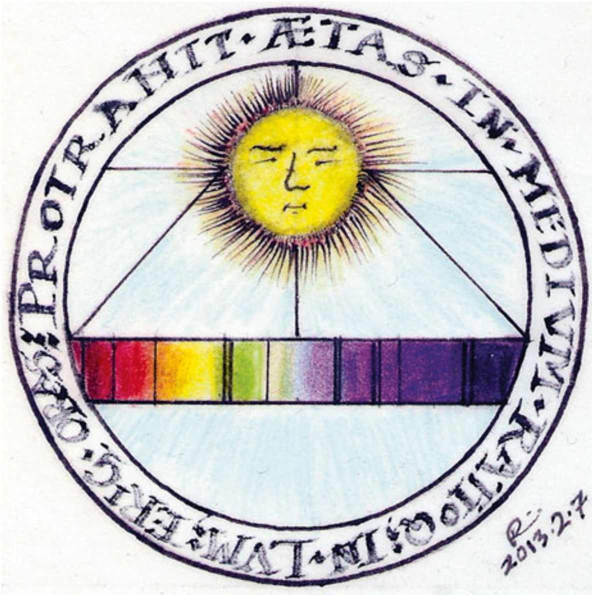


Fig. 11.10 Reconstructed 1897 design seal of Arthur Harvey (1834–1905) using colored pencils and pen and ink on paper. The drawing was based on descriptions of Harvey's lost design and incorporated a visual reference to the iconic drawing of the solar spectrum by Joseph Fraunhofer (1787–1826). (Image courtesy of the Royal Astronomical Society of Canada and *Specula astronomica minima*)

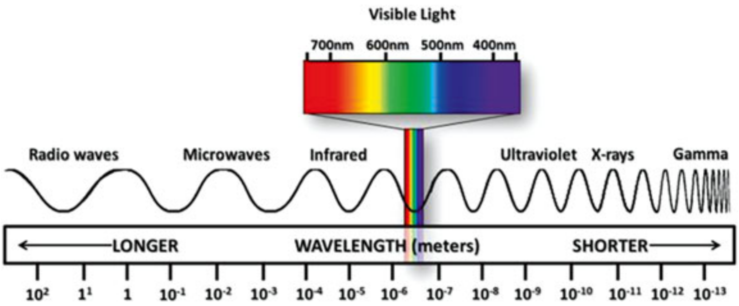


Fig. 11.11 The electromagnetic spectrum. (Image courtesy of NASA, public domain)

Although it's good to have a basic understanding of spectroscopy, the purpose of this section is to draw attention to the Sun's electromagnetic spectrum. Depending on the age group, you may even be able to delve into its composition and absorption lines.

Several inexpensive options are available to demonstrate the white light spectrum if you don't already own a spectroscope. The most obvious is a rainbow, as seen in Fig. 11.12. Rainbow spectrum diffraction prism glasses can be purchased separately or in bundles for the children to use and then take home. A small dispersive prism can be used to refract the light onto a dark backdrop. Likewise, a piece of diffraction grating or a DVD is similarly effective.

Small, affordable spectroscopes come in a broad range of designs. In fact, some include spectrometers for quantitative analyses. The pocket scope shown in Fig. 11.13 is a mere 2 in. long and comes in its own leather case. A small sun shield can be made of foam board to block the children's eyes from direct sunlight and to improve contrast (Fig. 11.14).

Homemade spectroscopes make great projects to do with older kids using materials found in most homes. A quick Internet search will result in numerous design options with easy-to-follow instructions (Figs. 11.15, 11.16, and 11.17)

The sketching process couldn't be simpler. Although colored pencils and crayons are suitable for this exercise, when it comes to fun, pastels take the prize every time! Pack enough to go around with plenty to spare.

Suggested Materials

- Black paper, any type (even construction paper is acceptable for this activity)
- Roll of artist or masking tape (or any tape that is easily removed)

Fig. 11.12 As the storm passed by, raindrops were captured by the Sun's emerging rays to produce the rainbow set against the dark clouds behind Kim Hay. Rainbows are made of all the visible colors of the solar spectrum. (By Kim Hay)

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 11.13 An inexpensive, entry-level pocket spectroscope that is perfect for outreach. (By Erika Rix)

Fig. 11.14 The pocket spectroscope is fitted with a homemade sun shield to improve contrast and protect the children's eyes from direct sunlight. (By Erika Rix)

Fig. 11.15 Homemade spectroscope using cardstock, black paper, electrical tape, glue, an aluminum can, and a DVD. (By Erika Rix)

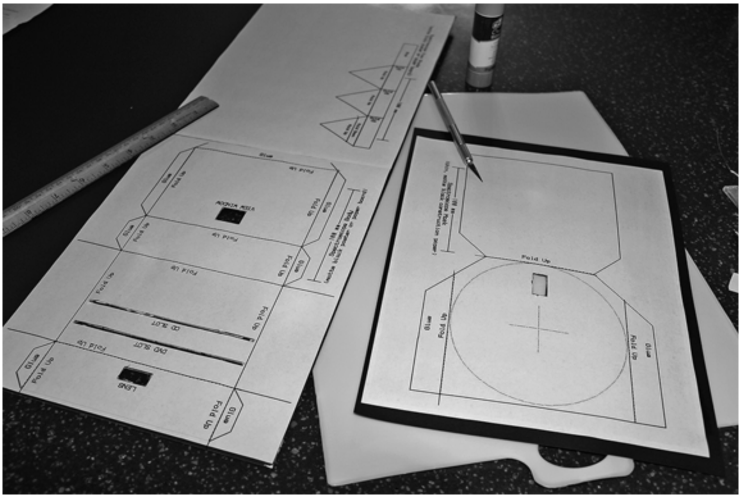


Fig. 11.16 Several types of homemade spectroscopes and the instructions to make them are available over the Internet. These make wonderful solar projects to do with children. (By Erika Rix)

Warning! ALWAYS use a suitable filter when directly observing the Sun

Fig. 11.17 Erika Rix using her homemade DVD spectroscope. (By Erika Rix)

- Pastel or chalk with various hues of the solar spectrum
- Clipboards or sheets of hard cardboard to tape the paper to
- Ruler
- Paper towels for cleanup
- Large rubber erasers
- Can of fixative spray

It's best to work in small groups for this activity station. There should be enough spectroscopes (or whichever spectral observing equipment you opted for) on hand so that each child within the group has one of their own to use.

Step 1

Attach the paper to the clipboard. Then, with several strips of tape, create a 4-inch by 8-inch rectangular outline onto the paper.

Step 2

Demonstrate how to use the spectroscope properly before handing it to the child. The view should resemble the color spectrum in Fig. 11.18.

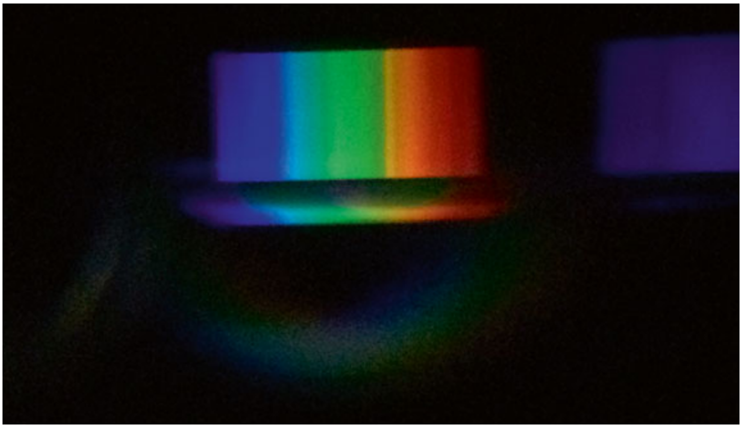


Fig. 11.18 Visible solar spectrum as seen through the pocket spectroscope. (By Erika Rix)

Fig. 11.19 Pastels are used on black paper to draw the visible solar spectrum as observed through a spectroscope. (By Erika Rix)

Step 3

Beginning with the color seen in the middle of the spectral view (shown as green in Fig. 11.18), the child should choose a matching pastel color to fill in that area of the rectangle on the paper. The markings should be as straight as the child can make them. Also, as different colors as added, they should overlap somewhat to represent the smooth transitions within the spectrum (Fig. 11.19).

Step 4

Starting at one end of the rectangle and working toward the opposite end, the pastel markings are rigorously blended with the child's fingertips. Again, the blending movements should be as straight as possible (Fig. 11.20).

Step 5

If absorption lines or streaks of darker color are seen, the pastels are used to draw them as shown in Fig. 11.21. Use a ruler and the corner of the pastel stick to create the line. Note that the same colors are used, only with more contrast.

Step 6

A final light blend completes the sketch. The tape should gently be removed and discarded. Next, the child can remove excess pastel dust outside of the rectangle with an eraser. Include the date and the child's name on the drawing and then lightly spray it with a fixative (Fig. 11.22).

The sky's the limit when it comes to outreach. The activities in this chapter barely scratch the surface on the many ways we can present solar astronomy to children. The more creative and fun the activities are…well, you know the rest. Have a great time exploring the options. And more importantly, have a *blast* sharing the Sun with kids!

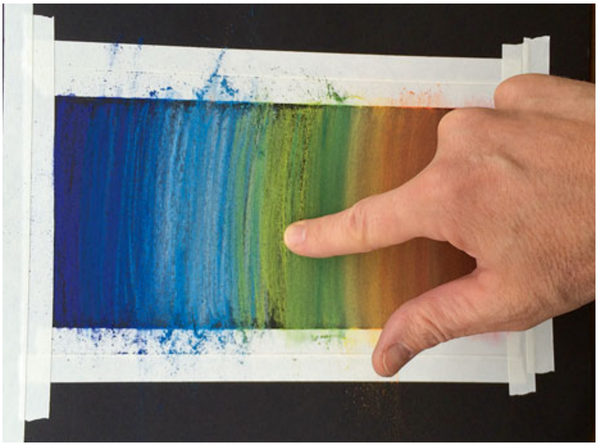


Fig. 11.20 Fingertips can be used to blend the pastel markings while rendering the smooth appearance of the spectrum. (By Erika Rix)

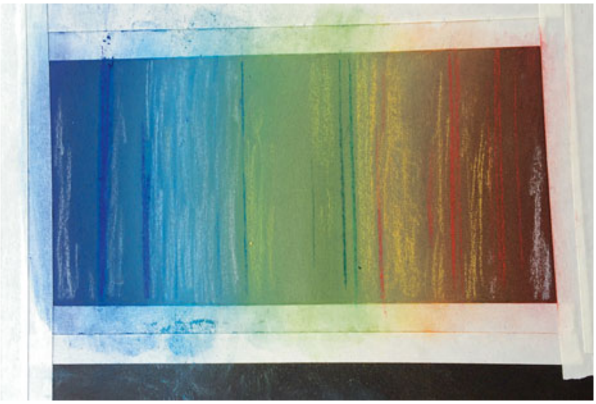


Fig. 11.21 Absorption lines are added next with the aid of a ruler. (By Erika Rix)

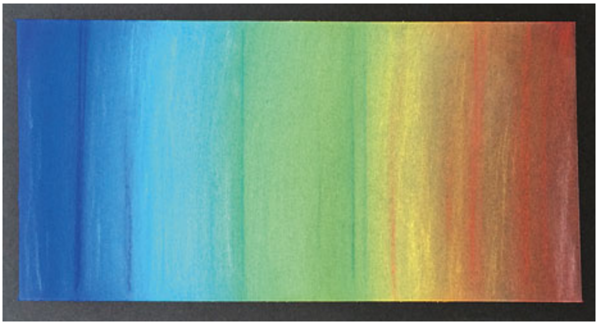


Fig. 11.22 Drawing the solar spectrum with colored pastels provides a fun hands-on activity for the children as they learn more about the Sun. (By Erika Rix)

A Final Note from the Authors

Many individuals have donated their time and talents to bring you a comprehensive stepping stone to discovering the Sun in its many aspects, whether represented in white light, Hydrogen-alpha, or Calcium K wavelengths. The techniques showcased in this unique volume portray a Sun we have perhaps never seen so strikingly—but a view that everyone, artist, scientist, and layman alike, can share.

We hope that you have enjoyed exploring the fusion of artistic technique, solar science, and observational methodology presented in this book. Regardless of your previous sketching and observing experience, there is always something new to learn about the Sun and how to capture it on paper in the media of your choice.

Liberty Hill, TX, USA	Erika Rix
Yarker, ON, Canada	Kim Hay
Wokingham, Berkshire, UK	Sally Russell
Jacumba, CA, USA	Richard Handy

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical Astronomy Series 178, DOI 10.1007/978-1-4939-2901-6

Fig. 1 Sally Russell with her Coronado double-stacked PST and Astro-Physics 105 mm f/5.8 Traveler fitted with a Kendrick white light filter

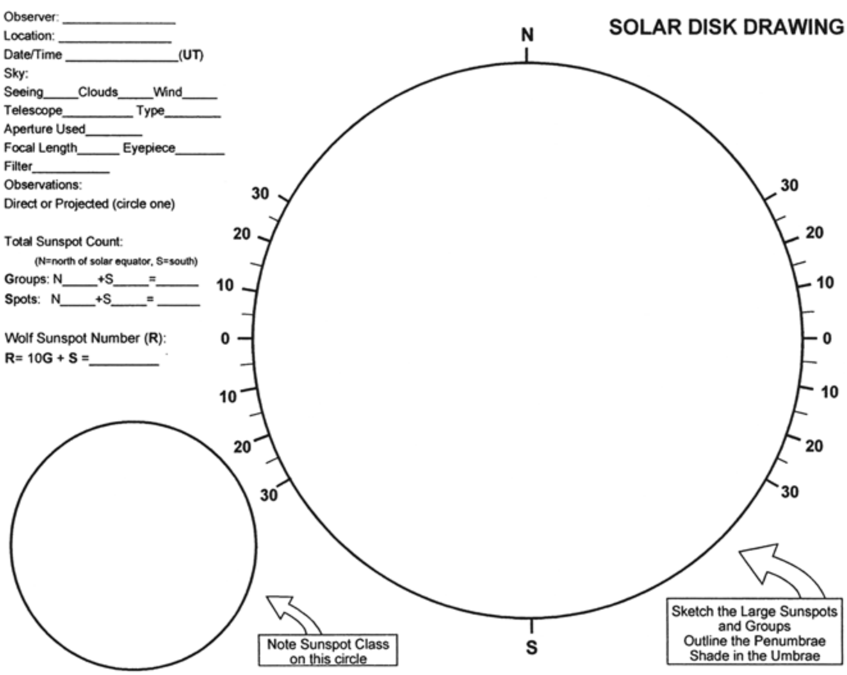
Fig. 2 Kim Hay with her Bausch & Lomb 100 mm SCT fitted with a Thousand Oaks type 2+ glass solar filter, optical density 5.0

Fig. 3 Rich Handy with his 8-inch Mak-Cass and sketching kit

Fig. 4 Erika Rix with her internally double-tacked H-alpha Coronado Maxscope 60mm and a Celestron Omni XLT 102 mm f/9.8 refractor fitted with a Thousand Oaks type 2+ glass solar filter, optical density 5.0

Appendix A

Observing Forms


Observer: ______________
Location: ______________
Date/Time ______________(UT)
Sky:
Seeing_____Clouds_____Wind_____
Telescope_________ Type_______
Aperture Used_______
Focal Length_____ Eyepiece______
Filter__________
Observations:
Direct or Projected (circle one)

Total Sunspot Count:
(N=north of solar equator, S=south)
Groups: N_____+S_____=______
Spots: N_____+S_____= ______

Wolf Sunspot Number (R):
R= 10G + S =________

SOLAR DISK DRAWING

Fig. A.1 AL solar disk drawing form (Image courtesy of The Astronomical League, www.astroleague.org)

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical Astronomy Series 178, DOI 10.1007/978-1-4939-2901-6

SUNSPOT DRAWING

Observer: ______________________________
Universal date/time: _____________________
Sky quality: ______________________________
(Excellent, good, fair, poor)
Seeing in arc seconds: __________________
(smallest detail seen where a photospheric granule is 1.5-2 arc seconds)

Location: ____________________________
Telescope effective aperture: __________
Telescope focal length: _____________
Eyepiece focal length: _____________
Magnification: ___________________
Filter type: __________________________

Three letter McIntosh Sunspot Classification: ______________________

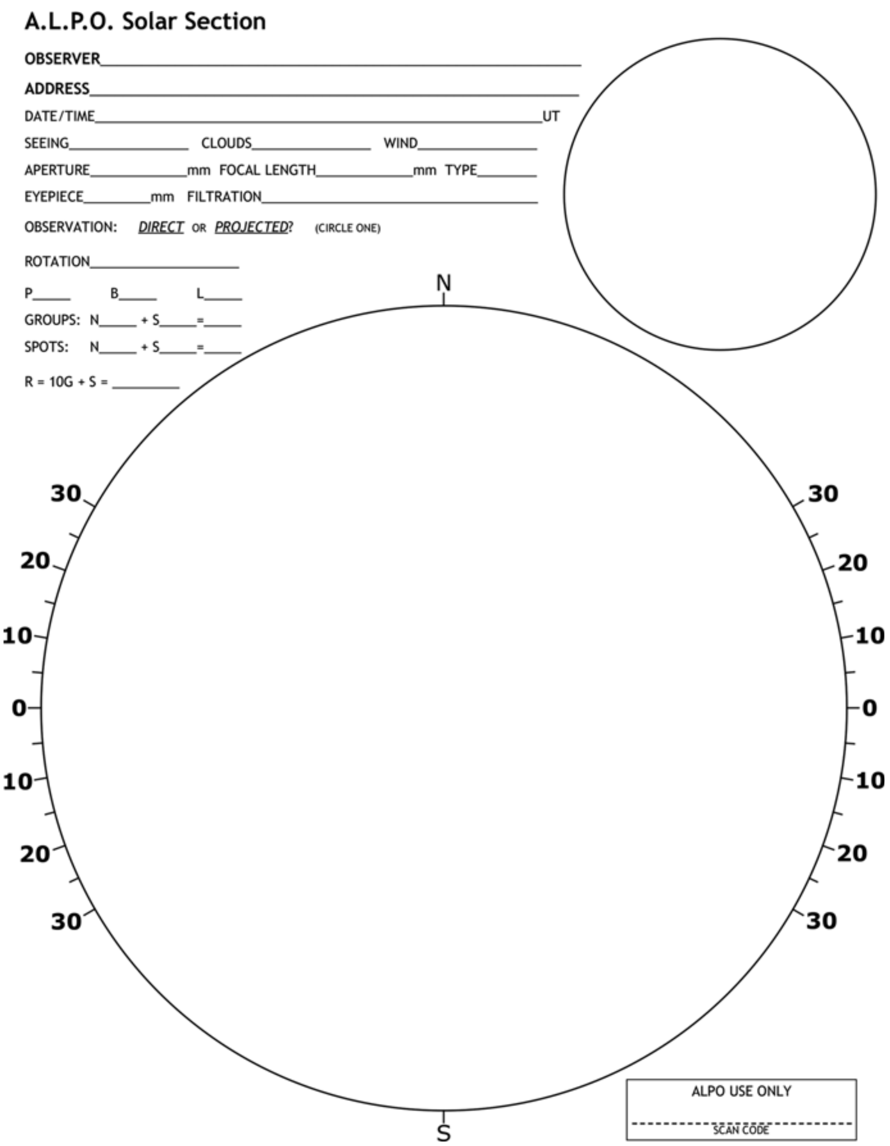
Label the following on your sunspot drawing:

- Umbra
- Penumbra
- Facula
- Light bridge (if present)
- Penumbril fibril (if visible)
- Show *approximate* direction of Solar North with an arrow

Answer the Following

-
- Is granulation visible? yes___ no___
- Is penumbral grain visible? yes __ no __
- Does drawing show Wilson effect? yes __ no __

Fig. A.2 AL sunspot drawing form (Image courtesy of The Astronomical League, www.astroleague.org)



A.L.P.O. Solar Section

OBSERVER____________

ADDRESS____________

DATE/TIME____________UT

SEEING________ CLOUDS________ WIND________

APERTURE________mm FOCAL LENGTH________mm TYPE________

EYEPIECE________mm FILTRATION____________

OBSERVATION: *DIRECT* OR *PROJECTED?* (CIRCLE ONE)

ROTATION____________

P_____ B_____ L_____

GROUPS: N_____ + S_____=_____

SPOTS: N_____ + S_____=_____

R = 10G + S = _________

ALPO USE ONLY

SCAN CODE

Fig. A.3 A.L.P.O. solar disk drawing report form (Permission granted by the Association of Lunar and Planetary Observers, www.alpo-astronomy.org)

A.L.P.O.SOLAR SECTION
ACTIVE REGION DRAWING REPORT FORM

SKY/SITE

Date/Time(UT) ____

Rotat.No. _____ A.R. _______ Cen.Meridian ______ Altitude ______

Sky cond. _________ Seeing _______ Clouds _________ Wind ______

Observatory type (circle one): roll off roof, roll off bldg., dome, none

TELESCOPE:

Inst. type _________________ Mounting type ____________________

Clock drive? ____ Type of drive _________________________________

Full aperture ___________________ Focal length ________ f/_____

Aperture stop/type ___________________ Final f/_________________

Address: Phone No. ( )area code________________

Fig. A.4 A.L.P.O. active region drawing report form (Permission granted by the Association of Lunar and Planetary Observers, www.alpo-astronomy.org)

BAA Solar Section

Year: **Month:**

Active Area and Relative Sunspot Number Report Form

Day	UT	S	gn	fn	gs	fs	g	f	R	NOTES
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										

Days observed:
Instrument:

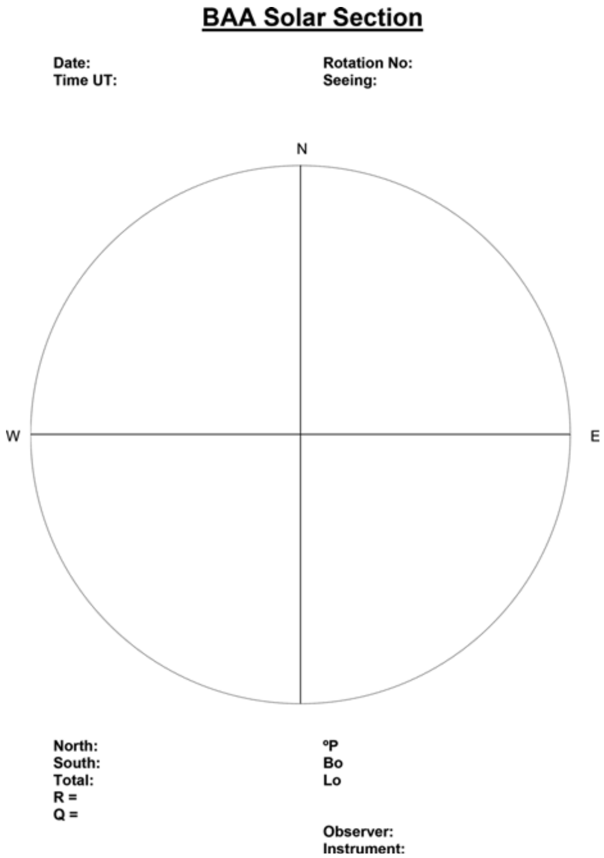
MDFgn=
MDFgs=
MDFg=
R=

Direct or Projection?

Name:
Address:

S = Seeing: 1 = Excellent; 2 = Good; 3 = Fair; 4= Poor; 5 = Bad

Fig. A.5 BAA active area and relative sunspot number report form (Shown by kind permission of the British Astronomical Association, www.britastro.org)



BAA Solar Section

Date: Rotation No:
Time UT: Seeing:

N
W E

North: °P
South: Bo
Total: Lo
R =
Q =

Observer:
Instrument:

Fig. A.6 BAA solar disk drawing report form (Shown by kind permission of the British Astronomical Association, www.britastro.org)

BAA Solar Section **Year:** **Month:**

Active Area Hydrogen Alpha Report Form

Day	UT	S	Prominences		Plages	Faculae	Filaments	Flares	NOTES
			Active	Quiet					
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
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19									
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21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									
Totals:									
MDF:									

Days observed:
Instrument:
Method:

Name:
Address:

S = Seeing: 1 = Excellent; 2 = Good; 3 = Fair; 4 = Poor; 5 = Bad
Q = Quality count

Fig. A.7 BAA active area hydrogen-alpha report form (Shown by kind permission of the British Astronomical Association, www.britastro.org)

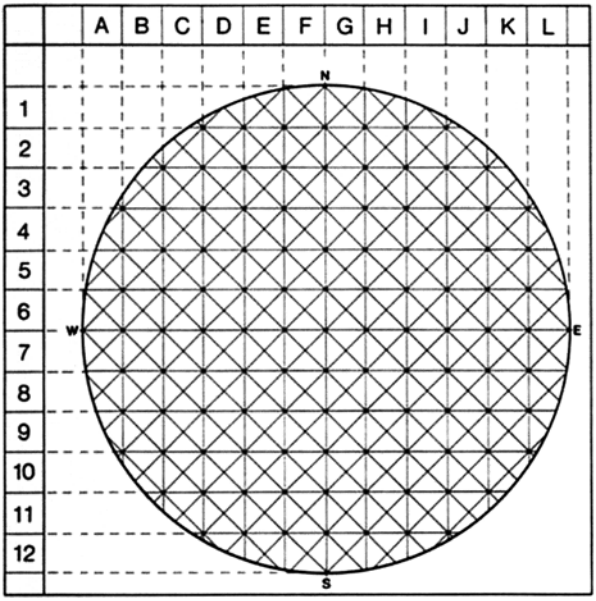


Fig. A.8 BAA solar grid (Shown by kind permission of the British Astronomical Association, www.britastro.org)

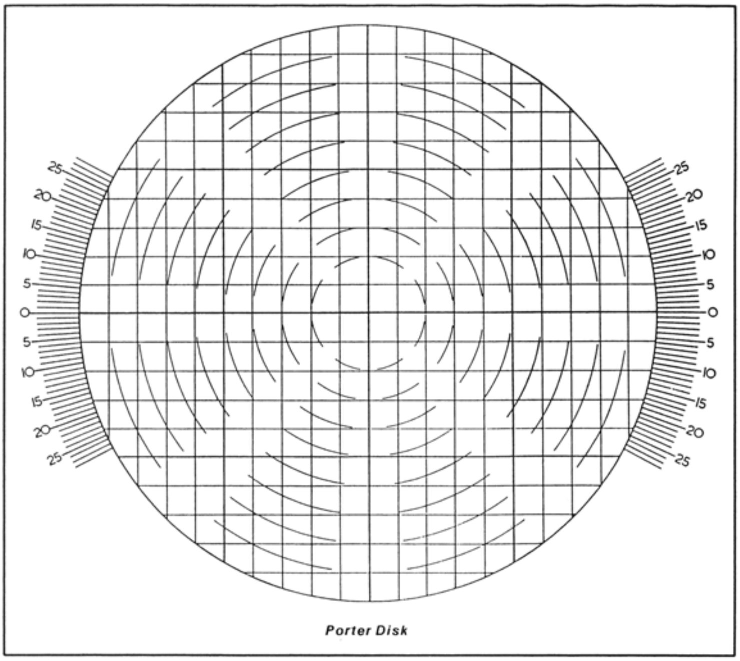


Fig. A.9 Porter disk (Shown by kind permission of the British Astronomical Association, www.britastro.org)

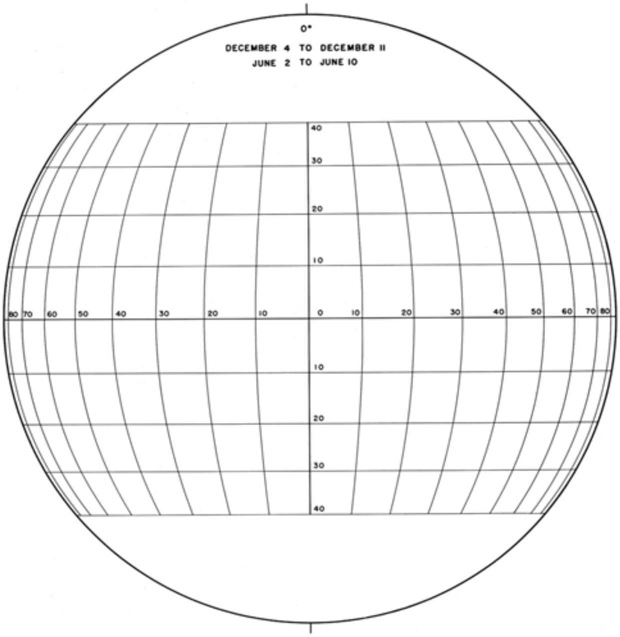


Fig. A.10 Stonyhurst disk 0° (Shown by kind permission of the British Astronomical Association, www.britastro.org)

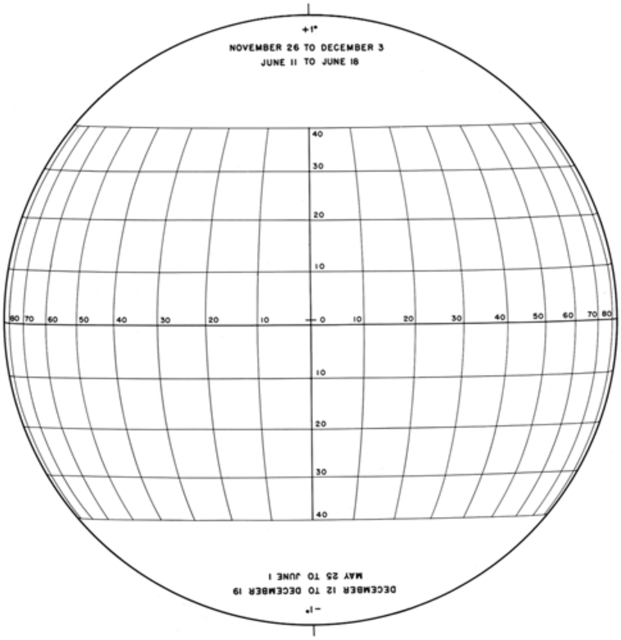


Fig. A.11 Stonyhurst disk 1° (Shown by kind permission of the British Astronomical Association, www.britastro.org)

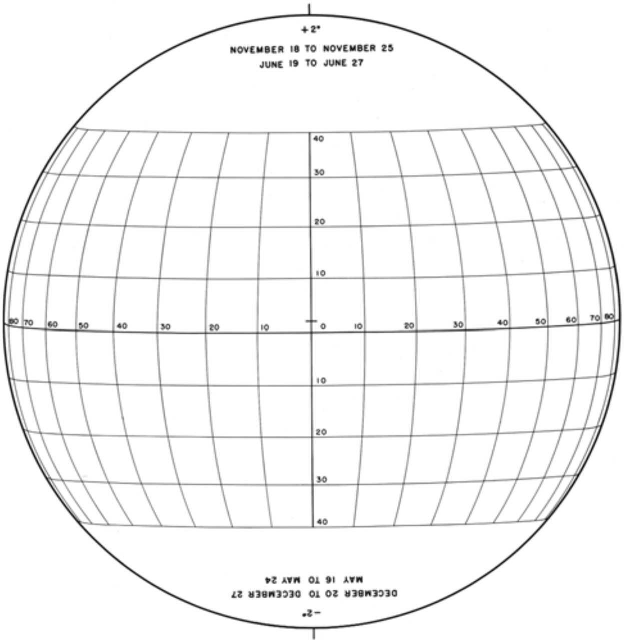


Fig. A.12 Stonyhurst disk 2° (Shown by kind permission of the British Astronomical Association, www.britastro.org)

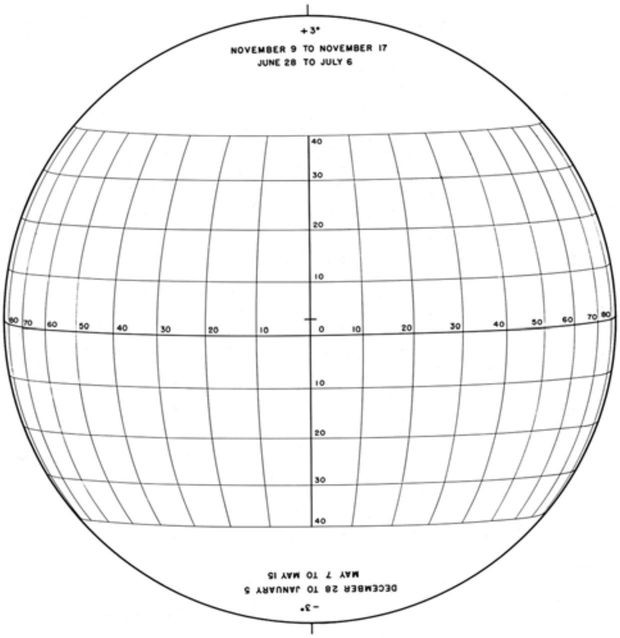


Fig. A.13 Stonyhurst disk 3° (Shown by kind permission of the British Astronomical Association, www.britastro.org)

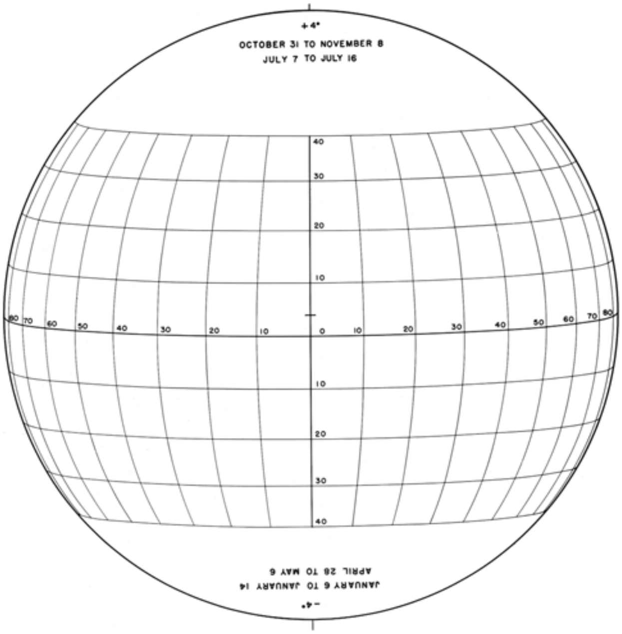


Fig. A.14 Stonyhurst disk 4° (Shown by kind permission of the British Astronomical Association, www.britastro.org)

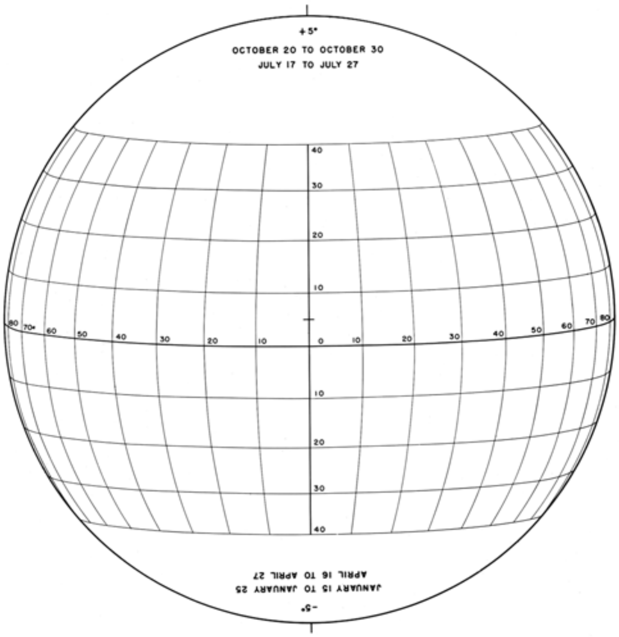


Fig. A.15 Stonyhurst disk 5° (Shown by kind permission of the British Astronomical Association, www.britastro.org)

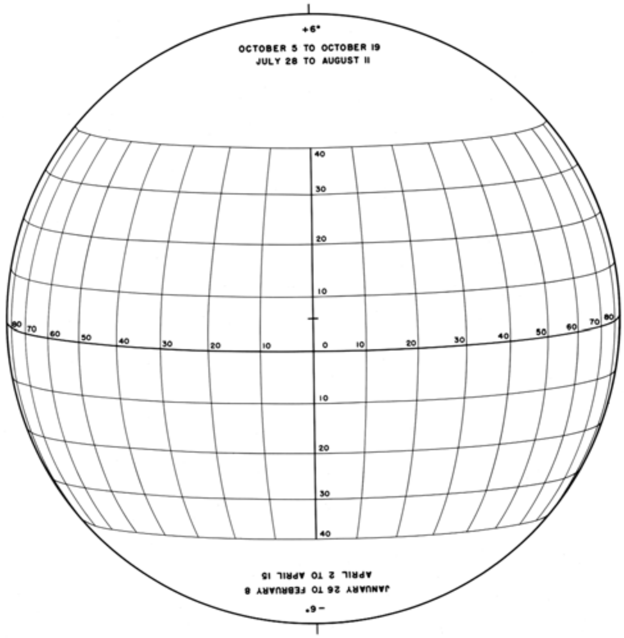


Fig. A.16 Stonyhurst disk 6° (Shown by kind permission of the British Astronomical Association, www.britastro.org)

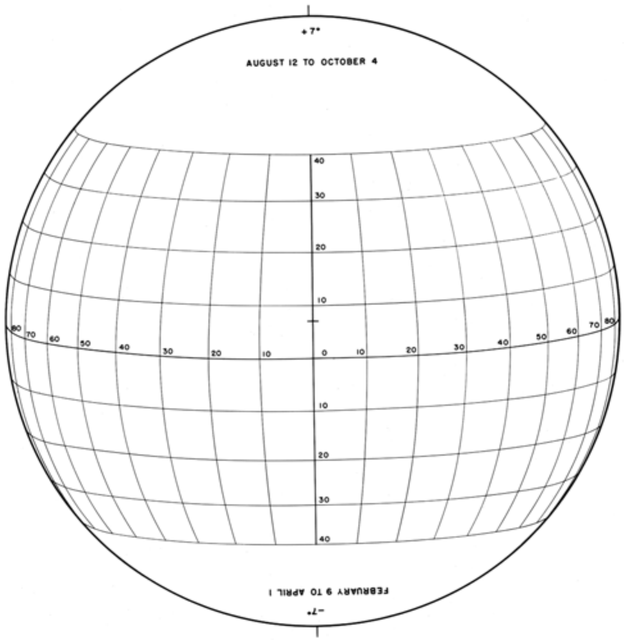
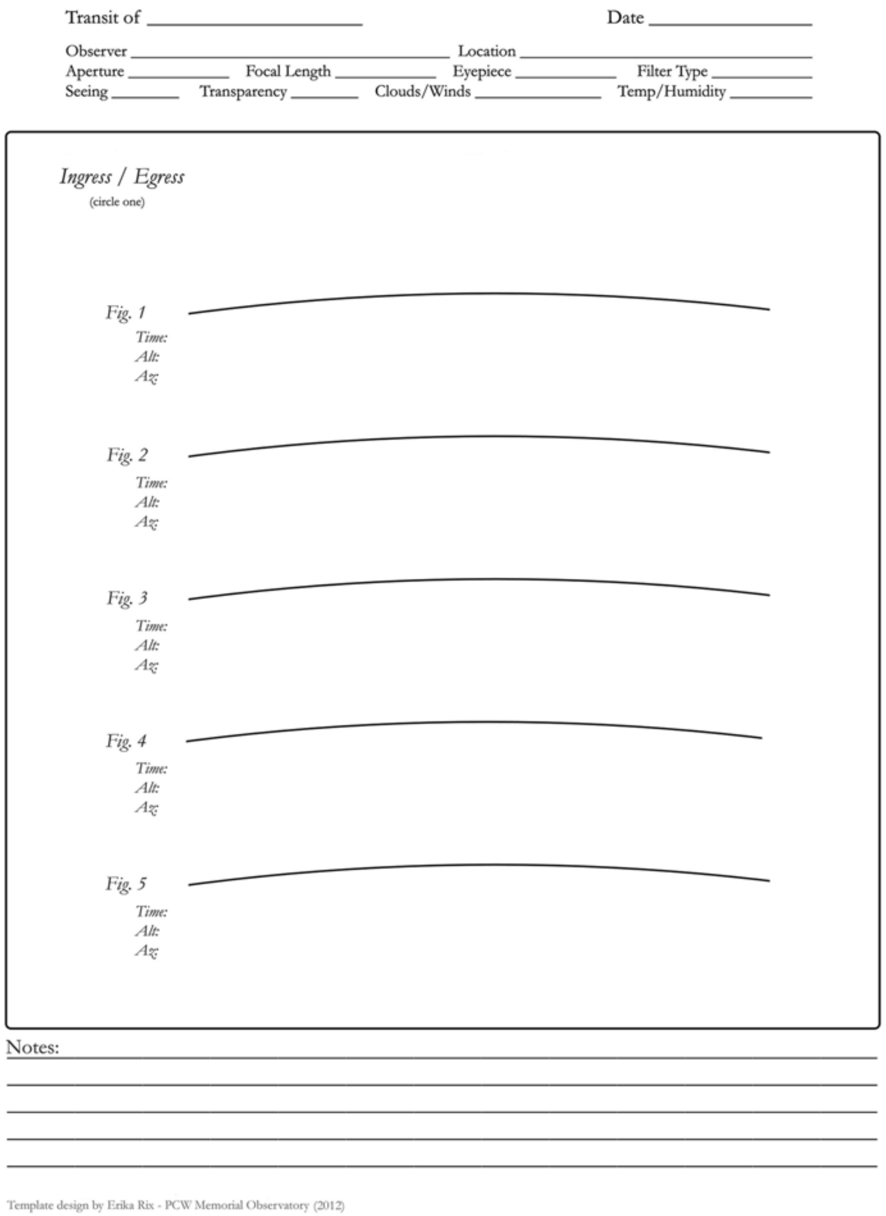


Fig. A.17 Stonyhurst disk 7° (Shown by kind permission of the British Astronomical Association, www.britastro.org)



Transit of ____________ Date ____________

Observer ____________ Location ____________

Aperture ________ Focal Length ________ Eyepiece ________ Filter Type ________

Seeing ______ Transparency ______ Clouds/Winds ________ Temp/Humidity ______

Ingress / Egress

(circle one)

Fig. 1
Time:
Alt:
Az:

Fig. 2
Time:
Alt:
Az:

Fig. 3
Time:
Alt:
Az:

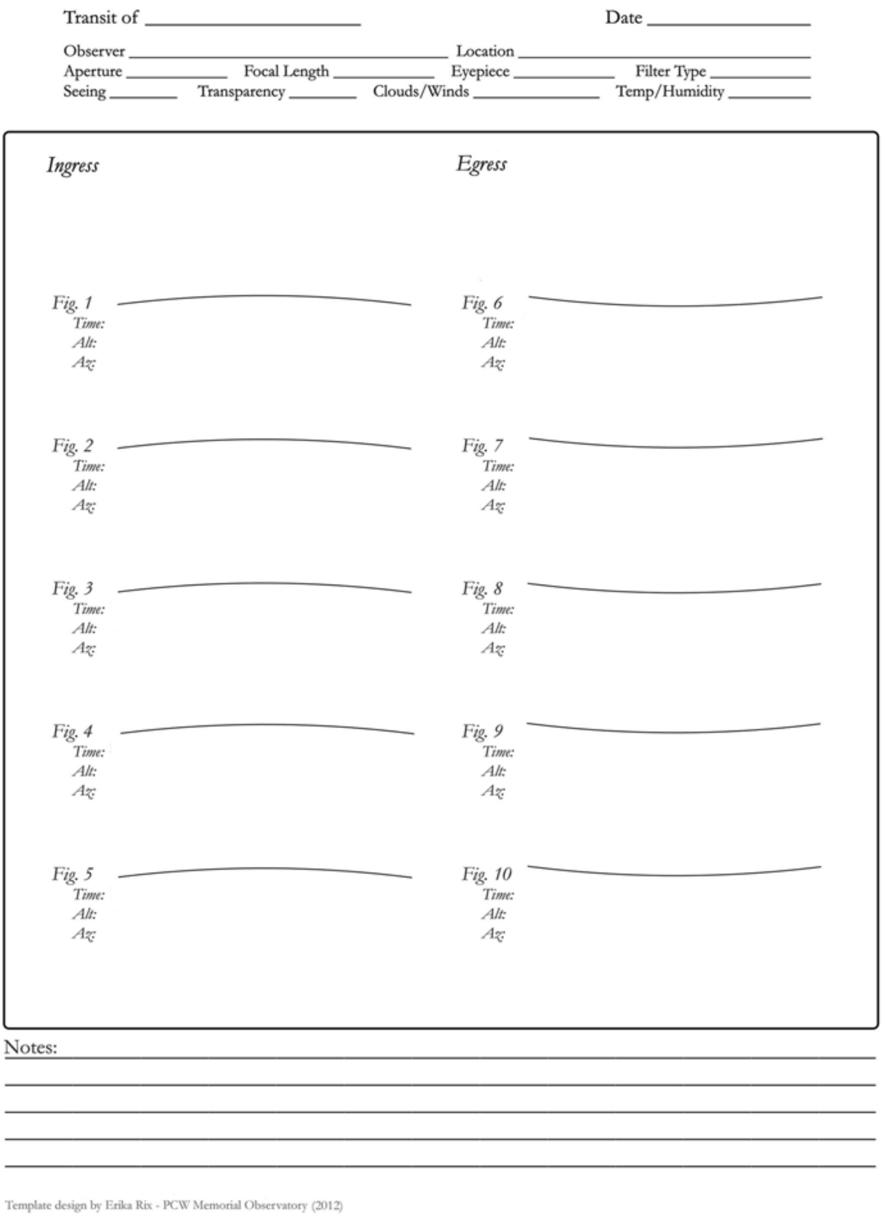
Fig. 4
Time:
Alt:
Az:

Fig. 5
Time:
Alt:
Az:

Notes: ____________

Template design by Erika Rix - PCW Memorial Observatory (2012)

Fig. A.18 Transit limb contact drawing form (By PCW Memorial Observatory, Erika Rix)



Transit of ____________ Date ____________

Observer ____________ Location ____________
Aperture ________ Focal Length ________ Eyepiece ________ Filter Type ________
Seeing ______ Transparency ______ Clouds/Winds ________ Temp/Humidity ______

Ingress

Fig. 1
Time:
Alt:
Az:

Fig. 2
Time:
Alt:
Az:

Fig. 3
Time:
Alt:
Az:

Fig. 4
Time:
Alt:
Az:

Fig. 5
Time:
Alt:
Az:

Egress

Fig. 6
Time:
Alt:
Az:

Fig. 7
Time:
Alt:
Az:

Fig. 8
Time:
Alt:
Az:

Fig. 9
Time:
Alt:
Az:

Fig. 10
Time:
Alt:
Az:

Notes: ____________

Template design by Erika Rix - PCW Memorial Observatory (2012)

Fig. A.19 Transit limb contact drawing form (By PCW Memorial Observatory, Erika Rix)

Transit of ____________________ Date ________________

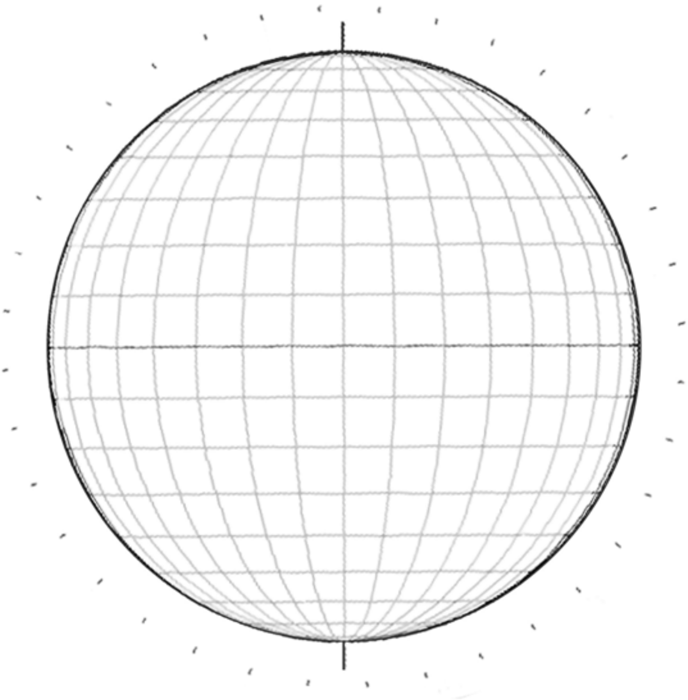
Observer ______________________________ Location ____________________________
Aperture __________ Focal Length __________ Eyepiece __________ Filter Type __________
Seeing _______ Transparency _______ Clouds/Winds ____________ Temp/Humidity ________

1st Contact
Time: ______ *Alt:* ______ *Az:* ______

3rd Contact
Time: ______ *Alt:* ______ *Az:* ______

2nd Contact
Time: ______ *Alt:* ______ *Az:* ______

4th Contact
Time: ______ *Alt:* ______ *Az:* ______



Notes: ____

Template design by Erika Rix - PCW Memorial Observatory (2012)

Fig. A.20 Transit disk drawing form (By PCW Memorial Observatory, Erika Rix)

Appendix B

Glossary

Acid-free paper Paper that is basic pH 7, and lignin- and sulfur-free.

Adobe Photoshop Raster graphics editing software that was developed and published by Adobe Systems for Windows and OS X.

Anchor (marker) points Small marks made on a sketch specifically to map out the shape and extent of the planned drawing, or previously drawn markings which can be used for the same purpose.

Antoniadi scale Scale used to record atmospheric turbulence, devised by E. M. Antoniadi.

1. Perfect seeing with no quivering
2. Slight quivering with moments of calm
3. Moderate seeing
4. Poor seeing with constant tremors
5. Very poor seeing to the point that it is near impossible to create a sketch

Aperture mask Circular piece of cardboard or metal plate that has been cut down to the size of a telescope's front cell. There is a 3- to 4-inch off center hole cut into the mask, so that when fitted over the front of the telescope, it stops down (decreases) the telescope aperture.

Arc A curved line, often drawn to represent the limb of the Sun. Arcs can be drawn using a compass, other template or freehand, depending on the scale of the drawing.

Art gum eraser Rubber gum eraser that crumbles easily for removing lightly applied Conté crayon, graphite pencil, and charcoal, or creating partial erasures.

E. Rix et al., *Solar Sketching*, The Patrick Moore Practical Astronomy Series 178, DOI 10.1007/978-1-4939-2901-6

Aurora A colorful visual display resulting from energetically charged particles from the Sun interacting with atoms in the Earth's upper atmosphere. The Earth's magnetic field channels the particles towards the polar regions.

Baily's beads Strand of bright beads of light visible at the Sun's limb during a solar eclipse just before and after totality. Caused by rays of sunlight shining through the Moon's valleys and terrain. Named after British astronomer, Francis Baily, who first described them in 1836.

Bipolar sunspot group Two or more spots that form an elongated cluster extending the length of three or more heliographic degrees. If there is a large principle spot, the cluster should then extend more than 5°.

Blending stump A pencil-sized instrument made of tightly rolled paper and pointed at two ends, used for precise blending and for the drawing of soft marks. Blending stumps can be cleaned and re-sharpened using sandpaper or a sanding block.

Calcium K (CaK) Observing the Sun in the calcium wavelength 393.37 nm, 3933.7 Å.

Cardinal directions The main compass points, north, south, east, west. These are usually added to a sketch to show the orientation of the drawing. This is particularly useful if an inverting optical configuration has been used.

Carpentry pencil sharpener Pencil sharpener for large graphite carpentry markers, also very useful when used to sharpen large pencils, Conté crayons, dry pastel sticks and compressed charcoal sticks.

Cartridge paper (Daler-Rowney) A smooth white paper available in various weights. Can be used for drawing and also for light washes.

Chalk pastel Sticks comprised of soft chalk, pigment and binder useful for making soft markings and quickly covering large areas. They shed a lot of powdery residue that needs to be frequently removed by gently blowing across the paper (use a bulb blower, or physically blow across the paper).

Chamois Soft leather cloth used to blend or remove layers of applied media.

Charcoal Carbonized wood medium applied to paper to produce a wide range of gray tones from deep black to brilliant white. Available in either compressed sticks of black, white or gray tones, or as charcoal vine.

Chromosphere The layer of solar atmosphere above the photosphere and below the corona.

Clipboard A wooden or metal back board with a mechanical clip to hold paper flat against a smooth surface while sketching.

Colored pencils Pencils having a pigmented wax-based core surrounded by a wooden casing.

Compass Instrument used for scribing accurate circles of varying radii.

Conté crayons Sticks of compressed powdered graphite and clay manufactured in France. Conté crayons have an intense, yet easily blended, pigment and apply readily to a wide range of paper types and textures.

Convective zone An inner layer of the Sun where energy is transferred by convection.

Corona The outer layer of the solar atmosphere, with low densities and high temperatures.

Coronal loops Structures from the lower corona. These are associated with magnetic flux from the Sun.

Coronal Mass Ejection (CME) An eruption of solar particles from the solar surface.

Cosmetic brush An inexpensive, soft bristle brush to remove erasure debris from a drawing.

Craft (utility) knife A sharp metal blade with a metal handle for precision cutting, trimming and sharpening of erasers, pencils, compressed charcoal or pastel sticks.

Derwent Graphitint Pencils Water-soluble graphite pencils with a hint of color to produce soft, smooth markings in a wide range of hues.

Driven mount A powered telescope mount that is capable of tracking celestial objects.

Dry cleaning pad Cloth bag filled with a fine non-abrasive gum rubber powder that is used to remove smudges from sketches.

Easel A metal or wooden frame or support for holding sketch pads, sketch boards or canvases upright.

Egress (during transits) The moment when a planet begins to leave the Sun's disk.

Eraser shield A thin metal sheet with precisely milled slots, arcs and holes used to protect the sketch while erasing details.

Facula (*pl.* faculae) Seen in the photosphere often near the limb. Shows up as a bright area and is associated with the appearance of sunspots.

Felt-tipped pens Hard tipped acid-free marker pens with an alcohol based pigment available in a broad range of colors, tip sizes, and shapes.

Filament Gas that is suspended above the photosphere by the Sun's magnetic field. When seen against the surface of the Sun, filaments show as dark lines.

Flare An eruption of energy, radiation and particles from the solar disk.

Gel pen A writing pen that uses a smooth, thick ink in which pigment is suspended in a water-based gel.

GIMP GNU Image Manipulation Program, freeware program for photo retouching, image composition, and image authoring.

Gradation A gentle blending of one tone into another.

Granulation The cellular structure of the photosphere seen during good resolution.

Graphite Lead powder, pencils and lead sticks, available in a wide range of gray tones. Softer leads blend more easily and produce darker tones, while hard leads create lighter tones.

Graphite pencils Pencils that are made from a combination of clay and graphite encased in wood. Graphite typically lacks the dynamic range of charcoal, but because of its finer grain, it has the ability to create smooth, finer detail. Graphite markings tend to be shiny, especially compared to the matte finish of charcoal. This can create a little difficulty seeing the details of the drawing when sketching under the glare of brighter lights, whether artificial or in direct sunlight.

Heliographic coordinates L_o (longitude)—center of the disk; P_o—position of the angle of north; and B_o (latitude)—center of the disk.

Hydrogen-alpha (H-alpha or H*a*) Observing the Sun in the Hydrogen-alpha wavelength 656.28 nm, 6562.8 Å.

India ink Black pigmented ink applied with a either a quill-tipped pen or as a tone wash with a brush.

Ingress (during transits) The moment when a planet begins to move across the Sun's disk.

Internal pentaprism A five-sided prism that deviates a beam of light by a constant 90°. Light is reflected twice inside the prism to transmit the image out at a right angle.

Kneaded (or kneadable) eraser Soft, pliable rubber eraser that can be molded into various shapes to remove or erase a wide array of media, including graphite, charcoal and pastels.

Limb darkening Darkened appearance of the edge of the visible solar disk when compared to the center, caused by the intensity of radiation moving in a vertical direction.

Marker (anchor) points Small marks made on a sketch specifically to map out the shape and extent of the planned drawing, or previously drawn markings which can be used for the same purpose.

McIntosh sunspot classification A system that grades sunspot activity.

Mean Daily Frequency (MDF) An average monthly index of solar activity determined by active regions.

Mechanical pencils Pencil barrels that hold bare leads of various sizes and thicknesses. Generally used for making precision markings.

Minium Bright orange-red pigment used for painting during the Middle Ages.

Mottling (stippling) Small spots or markings applied in a random fashion which give a uniform shading when viewed from a distance.

Mt. Wilson solar seeing scale Scale used to rate atmospheric turbulence during the course of a solar observation. Fractional values are used if the image quality falls between two values.

1. Solar image resembles a circular saw blade. Completely out of focus. Limb motion and resolution greater than 10 arcseconds. Unable to see smaller sunspots.
2. Solar image consistently out of focus with no sharp periods. Limb motion and resolution ranging 5–10 arcseconds.
3. Solar image in focus ~50 % of the time, out of focus ~50% of the time. Short periods of granulation visibility. Limb motion and resolution 3 arcseconds.
4. Solar image is sharper more often than not. Granulation nearly always visible. Limb motion and resolution ranging 1–2 arcseconds.
5. Solar image resembles an engraving. Limb motion and resolution 1 arcsecond or better.

Negative (inverted) sketching A drawing technique where dark markings that are applied to white sketch paper actually represent the light areas of the object. Typically the sketch is later scanned or photographed and inverted to represent the eyepiece view of the object.

O'clock position An imaginary clock face is used as an aid when positioning solar features on the disk. The o'clock position represents the location of a solar feature if a line were drawn across the face of the imaginary clock; e.g., 20° in from a line between 4 o'clock and 10 o'clock.

Oil-based pencils Pencils having a pigmented oil-based core surrounded by a wooden sheath. Creates rich, smooth markings without a waxy buildup.

Pastel A compressed powdered pigment or oil-based pigment available in stick or pencil form in a wide spectrum of colors.

Penumbra (*pl.* penumbrae) The area that surrounds the darker area (umbra) of a sunspot.

Photosphere The lowest layer of the solar atmosphere in which sunspots and faculae are viewed in white light.

Plage An extended area around an active region that appears during the early stages of a magnetic flux.

Plastic (vinyl) eraser A soft, non-abrasive eraser that is good for removing light pencil marks, but which is prone to produce smearing when used for darker marks or large areas. They can be cut to fine points using a craft knife.

Position angle (PA) 360° markings, clockwise, to represent prominence positions around the solar limb.

Positive (non-inverted) sketching A drawing technique where light markings are applied to black sketch paper to represent the actual light areas of the object. Because the drawing is viewed in its correct dark and light tones, there is no need to invert it after scanning to represent the true eyepiece view.

Prominence A filament of gas suspended over the photosphere by a magnetic field line. Extends from the Sun's limb.

Radial drawing The action of sketching outwards from a fixed point giving the effect of lines diverging from a common center.

Radiative zone A layer inside the Sun that releases energy with radiative properties.

Relative sunspot number An index measurement of sunspots and sunspot groups in the photosphere.

Sandpaper block Sandpaper strips mounted on a solid support, used to sharpen drawing media and blending stumps. Also used to create a powdered medium with the residue.

Scale The relative size of your sketch; e.g., a whole disk solar sketch drawn on a large scale will take longer to complete due to the larger area to cover in the time available, but with the ability to add more detail within that scale.

Schematic drawing A drawing in which the detail is simplified into symbolic shapes. Features may be drawn in outline rather than realistically.

Seeing Scale to rate atmospheric turbulence.

Solar cloth (or hood) Fabric that is black on the underneath and preferably white or reflective on top. It is placed over the head and eyepiece area while observing to cut out stray light and improve dark adaptation.

Solar core The Sun's center.

Solar cycle An 11-year cycle in which the Sun goes through a low activity level (solar minimum) to a high activity level (solar maximum).

Sponges Natural and synthetic sponges that are used to blend broad areas of applied media and are frequently cut to various sizes for easy application.

Stippling (mottling) Small spots or markings applied in a random fashion which produces a uniform shading when viewed from a distance.

Strathmore paper An acid-free drawing paper that is available in a number of colors and weights.

Sudden Ionospheric Disturbance (SID) Intense X-ray and ultraviolet radiation is released during a solar flare and this excites the D layer of Earth's atmosphere. This can result in an increase of radio-wave absorption detectable with SID receivers.

Sun Funnel Solar projection device that fits into the eyepiece holder of a telescope, constructed of projection screen material, a funnel, and an eyepiece.

Sun shield Flat panel usually made of foam board or metal that fits over the optical tube and blocks direct sunlight from the eyepiece.

Sunspotter Solar Telescope A self-contained Keplerian designed unit for ground or tabletop solar projection that enables safe solar observing, particularly around children or at outreach events.

Tachocline An area between the radiative and the convective zones of the Sun.

Technical pens Ink pens typically used for architectural and engineering drawing. They are available in precision widths and are regarded as flow pens because the ink is applied without a ball bearing tip as with standard ink pens.

Template A printable document including a pre-drawn circle to represent either the view through the eyepiece or the solar disk, with space for noting down the relevant data of the observation. Solar disk templates may include grid-lines that represent the inclination of the Sun at different times of the year. Many astronomical institutions have their own templates for the submission of observations.

Texture The roughness of a surface or paper. *See tooth (of the paper)*

TiltingSun Freeware that can be used to determine the absolute orientation of the solar disk at any time, anywhere on the Earth, using any kind of telescope and mount. www.atoptics.co.uk/tiltsun.htm

Tone The degree of lightness or darkness of the sketched area.

Tooth (of the paper) The texture of a paper that allows it to hold an applied medium.

Tortillon A pencil-sized instrument made of tightly rolled paper and pointed at both ends, used for precise blending and for the drawing of soft marks. Tortillons can be cleaned and re-sharpened using sandpaper or a sanding block.

Umbra (*pl.* umbrae) The dark area of a sunspot.

Unipolar sunspot group A single or compact cluster of sunspots with the greatest separation between spots being less than 3 holographic degrees.

Utility (craft) knife A sharp metal blade with a metal handle for precision cutting, trimming and sharpening of erasers, pencils or compressed charcoal or pastel sticks.

Vinyl (plastic) eraser A soft, non-abrasive eraser that is good for removing light pencil marks, but which is prone to produce smearing when used for darker marks or large areas. They can be cut to fine points using a craft knife.

Visualization A mental image of the visual view.

Watercolor pencils Pencils in wooden casings that have leads made of compressed watercolor pigments. The pencils are particularly useful for drawing on colored or black paper as the rich pigments show up well on dark backgrounds. On white paper the pencil strokes can be saturated with water and spread with brushes, acting like normal watercolor paint.

Weight The heaviness or density of a paper based on a standard size and quantity of the ream. Generally, the lighter it is in pounds, the thinner the paper, and the heavier, the thicker the paper will measure.

White light All available light viewed in the photosphere while using a proper solar filter.

X-Acto knife (utility knife) A sharp metal blade with a metal handle for precision cutting, trimming and sharpening of erasers, pencils or compressed charcoal or pastel sticks.

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Cloudy Nights – Solar Observing and Imaging Forum. http://www.cloudynights.com/forum/87-solar-observing-and-imaging/
CYN Observers and Observing – The Sunspotter Solar Telescope and Activity for the Sunspotter Solar Telescope. http://www.cnyo.org/2013/09/20/barlow-bobs-corner-x-2-the-sunspotter-solar-telescope-activity-for-the-sunspotter-solar-telescope/
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ESA/NASA Solar and Heliospheric Observatory (SOHO). http://sohowww.nascom.nasa.gov/
Historical Archive of Sunspot Observations. http://haso.unex.es/
Jhelioviewer – Visualization Software for Solar Image Data. http://jhelioviewer.org/
Lunt Solar Systems. www.luntsolarsystems.com
Meade Instruments – Coronado Solar Telescopes and Filters. www.meade.com/products/coronado.html
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NASA Solar Dynamics Observatory (SDO). http://sdo.gsfc.nasa.gov/
NASA Solar Terrestrial Relations Observatory (STEREO) – 3D View of the Sun and Heliosphere. http://stereo.gsfc.nasa.gov/
National Solar Observatory Global Oscillation Network Group (NSO GONG) – Data Archives and Near-Real-Time Data. http://gong.nso.edu/
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SolarChat!. http://solarchat.natca.net/
Solar Monitor – Near-Real Time and Archived Information on Active Regions and Solar Activity. http://www.solarmonitor.org/
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