Guidelines for the Reporting of Solar Phenomena

White Light

Monochromatic

Edited by

Jamey Jenkins

Asst. Coordinator, ALPO Solar Section

Originally compiled by

Rik Hill

Lunar and Planetary Labratory

University of Arizona

A Handbook of the Association of Lunar & Planetary Observers Solar Section.

January 2010

3rd Edition

Established 1947

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Acknowledgements

Welcome to the world of solar astronomy. The purpose of this book is to bridge the gap between the casual and serious observer wishing to contribute to the knowledge of the nearest star, our Sun. We are a division of the Association of Lunar and Planetary Observers, organized by Walter Hass in 1947; this Section being established in 1982. The function of the Solar Section is to *stimulate, organize, and disseminate* amateur work in the field of solar morphology. Through the archiving of solar observations we provide a resource for the professional community to supplement their research programs. While we do not offer recommendations regarding sunspot counting or radio flare patrolling, we do accept and archive submitted observations of that nature from observers. Any member wishing to involve themselves deeply in such work should additionally contact the American Association of Variable Star Observers (AAVSO) at 49 Bay State Road, Cambridge, MA. 02138 for guidance. Many of our observers participate in both organizations.

Solar morphology is a particularly rewarding field of study for the amateur astronomer since the features of the Sun are the most active and changing in the whole of the solar system. Because of this dynamic, solar activity requires diligent observing. Some work can be done within the space of a day or two while other projects require a commitment of many days, often consecutive. Neither type of observing is any more important than the other, so observers that make a contribution either way are encouraged to do so. The work of the Solar Section and consequently the focus of our efforts is the recording of visual and photographic observations of the Sun. There is a particular emphasis on photographic observations in white and monochromatic light since these are of the most use to the professional community. Space limitations will require some presumptions on our part that you, as an observer are familiar with astronomical terminology and principles. If you are a novice please contact the Solar Section Coordinator for guidance.

The preparation of this booklet required advice from a number of professional and advanced amateur astronomers to insure that the work of the Solar Section would have immediate and lasting value to astronomy. We gratefully acknowledge the support and aid of those listed below. For our observations to retain value, it will take dedication and commitment from our observers towards producing reliable data that will, by virtue of its own high quality be in demand now and in the future.

—ALPO Solar Section

Contributors

Richard Hill
Gordon Garcia
Rick Gossett
Eric Roel
Christian Viladrich
Phil Rousselle
Jeffery Sandel
Jen Winter
Jamey Jenkins
Fred Veio
Randy Tatum
Ginger Mayfield
Kim Hay
Art Whipple
Monty Leventhal
Vincent Chan
Howard Eskildsen
Ralf Vandebergh

Dr. David Hathaway, NASA/Marshal Space Flight Center
Big Bear Solar Observatory
Larry Combs, SESC

Table of Contents

Solar Section Observing Projects

Morphological Projects

The morphology programs of the ALPO Solar Section are divided into three distinctly different areas. These divisions are the recording of solar morphology through the use of pencil and paper, photographically, and lastly the observation of White Light Flares.

Many amateurs begin their solar observing journey by recording white light sunspot positions with whole disc drawings made at the eyepiece or through the use of the Hossfield projection screen. Some major observatories continue to this day, weather permitting, the making of daily drawings of spot positions. In addition one can make notation of group classifications and the location of faculae on the solar disc drawing. Drawings of solitary spots and sunspot groups (both are called *active regions*) can record fleeting detail that the photographic process misses. Atmospheric turbulence often smears some detail on photos that might otherwise be penciled in on drawings as glimpsed by the purely visual observer. Photographs **are** a particularly valuable resource, but they are not the final word in the observing record. Drawings continue to provide a valuable supplement to any photographic record of solar morphology.

On Photos and Flares

Regardless, the backbone of the Solar Section is the recording photographically of the Sun as either a “whole disc” via a wide angle image and as a close-up “high resolution” image of individual solar features. Many professional observatories attempt to secure a daily whole disc photograph of the Sun in white light but sometimes local weather conditions prevent the observatory from obtaining that record. You, as our lone observer recording the Sun that day may have the only whole disc ground based record available. Most likely you will have the only record available at THAT particular moment in time! It is because of the rapidly changing appearance of the Sun that all records are of equal value—due to their individuality.

High resolution photography can be particularly challenging for the novice. It is not that highly technical skills are required, but that the surrounding environment is constantly working against us. Seeing and instrumental defects are doubled and tripled as the image of the Sun is enlarged to facilitate viewing finer detail. But persistence is the key to success, using the suggestions found in our handbooks you may produce photographic results that rival observations made at large observatories.

Thirdly, we encourage the exploration of particularly energetic events called White Light Flares (WLF). These will appear as a sudden brightening in or very near a sunspot group. A WLF will reach peak brightness after only several minutes and then reverse direction, returning to normal photospheric brightness levels. These are important events because of their effect on the space weather and consequently our near earth environment. All solar observers should be on the lookout for them.

As more and more observers have become actively involved in monochromatic studies, the recording of the changing appearance of disk *and* limb phenomena has gradually overtaken white light observations. Making an excellent monochromatic drawing is more demanding than sketching in white light due to the abundance of features. The Solar Section’s observing forms may be used for either white light or monochromatic observations. Whole disc prominence drawings are better suited to a form that has the latitude guides N and S of the equator "whited-out".

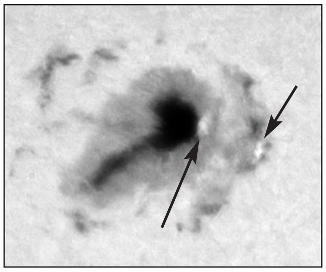


Image provided by Art Whipple of a White Light Flare produced in AR9236 on the 24th of November, 2000.

The arrows indicate areas of brightening which in white light lasted approximately 2 minutes, from 1508 to 1510 Universal Time.

You have taken the first steps in expanding your recreational pursuit of solar observing into a scientific endeavor. We sincerely hope that by now you have developed an appreciation for the inherent dangers in solar observing. Do not take any chances with your eyesight—remember, this is one activity that doesn't give you a second chance. Care and accuracy in making and reporting your observations cannot be overstressed here. You will need to be strictly honest and always be on guard for details perhaps created by the mind's eye; report **only** that of which you are absolutely certain. And lastly, be assured that your hard won efforts will result in a valuable asset!

White light Drawings

As with all forms of solar system drawing, there is a best procedure to follow to achieve the necessary recording of data in the shortest amount of time. Solar features go through rapid changes and must be recorded as quickly as possible.

For a whole disc drawing one should first crudely and quickly mark, using dots or short dashes, the positions of the features to be drawn. The purpose is only to indicate position— so no great amount of time should be wasted here. Next the observer should go back and concentrate on accurate rendering of each individual group. This is best done by first sketching in the umbral regions of each group, paying particular attention to shape and size with respect to the whole disc. Then the penumbral regions should be drawn in using a line to delineate the periphery. For these drawings thin lead mechanical pencils have been found to be the easiest to use. Penumbral areas should not be shaded in; simply outline the outer boundary of the penumbral areas.

With projection telescopes a "grid system" of finely drawn lines may be instituted on the projection screen and a similar grid used to back up the drawing form. The purpose of the grid is the accurate transferring of positions from the viewing screen to the drawing. By noting the positions of features relative to the grid lines on the viewing screen one may easily find the proper location on the recording form.

Direct viewing observers may wish to refer to the Harold Stelzer article contained in the Astronomical League's booklet "Observe and Understand the Sun" regarding the construction and use of a grid system for non-projection observers. Finally, the other information on the form should then be filled in completely and a good clean photo copy obtained to send to the Solar Section recorder.

With active region drawings the procedure is a bit different. First, the umbral regions are accurately drawn. Then the penumbral regions are lightly but accurately sketched in. Next the penumbral regions are to be shaded in, paying attention to intensities, a softer lead pencil may be called for here. The more prominent filaments and any detached umbral material or bright knots involved in the penumbra will be carefully displayed. Great care must be exercised when sketching spots where umbral material borders on normal photosphere since rudimentary penumbra can form and dissipate here in a matter of minutes. The same holds true for larger pores, which may be thought of here as umbral material. These drawings ideally will be completed as quickly as possible and in no cases should drawing times exceed 30 minutes. It is very important that the umbra and penumbra be the proper size in relation to each other and to any remainder of the disc shown. A common fault with many beginning solar observers is to make the regions being studied too large.

In solar projection systems, details may be more clearly seen by shaking the screen slightly back and forth or by moving a white card through the field. A few observers have even gone so far as to construct an observing table with a rotating screen that is fed by a stationary telescope so as to see these details. Both methods will work equally well.

If an observer decides to include the facular regions in their drawings they ought to make an estimate of their brightness in some standardized manner. A three step scale is sufficient for the purposes of the Solar Section. **Dim** is to be used for those regions that are only slightly brighter than the normal photosphere. **Bright** denotes those faculae that can be fairly easily seen near the limb. These would not be visible far into the disc. **Intense** faculae would be very obvious and can be seen well in towards the center of the disc.

These are nearly as bright as a flare and are as obvious as the sunspots. Faculae are to be drawn using dashed outlines to illustrate the difference between penumbra and facular regions.

All observers must be alert for white light flares. If such a flare is observed, a drawing should be made, both of the whole disc and detailed. Make a note of the time (UT), the event's duration, relative brightness, location, and color. Reports of flares should be made IMMEDIATELY to the Section Coordinator.

An indication of scale is to be provided with each drawing that is not whole disc. This can be obtained roughly and simply by measuring the feature sketched with the drift method. To use the drift method, an eyepiece with a reticle or sharp edged field will be needed. Set the reticle or the east edge of the field on the preceding edge of the feature to be measured. If the telescope has a drive, turn it off. Now simply time the feature as it transits the marker being used (be sure to use the same position on the marker for beginning and end). The measured time in seconds (t) is then multiplied by 15(cosD). In this case "D" is the celestial declination of the feature; for approximation just use the declination of the center of the Sun. This will give the width of the feature in arc seconds. The observer may wish to perform this measurement several times for each feature and then take an average of the measures. This measurement should then be indicated on the drawing, showing the points used as extremes in measuring as well as the time and/or arc seconds derived. (Tip! By drawing a line between these two points you have indicated the east-west baseline of your drawing; north-south is perpendicular to this). This will greatly aid the users of the data and make the observation increasingly valuable.

All drawings should indicate celestial north-south and east-west orientation. This can be determined at the same time the drift method measurement is taken (see above). For whole disc drawings with a projection telescope allow the Sun to drift through the field and then orientate the recording form accordingly.

If the observer can accurately determine it, heliographic orientation would be suitable. Rather than have heliographic orientation coordinates that are possibly incorrect, it would be better for the observer to include an accurately determined celestial orientation. Both orientations of course, would be ideal.

The Heliographic Coordinate System

When making whole disc drawings or photographs, provision should be made for obtaining a north-south or east-west line for the accurate determination of the solar poles, equator, and thereby the entire heliographic coordinate system. This line is to be located on the disc to within one degree along the limb. It is an easy matter for those observers who are doing such drawings or photographs using large format stationary image projection telescopes to make an observing table that will not only provide for the display of the celestial north-south line (or east-west line) but will also provide a display of heliographic north-south and east-west. But for those who do not have such a telescope the problem of determining heliographic coordinates would prove a formidable challenge.

As most amateur astronomers know, the earth's equator is inclined to the ecliptic (our orbital plane) by 23°26'. The solar equator is similarly inclined to our orbital plane by 7°15'. Because of these, the solar poles appear to systematically wander throughout the course of the year. The latter inclination appears to make the Sun's pole precess in a circle with a radius of 7°15' per year. While the former inclination causes the center of that circle to change it's position angle by 23°26' east and west.

These two movements have been reduced in our almanacs to: B_o - the heliographic latitude of the center of the solar disc and P - the position angle of the solar pole measured from celestial north. Only at rare times of the year does the observer see just one of these components displayed alone. Usually there is some combination of the two.

The heliographic longitude of the central meridian (L_o) of the solar disc is given, for each day at 0 hours UT, in several readily available sources. Sources that come to mind are the Astronomical Almanac and the RASC Observer's Handbook, both of which are published yearly as well as the ephemeris tables at the ALPO Solar Section website. An internet search should yield similar sites containing daily solar longitude tables. By interpolating these values, the observer can determine the longitude of the central meridian for any time of the year.

It is a simple matter, once the celestial north point on the limb is located to find the true solar pole or at least heliographic north on the limb. Once this is done the observer can proceed with finding the heliographic coordinates of any features. For most purposes an accuracy of 1° along the limb is sufficient. To facilitate the assignment of heliographic latitude and longitude the ALPO Solar Section recommends the use of 18cm diameter Stonyhurst discs. These are available to printout from links at the ALPO Solar Section web site. These are eight discs, 18cm in diameter, divided into latitude and longitude in 10 degree increments showing the appearance of the heliographic coordinates for the whole disc in each whole degree increment of B_o. The grids are designed for 0° to 7° use one way which is good for half of the year and by turning them 180° they will then display 0° to -7°, for the remainder of the year. Simply place the correct grid, according to the prevailing value of B_o for that date (found in the Almanac), on the observers 18cm diameter drawing or photograph and the relative heliographic latitude or longitude for any feature may be directly found (a light table is valuable here if paper grids are sandwiched with a drawing). If care is exercised in the location of the celestial orientation lines (n-s or e-w) and in the case of drawings the accurate recording of the relative positions of the features, the accuracy will be about 1° in either coordinate.

With such grids, the longitude is read as east or west of the central meridian. In professional publications it is common practice to leave the longitudes in the relative coordinates and just give a date and time of the observation. For detailed analysis of active regions, the full conversion to actual longitudes will be necessary. This however, is beyond the scope of this treatise and further discussion may be found in the suggested literature.

Monochromatic Drawing Techniques

Although a challenge, it is quite possible to record the numerous solar events visible to the monochromatic observer. Because there is a considerable amount of detail at even a 5-second of arc resolution often times more will be seen than can be drawn. Only the main features need to be drawn, the **filaments**, **plages** and **flares**, **limb prominences**, and **sunspot umbra**. The penumbra may be omitted. Monochromatic features are drawn in relation to the spot group umbral positions.

Remember, active regions can change very rapidly while making a drawing. The typical surge often begins as an active filament. Then without warning it develops strong line of sight velocities. It may erupt to pieces and disappear in a 30-60 minute period. Flares develop from nothing to maximum brightness often in 10 minutes or so. This "flash phase" lasts for several minutes then the flare slowly declines in brightness for 20 minutes or so. Plages do not change so quickly, but their appearance does change from day to day. The point being that speed, and an efficient system to record this activity is needed.

The initial task of the observer is to draw the positions of prominent sunspot umbra visible on the solar disk. This may be done accurately by using an indirect (projection) or direct (filtered) view of the *white light* Sun. On the standard whole disc recording form mark the umbra's location as small or large round black dots. Orientation of the drawing for N-S-E-W may be performed by using the drift method discussed earlier.

Once the umbrae are drawn the observer is to return to the monochromatic view and sketch only the main solar features. The focus of the work is to be observing the *position*, *shape*, *size*, and *relative brightness* of the features. The fastest events are surge prominences, surge filaments and flares. Surges generally spread out in an area and become more difficult to outline. Flares will tend to be confined in an area and easier to record.

Filaments should be drawn using short or long, narrow or wide black lines shaped as they appear to the eye. The positions of the features are placed relative to the spot umbra, hence the reason for accuracy. Plages and flares are drawn with closed lines much as penumbral outlines would be drawn in white light except no shading is necessary for the monochromatic features.

Limb prominences are drawn with a black outline. If possible note the position angle (P.A.) on the solar limb of the prominence relative to celestial north. The P.A. is measured from N=0°, E=90°, S=180°, and W=270°. Finding the position angle relative to the solar north point use your measured P.A. and re-calculate by adding or subtracting the east-west tilt of the Sun's axis (the value "P" as found in a solar ephemeris). The ideal measuring tool for finding P.A. is a graduated reticle, either seen in silhouette against the solar disk or one illuminated against the dark background sky. Once orientated by using the drift method, the P.A. of a prominence can be read directly from the reticule. The height of a prominence can be estimated from your drawing by first measuring the height of the feature on the drawing, and then dividing that number by the diameter of the drawn disk you are using. Multiply that figure by the Sun's true diameter (1,392,000 km) to find the approximate height in km. A more accurate result may be found by measuring the height at the eyepiece with the reticule or a filar micrometer and calculating accordingly.

When all the features are rendered on the drawing, the relative darkness and brightness of each is to be noted next to the feature. This is a simple matter and should be done quickly as a filament may be undergoing change, an appearance or disappearance. A plage could be a flare in progress, again either increasing or decreasing in brightness.

Brightness and Darkness Scale

On your drawing, next to the feature, jot down the corresponding numerical code that represents the brightness or darkness of it's appearance. Plage and prominences use the same brightness scale. Filaments have a relative darkness scale and flares use the brightness scale of plage/prominences with another yet brighter value.

If a written description of an event is to be noted, an abbreviation system is recommended when referring to the feature's brightness/darkness. Filament darkness is abbreviated as FD, flare brightness as FB, and prominence/plage brightness as PB. For example: "a bright flare near a faint plage with a nearby dark filament." Abbreviation: FB4 flare near PB2 plage with FD4 filament. Repeating again, time is critical and must be saved as events can progress rapidly.

Drawings of individual events may be sketched as insets on the whole disc drawing or by using the white light Active Region drawing form. Follow the procedures outlined in combination with the white light guidelines. Refer to the sample images for an example of a completed drawing form.

Whole Disc Photography

Whole disc solar photography or imaging as it is often called in this digital age is a relatively simple process. In fact, obtaining whole disc images of the Sun is very similar to photographing the whole disc of the moon. Both have approximately the same angular diameter in the sky and the visual white light objective filters commonly used on the Sun dim the solar brightness to about the level of the full moon. The central difference between the two projects would be the necessary light reduction and lower contrast of features when dealing with the Sun. It may be good preparation to setup the telescope/camera system and "practice" shooting the lunar disc for a time. When one has developed the necessary skills to produce clear, detailed lunar images the move to the Sun will be easier.

Whole disc images can be obtained with a film camera or more likely with a contemporary digital device. Success is possible with either in this arena, but we will limit our discussion to the use of electronic devices. Film has rapidly been replaced by electronic media the last several years and for solar imaging a greater success rate is possible for the digital photographer.

Based on the average solar diameter of 32' of arc, the best photographic system for whole disc white light photography is the prime focus or direct objective system, assuming the telescope's focal length is sufficient to produce a large scale

Filaments	Plage/Proms	Flares
1 = VERY FAINT GRAY	1 = VERY FAINT	1 = VERY FAINT
2 = FAINT GRAY	2 = FAINT	2 = FAINT
3 = MEDIUM BLACK	3 = MEDIUM BRIGHT	3 = MEDIUM BRIGHT
4 = DEEP BLACK	4 = BRIGHT	4 = BRIGHT
		5 = VERY BRIGHT

image at the focal plane. A relatively short focal length objective will require the photographer to utilize projection methods in order to obtain a scale in which detail can be clearly photographed. Of course if the image detector is of a size that limits the entire disc of the Sun to be captured with one shot, it will be necessary to photograph quadrants of the Sun and stitch the individual images together with photo software to create a composite likeness.

One advantage with prime focus imaging is the limited number of optical elements within the system. Having the fewest number of elements, the amount of scatter and wavefront error is reduced, thereby increasing the amount of fine detail seen. Refractors and Newtonian reflectors are well suited for this role.

For whole disc photography a digital single lens reflex (DSLR) camera is suitable with the addition of a simple screw-in prime focus adapter. Focusing is a challenge for cameras that do not possess interchangeable viewing screens. An extremely fine matte or clear screen being the best choice for those cameras that permit interchanging screens. For cameras with fixed screens shoot a frame or two and inspect the resulting focus on the camera's electronic viewing screen with a magnifier. An off camera monitoring screen is ideal for focusing and composing images. To reduce vibration always use an air activated cable release or electronic remote cord when tripping the shutter.

Short exposure times are required to freeze motions introduced by atmospheric turbulence, mountings, and shutter vibrations. Bad seeing will not be as apparent with whole disc images as with high resolution photography, but regardless try to obtain a telescope/filter/camera system that uses exposure times as short as possible, preferably faster than 1/125 second.

Several suppliers of objective solar filters market "photographic density" filters. These allow a greater transmission of light than the visual filters, thereby permitting the photographer to shorten exposures several stops or to introduce supplementary filters to enhance features without abusing exposure time due to "filter factors". Whereas normal visual objective filters have a photographic density of 5.0, the "thinner" photographic versions may have a density ranging from 2.5 upwards to around 4.0. It is important to realize that the photographic version of an objective filter is **not safe** for visual observation when used alone.

Additional filters at the eyepiece are a requirement to augment light reduction for safe visual observation with these filters. You will likely find it necessary to outfit the viewing system of the DSLR with a filter to dim the light sufficiently. Some camera systems permit snap-on or screw-in filters between the eye and viewing lens.

All whole disc photographs submitted as photographic prints should be a standard 8"x10" with the disc size being 18cm. If this is not possible a 5"x7" print with a 9cm disc could be used.

Professional astronomers prefer the 18cm disc as a standard size since it does fit neatly onto an 8x10 print and is large enough that detail is clearly visible down to the granulation size. Information regarding the acquisition of the photo should be on the back of the photograph. This can be accomplished simply by attaching completed copies of the recording form. Please be complete and thorough.

As with the whole disc drawing the value of the whole disc photograph is multiplied if an accurate indication of celestial east-west or north-south is included on it. This can be accomplished by aligning the camera so that the edges of the frames are oriented east-west and north-south. Another method would be to put a fiduciary mark at some intermediate focus (if projection is used) or against the detector in prime focus systems. These indicators should be placed better than 1º accuracy on the solar limb.

Photograph in the black and white mode if possible using the highest image quality settings of the camera. B/W images tend to be sharper than color RGB images. If the camera has a self timer or remote cord use that to prevent vibration of the camera when tripping the shutter. A simple bracket with an air activated cable release often can be homemade to trip the shutter button—explore that possibility if vibrations persist. Use the highest shutter speeds possible but not the most sensitive (ISO) settings for the detector. Achieving accurate focus on a small LCD monitor screen is possible, but an off camera monitor (9 to 12-inches) is better. Use it to focus and frame your photos. If you are not certain of accurate focus, then "bracket focus" by tweaking the focus on either side of apparent best focus, shooting photos there also, so as to increase the odds of having some images at proper focus.

The features of so many DSLR cameras differ it is not practical to make suggestions beyond these. Some cameras have metering functions that others do not, multiple sequence photography, if available increases your chances of catching the moment of best seeing conditions.

Raw digital images must be processed using photo editing software. The industry standard is Adobe's Photoshop although a number of other editing programs can perform the same functions. Physical dimensions (e.i. 8x10, etc.) of the digtal file are of lesser concern to us in the Solar Section since hardcopy outputs can be scaled up or down as long as the scaling does not introduce low resolution pixelation. We receive so many solar images regularly that we do request that our observers follow specific guidelines regarding file format and size to facilitate archiving requirements.

Submitted images should be in a **JPEG** format. Although this is a lossy format it is one compatible with a variety of computer platforms. File sizes should be limited when possible to several hundred kb in size. We post observers images on the internet for downloading and viewing purposes in addition to maintaining a library of archives, this size is suitable for these purposes. Data pertaining to the image should be pasted into the file during image processing. Refer to the conventional photography form at the end of this section for information requested to be included with the whole disc image. How and where this information is placed on the image is for the most part left to the observer.

Email services have become the standard means of submitting digital images. If you do not have access to such you may wish to save images and use the postal system to submit them on other media, such as a CD or thumb drive. The advantage of attaching your images to email is the speed with which they can be received, posted, and archived. This makes them available to the world at a much greater pace. **Contact the Section Coordinator for current addresses and procedures.**

Do not get bogged down in planning and building. GET GOING. While some planning and building may be necessary, too many potential observers fall by the wayside, caught up in the *details* of instrumentation. For example, it might be advantageous that the filtration system used by white light observers be of as flat a spectral response through the visible portions of the spectrum as possible. Filters that are weighted in spectral response to the blue or red ends of the spectrum often display features on the Sun that other filtration systems will not. Ideally, for the work of the Solar Section to be most useful, it would be desirable to have everyone using identical filters for white light observations. But of course this is not practical, and that is why it is only a minor consideration. In other words, contributing observations is far more important than waiting for specific equipment to be available.

Supplementary Filters

It has been mentioned how colored glass filters located at the eyepiece (with other safe filtration on the telescope) may be used to enhance the contrast or visibility of certain white light features of the Sun. The solar observer should take advantage of this in order to favor the subject being observed. See below.

Broad band color filters are marketed by a number of manufacturers. Eyepiece makers typically offer a wide selection of filters that screw into the standard barrels of their eyepieces. If one uses 2-inch eyepiece accessories then standard 48mm camera filters are adaptable for your needs. Of course the deeper or denser a color filter is, the greater it affects the required exposure time. This is called the filter factor and exposures must be adjusted accordingly. It's important to make trial exposures and keep adequate notes to find the correct exposure adjustments for your system.

The use of a broad band filter allows the photographer increased opportunity to obtain arc second resolution the farther the Sun is from the zenith. Remember that atmospheric refraction becomes greater than one arc second as you observe more than 25º away from overhead. Broad band filters improve this situation by "filtering" out the other prismatic colors. The narrower the transmission of the filter the better.

Active Region Photography

The main goal of active region photography is the recording of individual centers of activity with a resolution of 1-arc second or better. Sky conditions necessary for such work only occur occasionally

COLOR	WRATTEN FILTER	SPECTRAL TRANSMISSION	EXPOSURE FACTOR	APPLICATION
DK. RED	29	6100-7000+Å	16	Red and Orange filters increase the contrast of knots and radial streaks in the penumbrae of sunspots.
RED	25A	5900-7000+Å	8	
LT. RED	23A	5700-7000+Å	6	
ORANGE	21	5400-7000+Å	5	
YELLOW	11	4200-7000+Å	4	Yellow...neutral all-around filter that will lessen achromatic color errors.
LT. GREEN	56	4600-6200Å	6	Green filters increase the visibility of granulation and faculae.
GREEN	58	4700-6100Å	8	
DK. GREEN	61	4800-6000Å	12	
BLUE	47	4000-5200Å	6	Blue will assist in seeing faculae further from the limb than normal.

during the course of a day, and on many days not at all. The photospheric granulation is a good indicator of the moments of best seeing. If the seeing is 1-arc second, then the granulation is clearly evident. If the granulation is not clear but still can be made out then the seeing is 2-3 arc seconds quality. Anything worse than this is marginal and should be worked only if the feature under observation is going through some important change. These observations, even in the last category, may be the only ones available and therefore should be reported.

Another project the amateur may attempt to pursue is the photography of the internal structure of sunspot umbrae. This is done by making overexposures of as many as five stops with an aperture stop near the camera that cuts out the surrounding photosphere and penumbra. The aperture is best placed between the telescope and projection system. For example, at the focus of the eyepiece in a projection camera. It takes a skillful astrophotographer to successfully achieve useable results.

The regular patrolling of small developing groups of pores is also a very valuable pursuit for the solar photographer. By patrolling groups of pores, especially those associated with large or bright facular regions, an observer may catch the entire life cycle of a group over the period of a week or two. The success rate of such a project would be low, but the results would be important. Similarly, patrolling just the bright facular regions that have no pores would be most significant though the rate of success would be lower. The object is to capture pores as they are born.

Factors Affecting High Resolution Photography

Successful high resolution solar photography requires the photographer's control over several factors and either just a bit of luck or patience with another. The quality of an objective filter has an immediate effect on a telescope's performance and the minimum diameter aperture required to obtain arc second resolution must be considered. Fewer components mean less opportunity to introduce aberrations. In a nutshell solar telescopes are best when made simple, though delivering sharp and contrasty images.

Camera shutter speeds should be as fast as allowable to freeze motions encountered by the atmosphere, unstable telescope mountings (wind on the tube), or vibrations introduced by the camera system. The thin "photographic density" white light filter is used to advantage in this work as well as broad band "planetary" filters to enhance the contrast of selected features. Focus is as critical as the quality of the telescopic assembly. The rule of thumb is this, if fine detail approaching the limit of resolution cannot be seen visually, it will not be photographed either.

These factors the photographer has control over, that is the quality of his telescopic system, any filters in use, shutter speeds, the detector he chooses, basically all the mechanical aspects of his equipment. The most critical factor however is the one over which he has little or no control...the atmospheric seeing conditions.

By being cautious with the observing site and avoiding certain problematic situations, by studying local seeing patterns one can have a limited amount of control but ultimately the observer is always at the mercy of the air.

From the amateur standpoint there are two sucessful methods of winning the seeing dilemma. One we call, selective photography, which is done only during those moments of especially fine seeing conditions. The other method is known as random photography. In this technique many images are obtained adhoc and then sorted out later, the good images from the bad.

Selective Photography Techniques

Selective photography is done by patiently watching and waiting at the telescope until the seeing conditions have steadied and a sharp, clear view is visible. When the view is sharpest, the camera's shutter is tripped and with a bit of luck a crisp image is registered. Anticipation is important as the moments of fine seeing are often fleeting. The reaction time of the photographer/camera system is critical since fine seeing is often gone before the shutter opens. Many single pictures must be taken in the hope of obtaining several sharp examples.

It is best to observe or monitor the atmosphere through the same telescope that is used to take the photos. This may be accomplished with a beamsplitter that sends light from the telescope to a separate eyepiece for observing or with a reflex camera having a clear focus screen. Many observers use an off-camera TV monitor (9-12" screen) for viewing the output from their camera. Laptop computers are favored with many camera systems. Regardless, if a TV monitor or laptop is used some sort of daylight shade is necessary.

Random Photography Method

Perhaps the least labor intensive method of imaging is random photography. In the simplest description one just focuses the camera accurately, and blindly "fires away". Web-cam type cameras which are able to produce video clips are ideal for this technique.

The camera is set to image anywhere from 15-60 frames per second for a duration of 10-15 seconds, capturing literally 100s of frames of individual pictures. Several of these clips are acquired from which many sharp individual frames are usually culled.

Image processing often includes the "stacking" of dozens or more of these images to produce a clean, sharp "raw" image which is further processed to adjust the sharpness, tonal range, etc. This process has been successfully used by white light and monochromatic imagers.

The Recording Forms

On following pages you will find samples of whole disc and active region drawings and images. With the drawings is included line by line instructions on completing the data portion of the forms. When the postal system is used to submit observations the normal procedure is to mail the whole disc drawings of a single Carrington rotation collectively. As active region drawings are usually more sporadic these may be submitted individually at the earliest possible convenience.

Many observers will have access to email services, computers and scanning devices. Therefore you may wish to scan the drawings and send them (whole disc or active region) to the solar section via email on a more or less daily basis. The forms should be scanned full size (8-1/2x11 inches) at 72 dpi and saved in a JPEG low compression grayscale format. This formula has worked well for observers in the past and does not require a large amount of storage space in our archives. Contact the Solar Section Coordinator for current email and mailing addresses.

We have included in this file blank recording forms which you may use as masters and generate copy for future use. To save time fill in data on the master that would otherwise be redundant. Remember to retain the original observation and submit only a good, clean photocopy or scan of the original observation.

A.L.P.O. Solar Section
Active Region Drawing

OBSERVER John Doe

ADDRESS 123 Main, Sol Spotte, Arizona, 12345 USA

A.R. 4123

DATE/TIME 2004 07 04 1750-1810 UT ROTATION 2018

SKY CONDITIONS: SEEING <1" CLOUDS 10% WIND 0

APERTURE 125 mm FOCAL LENGTH 2250 mm TELESCOPE TYPE refrac

EYEPIECE 25 mm BARLOW 2x MAGNIFICATION 180x

FILTRATION Baader Visual Objective & #56 Green

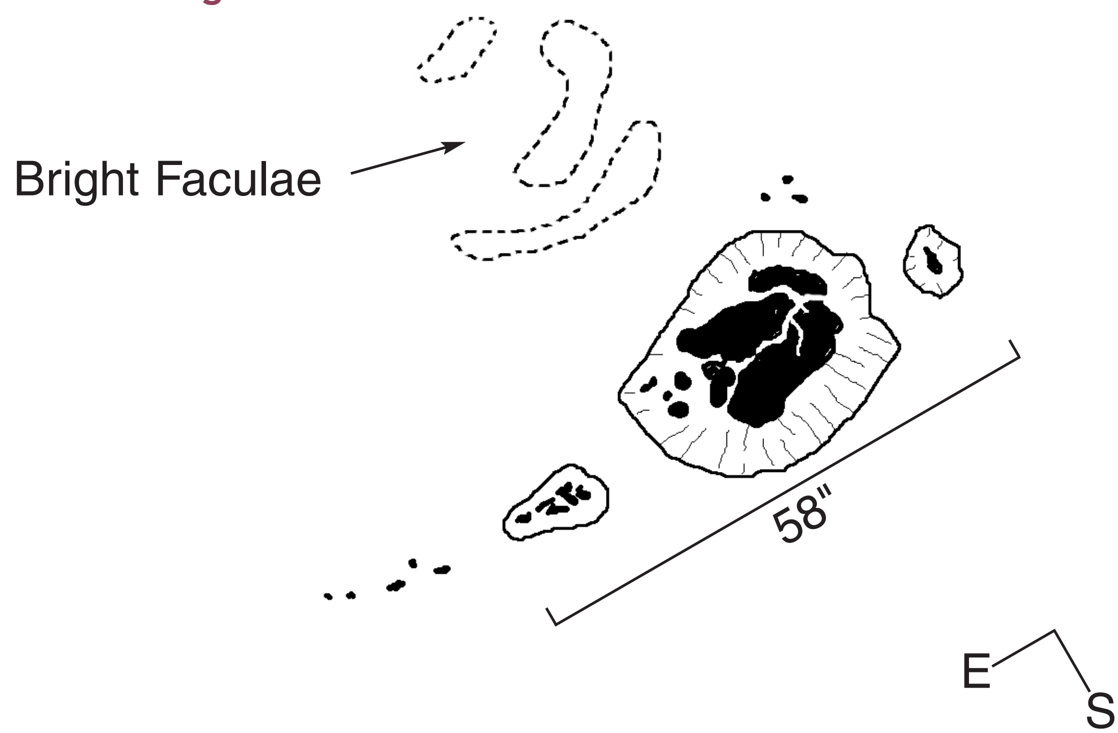
OBSERVATORY DESIGN Roll Off Roof MOUNTING TYPE G.E.M. DRIVEN? Y

CENTRAL MERIDIAN 136.1° ALTITUDE 65°

HELIOGRAPHIC COORDINATES S12 W11

Sample Active Region Drawing

Light bridge transversing NORTH half of umbra is brighter than remaining bridges.
—J.D. 7/4/04



—INDICATE SCALE AND DIRECTIONS—

ALPO USE ONLY

SCAN CODE

A.L.P.O. Solar Section

OBSERVER John Doe

ADDRESS 123 Main, Sol Spote, Arizona, 12345 USA

DATE/TIME 2004 07 04 1750-1810 UT

SEEING 2-3 sec CLOUDS 0% WIND MOD

APERTURE 50 mm FOCAL LENGTH 1500 mm TYPE RERF

EYEPIECE 32 mm FILTRATION .6Å H-alpha

OBSERVATION: *DIRECT* OR *PROJECTED*? (CIRCLE ONE)

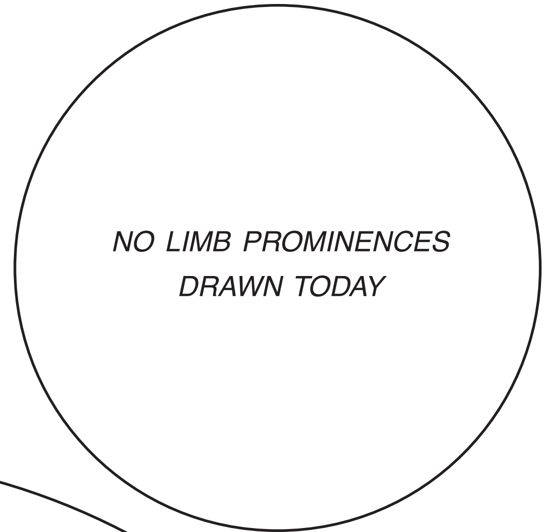
ROTATION 2018

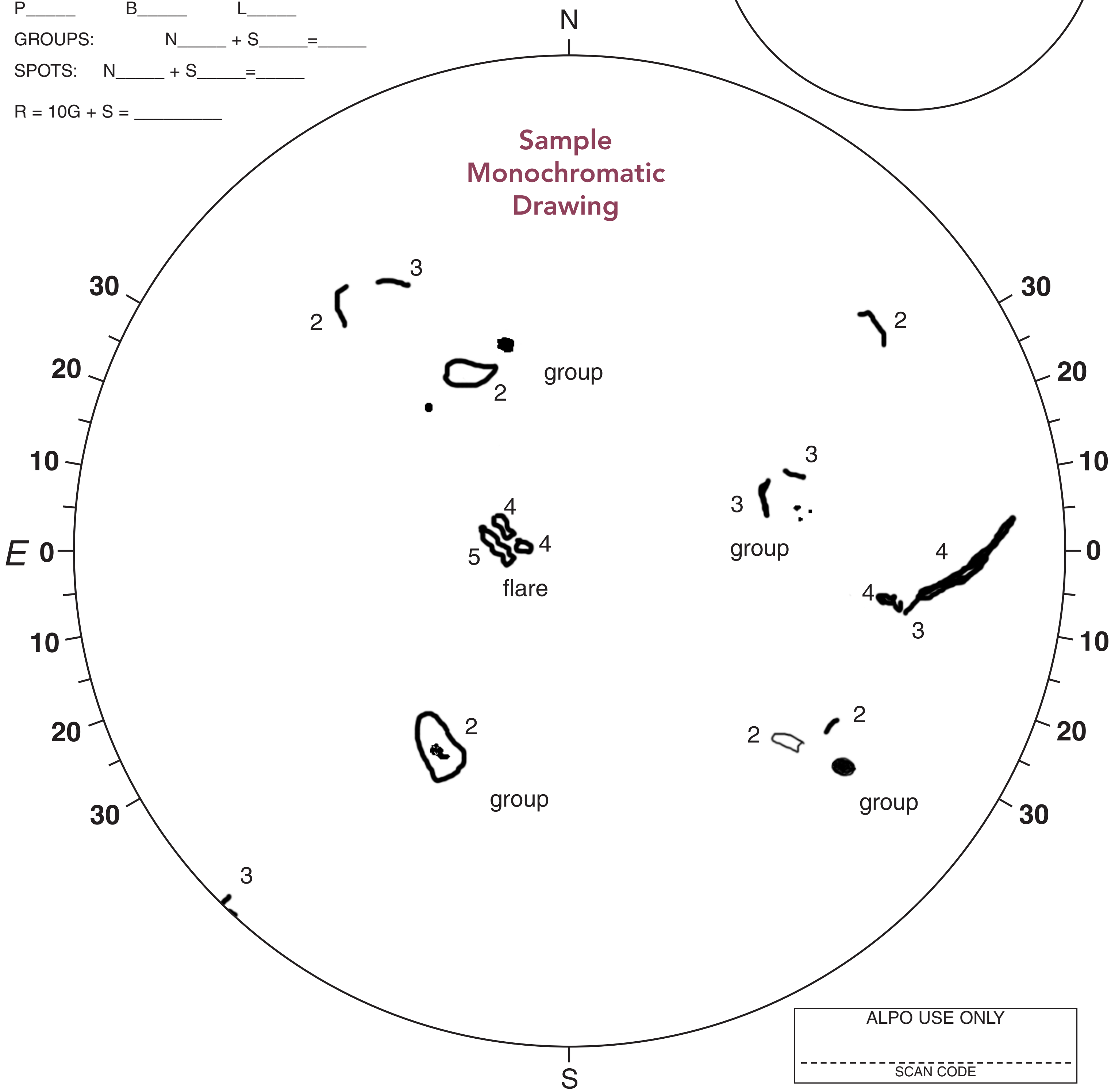
P_____ B_____ L_____

GROUPS: N_____ + S_____ =_____

SPOTS: N_____ + S_____ =_____

R = 10G + S = _________





ALPO USE ONLY

SCAN CODE

A.L.P.O. Solar Section

OBSERVER John Doe

ADDRESS 123 Main, Sol Spote, Arizona, 12345 USA

DATE/TIME 2004 07 04 1750-1810 UT

SEEING 2-3 sec CLOUDS 0% WIND MOD

APERTURE 100 mm FOCAL LENGTH 1000 mm TYPE NEWT

EYEPIECE 25 mm FILTRATION NONE

OBSERVATION: *DIRECT* OR *PROJECTED*? (CIRCLE ONE)

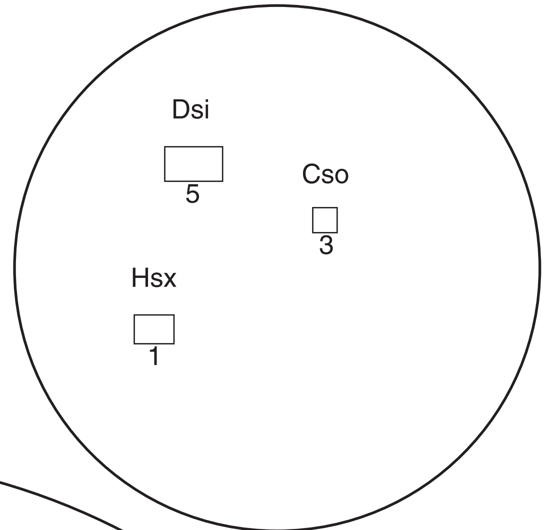
ROTATION 2018

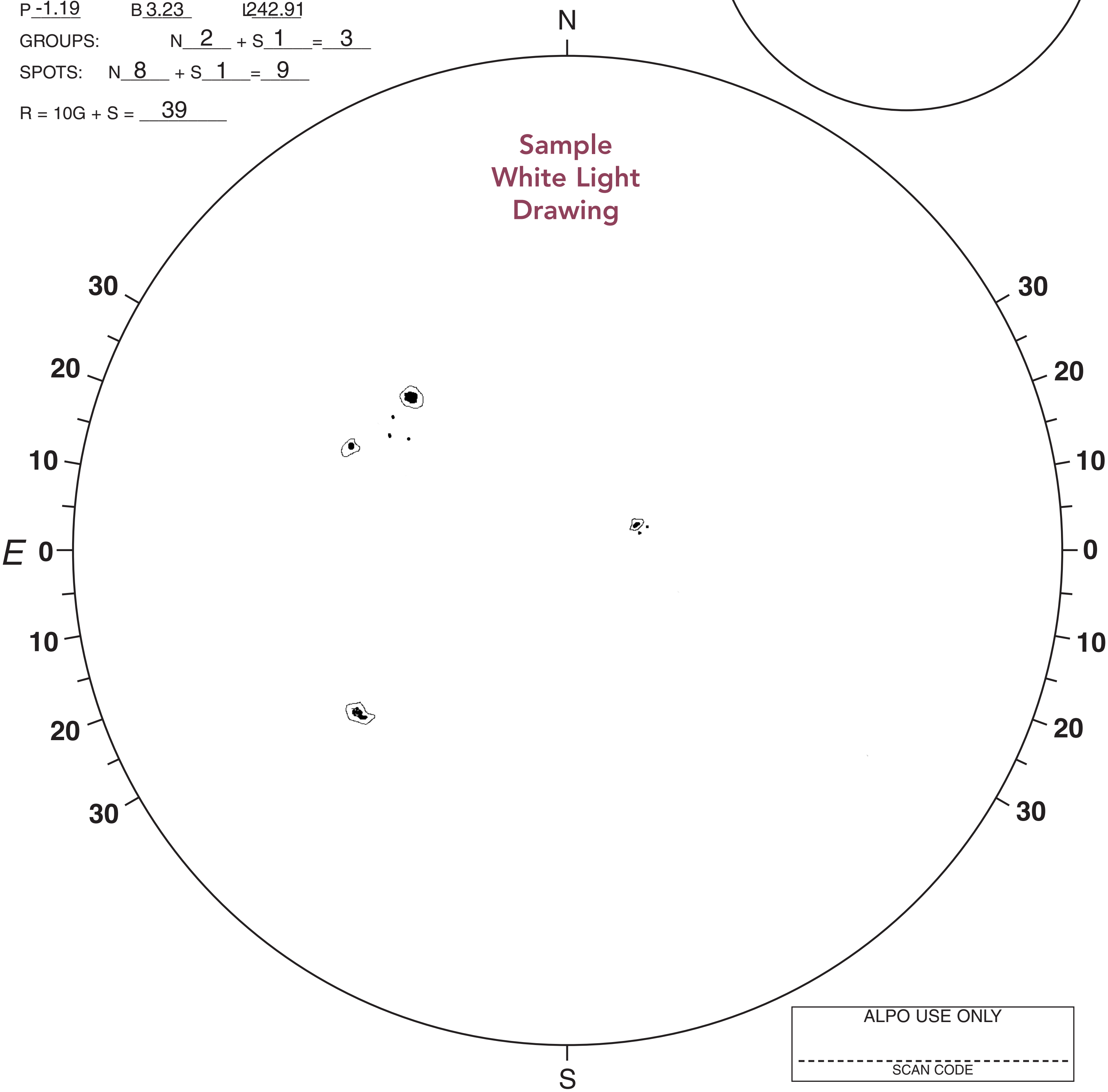
P -1.19 B 3.23 L 242.91

GROUPS: N 2 + S 1 = 3

SPOTS: N 8 + S 1 = 9

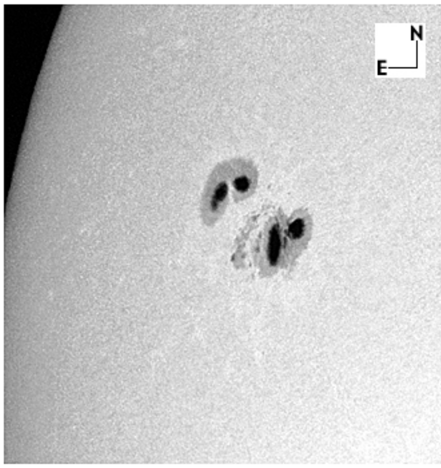
R = 10G + S = 39



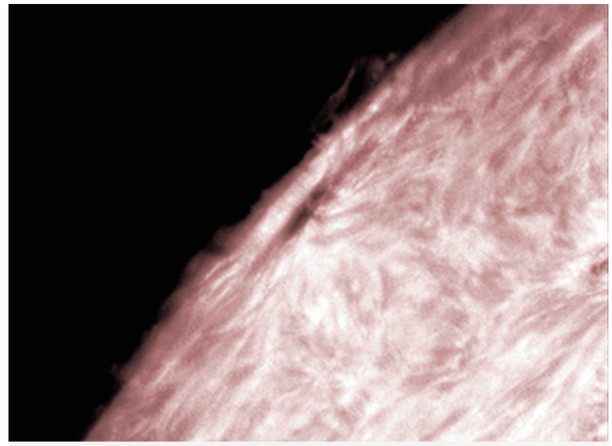


ALPO USE ONLY

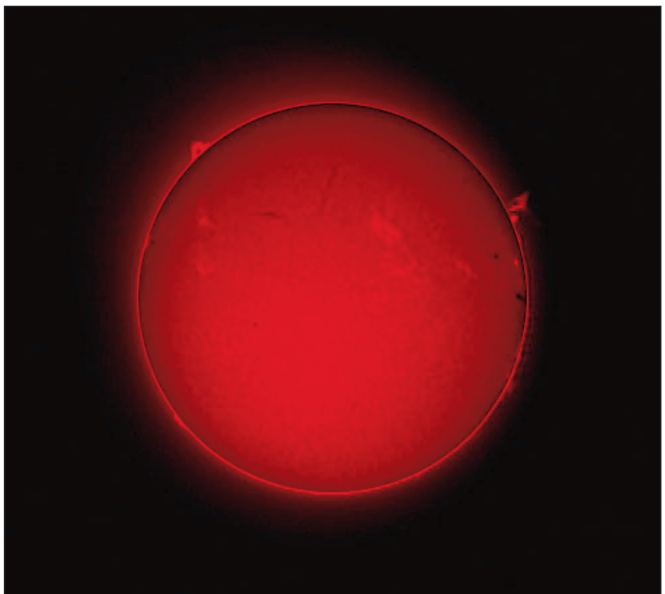
SCAN CODE



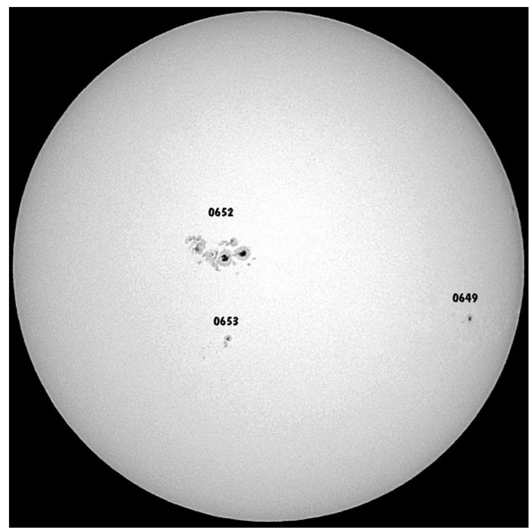
AR9415 Rotation 1974 20010405.1450UT
125mm refractor @ f/44 #58+2415 Tech Pan
Seeing—2" jenkinsjl@yahoo.com



2000 05 14, 16:12 UT, Rotation 1962, AR 9002, seeing 3-4" clear
155 mm Astro-Physics Star ED refractor f/9 with TeleVue 4X Powermate
150 mm ERF on-axis, DayStar 0.56 Angstrom H-alpha filter tuned to centerline
AVA Astrovid 2000 video camera with MRT VideoPort Professional (live frame grab)
North - up, West - right
Gordon Garcia, Hoffman Estates, IL (gordg@megsinet.net)

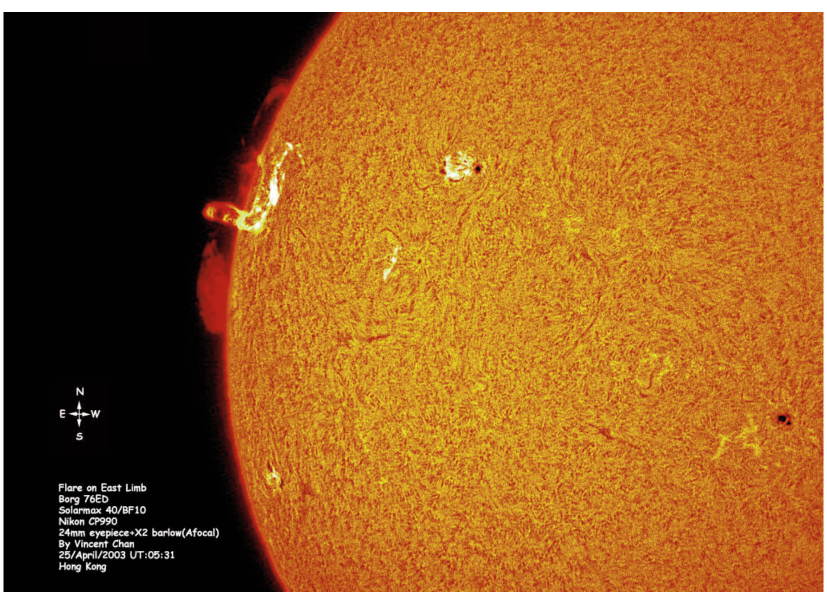


2003 11 30, 17:57 (disk), 17:37 (prominences) UT, Rotation 2010
Borg 45 mm f/6.6 refractor with Coronado 40 mm H-alpha solar filter
mounted on photo tripod, N - up, W - right, Astrovid 2000 video camera,
live frame grabs. Color added with Images Plus
Gordon Garcia, Hoffman Estates, IL



Carrington Rotation Number: 2019 2004 July 22, 12:03 UT
Altitude: 17 Seeing: 1", Sky Condition: Hazy, Wind: Calm
Telescope: Mak-Cass (Meade ETX 125), Fork Mounting, Electric Drive
Aperture: 125mm, FL 1900, F/15, AstroSolar Photofilm
Photo System: Afocal, 40mm MaxView, Orion W15 Yellow Filter
Nikon Coolpix 4300, 12.2 mm fl, Exposure Time: 1/394 sec. Photo File # 040722a
Howard Eskildsen P.O. Box 830415, Ocala, FL 34483
HowardEskildsen@msn.com

N
E W
S



Sample Images from ALPO
Solar Section Observers

Association of Lunar and Planetary Observers
Solar Section
Whole Disc Photography Report Form

Observer____
Address____
Date/Time______________________C. Rotation__________
Seeing__________ Clouds__________ Wind__________
Aperture______________ Focal Length________________
Telescope Type__________________________________
Filtration(s)___________________________________

Photographic System: FILM_______ DIGITAL_______

PrimeFocus ____________________________________
Pos. Proj. ____________________________________
Neg. Proj. ____________________________________
Afocal ______________________________________
Web Cam ____________________________________
Video _______________________________________

Notes____

To use this form make copies and cut out on the dotted line, attaching to the backside of the photographic print or computer printed hardcopy. Refer to the whole disc drawing instructions for the upper portion of the form. On the lower section check whether your detector is **film** or **digital**. The next lines ask you to describe the photographic system in greater detail. For example, under afocal you may have written "40mm Televue Plossl coupled w/Nikon CP995".

Under "Notes" make reference to any additional information that the observer believes to be pertinent, especially if it caused below average quality of observation.

For digital submissions embed this information within the digital file oriented with north at the top and east to the left or include a directional indicator on the image.

Association of Lunar and Planetary Observers
Solar Section
Active Region Photography Report Form

AR__________________
Observer____
Address____
Date/Time__________________________________C. Rotation_________________
Seeing________________ Clouds________________ Wind________________
Aperture______________________ Focal Length____________________________
Telescope Type____
Filtration(s)____

Photographic System: FILM_______ DIGITAL________

PrimeFocus ____
Pos. Proj. ____
Neg. Proj. ____
Afocal ____
Web Cam ____
Video ____

Notes____
____
____
____
____

To use this form make copies and cut out on the dotted line, attaching to the backside of the photographic print or computer printed hardcopy. Refer to the Active Region drawing instructions for the upper portion of the form. On the lower section check whether your detector is **film** or **digital**. The next lines ask you to describe the photographic system in greater detail. For example, under afocal you may have written "40mm Televue Plossl coupled w/Nikon CP995".

Under "Notes" make reference to any additional information that the observer believes to be pertinent, especially if it caused below average quality of observation.

For digital submissions embed this information within the digital file oriented with north at the top and east to the left or include a directional indicator on the image. If possible include a scale marker in arc seconds.

WHOLE DISK DRAWING FORM INSTRUCTIONS

OBSERVER: Print your name as you would wish to be credited.

ADDRESS: This should be your mailing address, preferably a home address and not a Post Office Box.

DATE/TIME: Enter the Universal Time (UT) drawing began and ended as follows: YYYY MM DD HH:MM to HH:MM.

SEEING: Put in the seeing in arc seconds where: <1” = granulation is clearly and steadily seen, 1-2” = granulation can just be seen, 2-3” = penumbrae are mottled but individual fibrils cannot be made out, 3-4” no penumbral detail seen, 4-5” = boundary of penumbra/umbra not clear, >5” = penumbrae not distinguishable from umbrae (you should probably not be working!)

CLOUDS: Put in your estimated percentage of cloud cover. This may require a note underneath to describe cloud type. For example, if you are observing through hazy cirrus that covers the whole sky. Your percentage would be 100% and without a note explaining that it is haze or cirrus this would be confusing.

WIND: A simple indication of none (0), light (lt), moderate (mod), and heavy (hvy) will be enough.

APERTURE: This should be self-explanatory. Preference is mm.

FOCAL LENGTH: Give this in the same units as the aperture.

TELESCOPE TYPE: Enter your telescope optical configuration: SCT, Refractor, Newt., etc.

EYEPIECE: Enter eyepiece focal length.

FILTRATION: Describe the filter system in use (type of objective filter, colored filters, herschel wedge, etc).

OBSERVATION: Are you viewing direct or using a projection arrangement? Circle one.

ROTATION: This is the Carrington Rotation Number for the date of observation. This can be found in any good astronomical almanac or in the ALPOSS ephemeris at: http://www.lpl.arizona.edu/~rhill/alpo/solstuff/ephems/solephem.html.

P, B, L: These are the values of the position angle of the solar pole as measured from celestial north, the heliographic latitude of the apparent center of the sun’s disk, and the longitude of the central meridian, respectively. They should be as close to the time of observation as possible and can be found in any good astronomical almanac or as above.

GROUPS: Enter the number of sunspot groups seen in the northern (N) and southern hemisphere (S) and then their total number.

SPOTS: Enter the number of spots for the northern (N) and southern hemisphere (S). Count all umbrae, whether in a group or alone, whether in a penumbrae or not. A single penumbra often encloses a dozen spots in a well developed, active sunspot group.

R=10G+S=: Go ahead and figure the Sunspot Number according to the classical formula. You will find that your total will vary from the published totals. This is due to the complex method by which observations of individual observers, with dissimilar observing experience, using different apertures of telescopes, at sites of widely varying conditions, are combined.

Make your drawing of disk features in the **large circle** noting the East or West so we can determine the image directions.

THE MYSTERIOUS SMALLER CIRCLE: This smaller circle is there for the convenience of observers when tallying sunspot counts (with the AAVSO for example). This gives a place where you can note the McIntosh class and/or number of spots.

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)

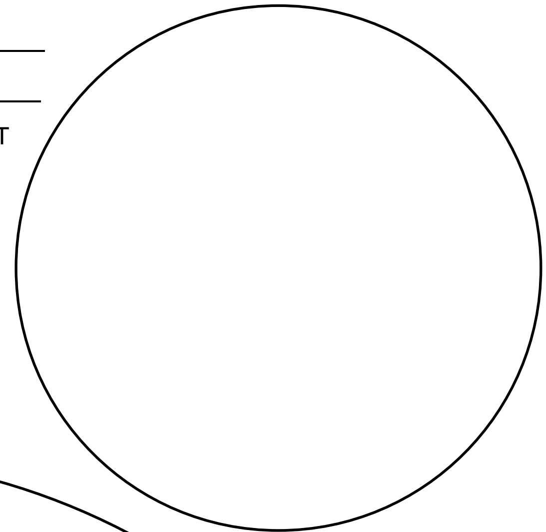
ROTATION____________

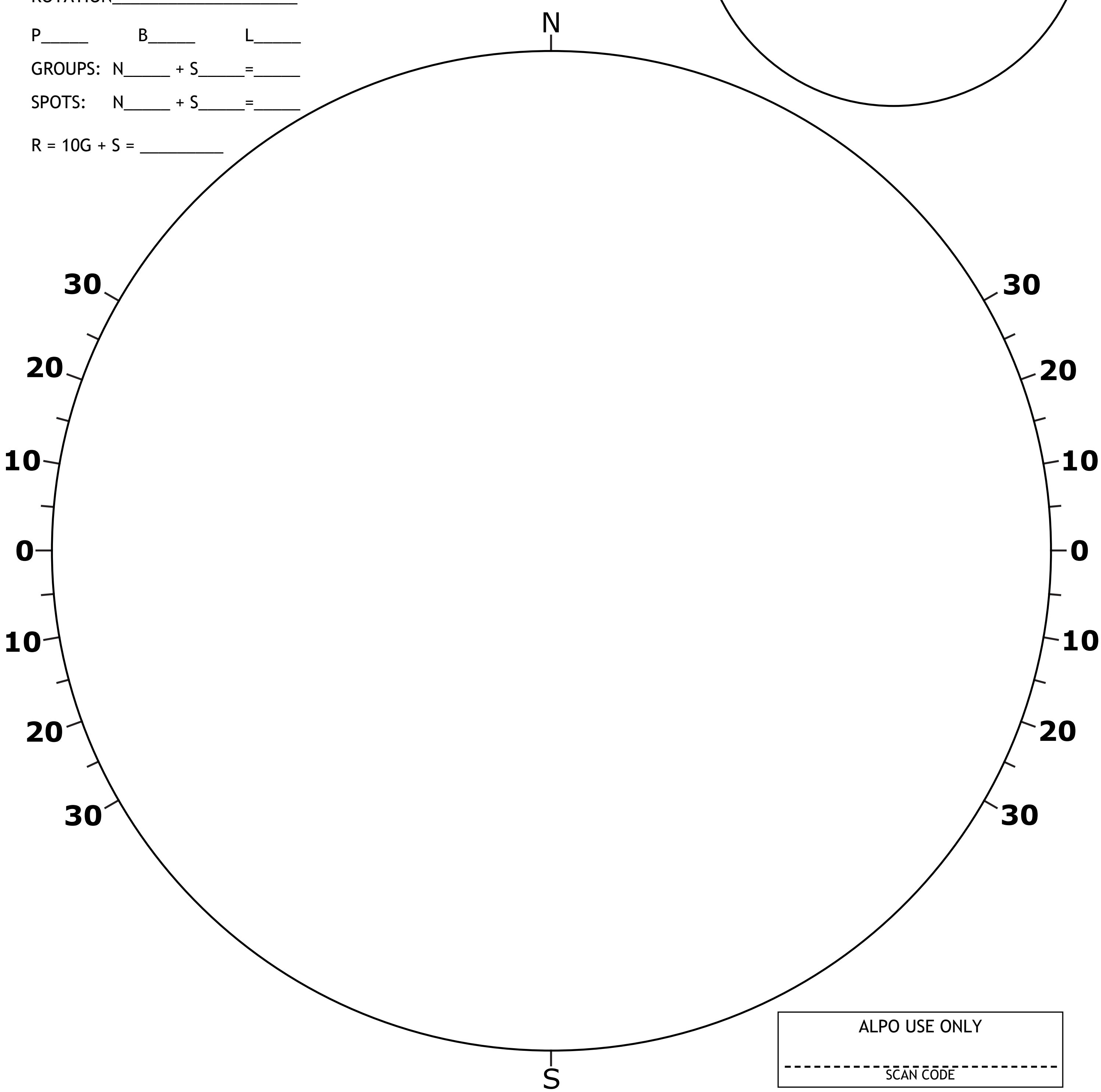
P_____ B_____ L_____

GROUPS: N_____ + S_____=_____

SPOTS: N_____ + S_____=_____

R = 10G + S = __________





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ACTIVE REGION DRAWING FORM INSTRUCTIONS

OBSERVER: Print your name as you would wish to be credited.

ADDRESS: This should be your mailing address, preferably a home address and not a Post Office Box.

A.R.: Put the Active Region identification number, issued by NOAA/SESC, here, if applicable.

DATE/TIME: Enter the Universal Time (UT) drawing began and ended as follows: YYYY MM DD HH:MM to HH:MM.

ROTATION: This is the Carrington Rotation Number for the date of observation. This can be found in any good astronomical almanac or in the ALPOSS ephemeris at: http://www.lpl.arizona.edu/~rhill/alpo/solstuff/ephems/solephem.html.

SEEING: Put in the seeing in arc seconds where: <1” = granulation is clearly and steadily seen, 1-2” = granulation can just be seen, 2-3” = penumbrae are mottled but individual fibrils cannot be made out, 3-4” no penumbral detail seen, 4-5” = boundary of penumbra/umbra not clear, >5” = penumbrae not distinguishable from umbrae (you should probably not be working!)

CLOUDS: Put in your estimated percentage of cloud cover. This may require a note underneath to describe cloud type. For example, if you are observing through hazy cirrus that covers the whole sky. Your percentage would be 100% and without a note explaining that it is haze or cirrus this would be confusing.

WIND: A simple indication of none (0), light (lt), moderate (mod), and heavy (hvy) will be enough.

APERTURE: This should be self-explanatory. Preference is mm.

FOCAL LENGTH: Give this in the same units as the aperture.

TELESCOPE TYPE: Enter your telescope optical configuration: SCT, Refractor, Newt., etc.

EYEPIECE: Enter eyepiece focal length.

BARLOW: If using a barlow indicate power. (2x, 2.4x, 3x, 5x, etc.)

MAGNIFICATION: Total magnification of your system. (ex. 120x)

FILTRATION: Describe the filter system in use (type of objective filter, colored filters, herschel wedge, etc).

OBSERVATORY DESIGN: Describe the observing site you used. (domed, roll off roof, open air, etc.)

MOUNTING TYPE: Dobsonian, German Equatorial, Fork, etc.

CLOCK DRIVEN?: A simple yes or no is all that is needed.

CENTRAL MERIDIAN: Enter heliographic longitude of the central meridian of the Sun. This can be found in a good astronomical almanac and interpolated to the time of observation. Accuracy of 1-degree is good enough for most purposes.

ALTITUDE: This is the altitude of the sun in degrees ABOVE the horizon.

HELIOGRAPHIC COORDINATES: If you can determine the relative heliographic coordinates of the feature you have drawn include that here. (example: S12 W11)

Put in your drawing any notes about unusual conditions or equipment, or observations made concurrently. Typical comments tell happenings on the sun during the observation (flares, rapid motions, etc.). Note either celestial cardinal directions (north, south, east, west) or heliographic cardinal directions. If you know the scale of the drawing please include that. The scale can be quickly determined by measuring the transit time of the feature when the feature first touches the edge of your eyepiece field and when the last bit disappears. Take this timing in seconds and plug that into the simple equation: Distance in arc seconds $= 15\, t\, (\cos D)$, where “t” is your timing and “D” is the declination of the sun on the date of observation.

A.L.P.O. Solar Section
Active Region Drawing

OBSERVER____

ADDRESS____

A.R.________________________

DATE/TIME______________________________________UT ROTATION__________

SKY CONDITIONS: SEEING__________ CLOUDS__________ WIND__________

APERTURE__________mm FOCAL LENGTH__________mm TELESCOPE TYPE_______

EYEPIECE____________mm BARLOW__________ MAGNIFICATION__________

FILTRATION____

OBSERVATORY DESIGN________________ MOUNTING TYPE______________DRIVEN?___

CENTRAL MERIDIAN__________________ ALTITUDE__________________

HELIOGRAPHIC COORDINATES________________________________

—INDICATE SCALE AND DIRECTIONS—

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Suggested Reading List

(Ed.note—while no list can be complete because it will be out of date yearly as new books are published, this listing will satisfy most readers and supply sources to answer many questions not addressed in this Handbook.)

Books of Primarily Historical Interest

Abbot, C.G., **THE SUN**, D. Appleton & Co., NY, 1912
Abetti, G., **THE SUN**, Macmillan Co., NY, 1961
Abetti, G., **SOLAR RESEARCH**, Macmillan Co., NY 1963
Baxter, W.M., **THE SUN AND THE AMATEUR ASTRONOMER**, Drake Publ. Inc., NY, 1973
Ellison, M.A., **THE SUN AND ITS INFLUENCE**, Macmillan Co., NY, 1955
Kuiper, G.P., editor, **THE SUN**, University of Chicago Press, Chicago, 1953
Meadows, A., **EARLY SOLAR PHYSICS**, Pergamon Press, 1970
Menzel, D.H., **OUR SUN**, Harvard University Press, Cambridge, MA, 1959
Mitchell, S.A., **ECLIPSES OF THE SUN**, Columbia University Press, NY, 1935
Moore, P., **THE SUN**, Norton, NY, 1968
Newton, H.W., **THE FACE OF THE SUN**, Penguin Books, London, 1958
Pepin, R.O., **THE ANCIENT SUN**, Pergamon Press, NY, 1979
Proctor, M., **ROMANCE OF THE SUN**, Harper & Bros. Publishing, NY, 1927
Stetson, H.T., **SUNSPOTS IN ACTION**, Ronald Press, NY, 1947
Thackery, A.D., **ASTRONOMICAL SPECTROSCOPY**, Macmillan, NY, 1961
Young, C.A., **THE SUN**, D. Appelton & Co., NY, 1898
Zurin, H., **THE SOLAR ATMOSPHERE**, Blaisdell Publishing, Waltham, MA, 1966

General Interest Reading

Giovanelli, R.G., **SECRETS OF THE SUN**, Cambridge University Press, NY, 1984
Lang, K.R., **THE CAMBRIDGE ENCYCLOPEDIA OF THE SUN**, Cambridge University Press, NY, 2001
McKinnon, J.A., **SUNSPOT NUMBERS: 1610-1985**, World Data Center, Boulder, CO, 1987
Nicholson, I., **THE SUN**, Rand McNally, NY, 1982
Noyes, R.W., **THE SUN, OUR STAR**, Harvard University Press, Cambridge, MA, 1982
Pasachoff, J.M., **THE COMPLETE IDIOT'S GUIDE TO THE SUN**, Alpha, NY, 2003
Waldmeir, M., **THE SUNSPOT ACTIVITY IN THE YEARS 1610-1960**, Zurich, 1961

Novice/Intermediate/Advanced Reading

Beck, R., **SOLAR ASTRONOMY HANDBOOK**, Willman-Bell, Richmond, VA, 1988
Bray, R.J./Loughhead, R.E., **SUNSPOTS**, Dover, NY, 1964
Bray, R.J./Loughhead, R.E., **THE SOLAR CHROMOSPHERE**, Dover, NY, 1974
Bray, R.J./Loughhead, R.E., **THE SOLAR GRANULATION**, Chapman & Hall, London, 1967
Brody, J., **THE ENIGMA OF SUNSPOTS**, Floris Books, Edinburgh, Scotland, 2002
Cram,L.E./Thomas, J.H., **THE PHYSICS OF SUNSPOTS**, Sacramento Peak, Sunspot, NM, 1981
Espenak, F., **FIFTY YEAR CANON OF SOLAR ECLIPSES 1986-2035**, NASA, Washington, D.C., 1987

Novice/Intermediate/Advanced Reading *(cont.)*

Foukal, P.V., **SOLAR ASTROPHYSICS**, Wiley & Sons, NY, 1990
Gibson, E.G., **THE QUIET SUN**, NASA, Washington, D.C., 1973
Henderson, S.T., **DAYLIGHT AND ITS SPECTRUM**, Halstead Press, NY, 1977
Jenkins, J.L., **THE SUN AND HOW TO OBSERVE IT**, Springer-Verlag, NY, 2009
Kippenhahn, R., **DISCOVERING THE SECRETS OF THE SUN**, Wiley & Sons,NY, 1994
Kitchin, C., **SOLAR OBSERVING TECHNIQUES**, Springer-Verlag, London, 2002
Kitchin, C., **OPTICAL ASTRONOMICAL SPECTROSCOPY**, IoP Press, 1995
Macdonald, L., **HOW TO OBSERVE THE SUN SAFELY**, Springer-Verlag, London, 2003
Neidig, D.F., **THE LOWER ATMOSPHERE OF SOLAR FLARES**, Sacramento Peak, Sunspot, NM, 1981
Phillips, K.J.H., **GUIDE TO THE SUN**, Cambridge University Press, NY, 1992
Sawyer, R.A., **EXPERIMENTAL SPECTROSCOPY**, Prentice-Hall, 1946 (Dover, 1963)
Spence, P., **SUN OBSERVER'S GUIDE**, Firefly Books, Richmond Hill, Ontario, 2004
Stix, M., **SUN**, Springer-Verlag, London, 1991
Strong, C.L., **THE AMATEUR SCIENTIST**, Simon & Schuster, NY, 1960
Sturrock, P.A., editor, **SOLAR FLARES**, Colorado Assoc. University Press, Boulder, CO, 1980
Sturrock, P.A., editor, **PHYSICS OF THE SUN**, D. Reidel Publishing, Dordrecht, 1986
Svestka, Z., **SOLAR FLARES**, D. Reidel Publishing, Dordrecht, 1976
Tandberg-Hanssen, E., **SOLAR PROMINENCES**, D. Reidel, 1974
Taylor, P., **OBSERVING THE SUN**, Cambridge University Press, NY, 1991
Taylor, P./Hendrickson, N., **BEGINNER'S GUIDE TO THE SUN**, Kalmbach Books, WI, 1995
Veio, F., **THE SUN IN H-ALPHA LIGHT WITH A SPECTROHELIOSCOPE**, Veio, 1991
White, O., **THE SOLAR OUTPUT AND ITS VARIATION**, Colorado University Press, Boulder, Co, 1977
Xanthankis, J.N., **SOLAR PHYSICS**, Wiley & Sons, NY, 1968
Zurin, H., **ASTROPHYSICS OF THE SUN**, Cambridge University Press, NY, 1968