Solar Section

Observing polar faculae

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Although sunspots are few and far between at the moment, there is one solar photospheric feature that is at maximum – polar faculae. A professional paper by Muñoz-Jaramillo *et al.* (2013) on 100 years of polar faculae measurements gives in its introduction the following:[1]

'Solar faculae are bright features on the surface of the Sun associated with accumulations of magnetic flux inside inter-granular lanes. They are believed to be the consequence of a depression in the optical surface of the Sun caused by the magnetic field, which allows the observer to see the warmer (and hence brighter) walls of the granular up-flows and makes them easier to spot near the solar limb. As a result of this physical relationship, it is not surprising that faculae can be used to track magnetic flux and follow the evolution of surface magnetic fields. In fact the numbers of polar faculae ... have been found to be modulated by the solar cycle. In addition, there is a strong correlation between the polar faculae and the ... magnetic field ... This correlation and the ability to see them clearly at the poles, make faculae as valuable for studying ... aspects of the solar cycle as sunspots.'

Given that the solar magnetic field is key in creating solar activity, the often-neglected observation of polar faculae is as important as that of sunspots. Figure 1 shows the BAA monthly mean daily frequency over the last solar cycle, based on white-light observations from Franky Dubois, Jan Janssens and more recently Colin Briden.

There is a clear inverse correlation with sunspot activity, where the number of polar faculae is greatest during periods of low sunspot activity including solar minimum. The purpose of this article is to encourage more observers of polar faculae while their numbers are expected to continue to be high.

Figure 1 also shows an annual variation for each hemisphere, with the southern hemisphere having a higher mean daily frequency (MDF) in the early part of the year and the northern in the latter part. Given that polar faculae occur above/below a latitude of ~70° and that the orientation of the Sun as viewed from Earth changes throughout the year, there are times when more of one pole can be seen than the other. The best time for the southern pole to be observed is between the third week of February and the third week of March, while the northern pole is best observed between late August and late September each year (*i.e.* when the heliographic latitude of the middle of the solar disc is either less than –7° or greater than 7°). This is not to say that polar faculae cannot be seen at other times of the year.

The *Solar Dynamics Observatory* (SDO) Helioseismic & Magnetic Imager (HMI) Continuum image shown in Figure 2, from 2019 Feb 3, shows polar faculae near the southern pole – they are quite small compared to faculae associated with sunspot groups when near the limb. This makes them more difficult to observe, but they can be seen with amateur solar equipment. An animation of SDI HMI images from 2019 Feb 16–21 can be seen at **petermeadows.com/baasolar/** (scroll to the bottom of the page to start the video).

During 2019, the Solar Section had its own Observer's Challenge for polar faculae. Three members responded: Carl Bowron and Alexandra Hart, who both provided images, and Colin Briden who provided MDF values that have been included in Figure 1. Briden also wrote about his polar faculae observing experience using a Sky-Watcher Evostar 90mm *f*/10 achromatic refractor, a 1.5-inch Lunt solar wedge and (usually) an 18mm eyepiece:[2]

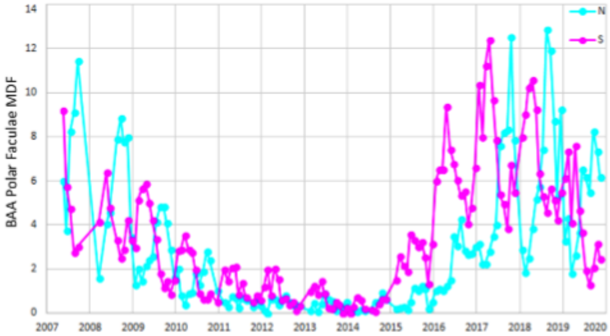

Figure 1. BAA polar faculae monthly mean daily frequency since 2007 April.

Observers of polar faculae face the immediate problem that relative to sunspots (or for that matter to the bright faculae associated with Active Regions) they are rather lacking in contrast. In practice this lack of contrast means that there is very little point in trying to count polar faculae when the seeing is poor. Seeing [on the Antoniadi scale of I–V] should always be III (fair) or better for polar faculae observation; if I can see the granulation moderately well then I can see polar faculae. I improved the contrast still further by lining the interior of the telescope drawtube with self-adhesive matt black fabric and for observing I use the kind of 'dark cloth' used by Victorian photographers, which makes a big difference.

To control glare, Lunt recommend the use of a polarising filter with the solar wedge and I duly fitted one. However, I have recently been experimenting with a Baader continuum filter. This very interesting accessory has a bandwidth of only 20nm, centred on 540nm – which is the frequency in the solar spectrum to which our eyes have evolved to be most sensitive. Translated into visual terms the filter gives a beautiful leaf-green image which takes a little bit of getting used to! Meanwhile the narrow band does away with chromatic aberration problems, while at the same time allowing the focus to 'snap to' in a remarkable way. If there are sunspots visible, the focusing is very simple: if not the limb provides a slightly trickier alternative. In good conditions

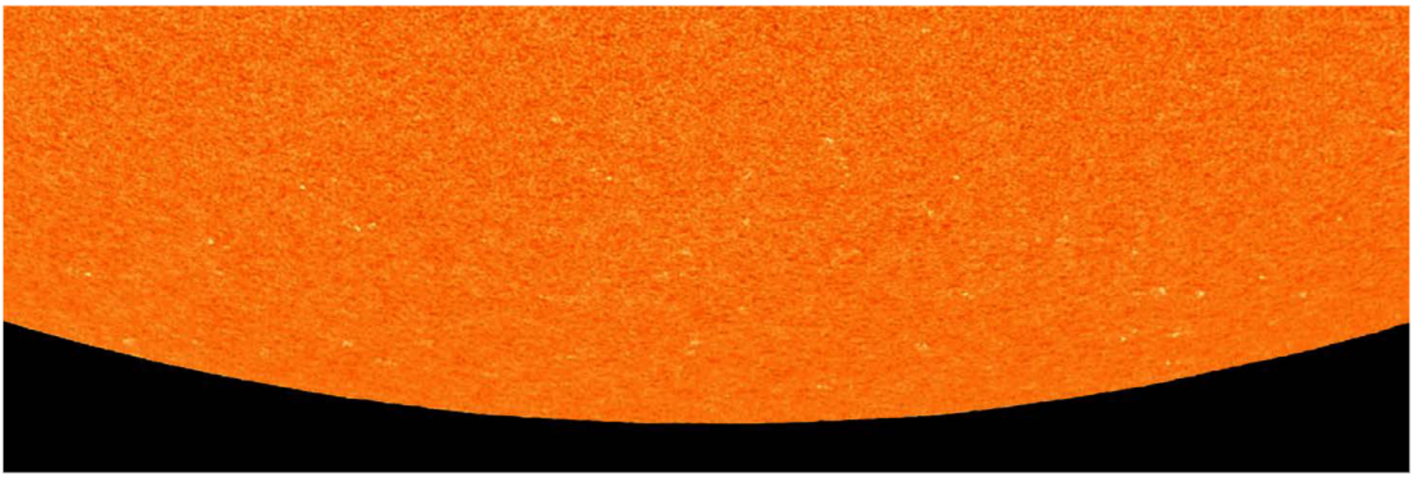

Figure 2. SDO HMI continuum image (gamma enhanced) from 2019 Feb 3, showing southern polar faculae (small white dots). *SDO HMI Continuum, NASA SDO*

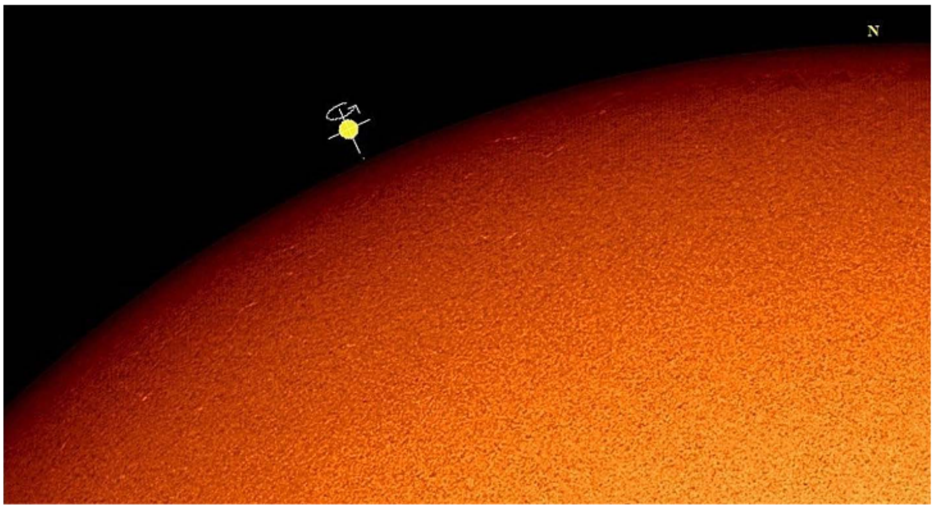

Figure 3. North polar faculae, 2019 Sep 20, 08:35 UT. *Carl Bowron*

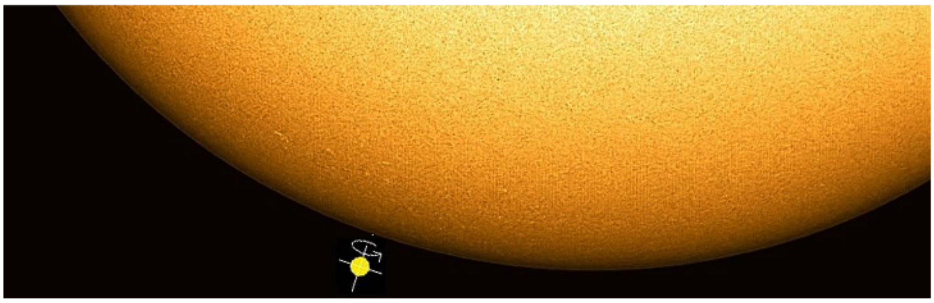

Figure 4. South polar faculae, 2019 Feb 16, 10:05 UT. *Carl Bowron*

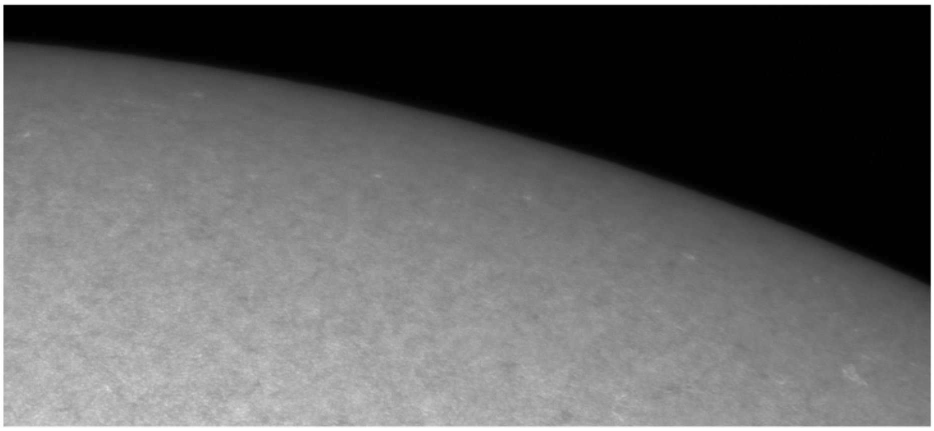

Figure 5. North polar faculae, 2019 Mar 29, 09:45 UT. *Alexandra Hart*

it is sometimes possible to focus using the polar faculae themselves.

Before starting it is helpful to identify the position angle of the poles at the time of your observations. There are various ways of doing this, but personally I use a very helpful little piece of software called *TiltingSun*.[3] Patience is definitely a virtue when it comes to this kind of observing and I spend a lot of time scanning what appears at first to be a featureless disc. Then suddenly a tiny, bright spot becomes visible and very quickly the eye adjusts itself to see more. The lower limit of visibility can be a highly subjective thing: personally I tend to err on the side of caution and count only those faculae I have seen more than twice as I scan from one side of the polar region to another. ’

Carl Bowron obtained images of northern and southern polar faculae on several occasions, using a 120mm refractor at *f*/7.5 and a Celestron Neximage 10 Colour Imager. Two examples are shown in Figures 3 & 4. Carl describes below how he obtained the polar faculae image shown in Figure 4:

‘ Polar faculae are by nature small features at the limits of telescopic resolution, usually hampered by poor atmospheric stability. A 120mm refracting telescope has a theoretical point source optical resolution of 1.15 arcseconds (″), which reduces to 0.96″ when using Dawes limit calculations. These limits, however, do not apply to extended surface features.[4] The limit for extended surface features is almost half the value of the Dawes limit (for a 120mm telescope, 0.45″) for perfect observing conditions. Some observers have been able to even exceed this, by recording details down to one third of the Dawes limit!

Telescope magnification will dictate the area of coverage of the solar surface visible at the camera chip. However, increase in magnification will also magnify the turbulence effects. The NexImage 10 camera has a 1.67-micron pixel size arranged in an array of 3856×2764 pixels. This small pixel size when used with the 120mm *f*/7.5 (900mm focal length) refractor gives a pixel resolution of 0.38 arcseconds per pixel,[5] just about matching the extended surface resolution mentioned above. This means that prime focus imaging will record all the information visible without the need for further magnification (the use of a Barlow lens). The area of coverage of the polar region is dictated by the chip size. For example, the original image in Figure 4 was 3520×1366 pixels and covered all of the area of interest. The telescope and camera were ideally matched for this task.

Orientating the image at the time of taking will make positioning the north point and the solar spin axis easier at the final processing stage. The image is aligned as viewed with the naked eye. The north or south edge must also traverse across the screen with the drive switched off, along or parallel to the upper and lower image frame. Flipping the image using the camera capture software and rotating the camera will facilitate these requirements. This process assumes that the OTA is on an equatorial mount.

The AVI sequence was then processed using *AutoStakkert! 2.6.8*,[6] to produce a single TIF image. The Image Stabilization was set to Surface, with the Quality Estimator set at Gradient 3. On inspection of the resultant analysis graph the Stack Size was set at 100 and Alignment Point size at 48 pixels to complete the process. This TIF image was then processed in *RegiStax V6*.[7] At the Functions panel, using Colour Mixing, the image was converted to black and white (NexImage 10 is a colour camera). An image that is either too faint or too dark can be adjusted using the Gamma function to give a normal, well-balanced grey image. In the Wavelets panel, Linear and Gaussian were selected and the Use Linked Wavelets box ticked. The Layer 1 slider was then moved to the far right of its limit. This results in a grainy image with little or no details present. All is not lost! By increasing the Denoise value the image returns gradually to a point where it looks quite normal. Increasing the Sharpen value contrasts the image features. A combination of both Denoise and Sharpen may be required to obtain the desired result. With processing complete, the image was saved for further manipulation.

GIMP 2.6 was then used to further sharpen, colour, contrast-stretch and rescale (in this case from 3520 pixels across to 900 pixels).[8] To position the rotational axis point, the amount of axial tilt needs to be determined. This can be derived from tables in the BAA *Handbook* or using the *TiltingSun* program for the time of observation.[3] Using a partial image makes the solar axis point difficult to define; however, it is possible to ►

Deep Sky Section

Sagitta – explore the assassin's arrow

Stewart Moore
Director, Deep Sky Section, 2004–'13

Despite being one of the smallest constellations in the sky – only Crux and Equuleus are smaller – Sagitta is also one of the most distinctive and really does look like an arrow. Although the brightest of its 'shape' stars is only mag. +3.5 – with the others ranging between mag. +4 and +5 – it is still an easy object to pick out in the summer Milky Way from a rural location. It lies around 10 degrees south-east of Albireo (beta Cygni), the beautiful double star that forms the swan's head, and from the UK it will be found around 57 degrees up in the southern sky towards the end of August.

Sagitta features widely in mythology and has been associated with many dastardly assassinations, from the arrow that Apollo used to slay the Cyclops, to the arrow that slew the Eagle of Jove. But, in a slightly less blood-thirsty guise, it has also been identified as Cupid's arrow.

Palomar 10. *David Boyd*

Palomar 10. *David Finnegan*

The premier and most popular deep sky object within its boundary is undoubtedly the globular cluster **Messier 71**. There are other treats within its confines that are well worth tracking down, including another globular cluster, but these will be much more of a challenge (certainly for the visual observer).

Charles Messier observed M71 in 1780 October and in his notes refers to it as being discovered by his observing colleague Pierre Méchain in 1780 June. He was unaware that it had already been observed by Johann Gottfried Koehler in 1775, and was probably discovered by the Swiss astronomer Jean-Philippe Loys de Chéseaux in 1746. Messier described M71 as '…very faint and [it] contains no stars. The slightest illumination causes it to disappear.' M71 lies at RA 17^h 53^m 47^s and Dec. +18° 46′ 45″, which puts it almost exactly between and very slightly south of the two stars gamma and delta Sagittae. Although Messier was unable to resolve any stars in M71, no one observing the cluster nowadays with a modern small telescope (say a 150mm reflector or 80mm refractor) should have that problem. Small binoculars will also show it as a misty patch. Because the globular is very open and lies in a rich region of the Milky Way, wide-field images will give the most aesthetically pleasing view.

For a long time there was uncertainty as to whether M71 was a very open globular cluster

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► use the line function to construct a tangent line with an angle equal to the tilt. Moving this line to the edge of the solar curve will just touch at the point where the axis should be. Note the coordinates of this point and delete the tangent line. Mark the axis on the image. The final result is shown in Figure 4. ’

Alexandra Hart's images, shown in Figures 5 & 6, were obtained using a 140mm refractor, Baader Herschel wedge with a Continuum filter, 3× Barlow and ZWO ASI 174 camera. Alexandra also acquired images in hydrogen alpha which indicate that photosphere polar faculae are also present in the chromosphere. She describes acquiring her images on 2019 Mar 29:

‘ When I imaged these bright points I didn't do anything other than my normal viewing sequence. As there were no sunspots that day, I started by imaging the centre of the disc as it is easier to focus on granulation cells in this area and achieve a good focus. It also gives a good indication of seeing conditions. As the seeing was good I proceeded to investigate the polar regions and found that the bright points stood out quite clearly by eye when viewing the live video feed. I then switched to hydrogen alpha and found I could also see these bright points in that wavelength too. ’

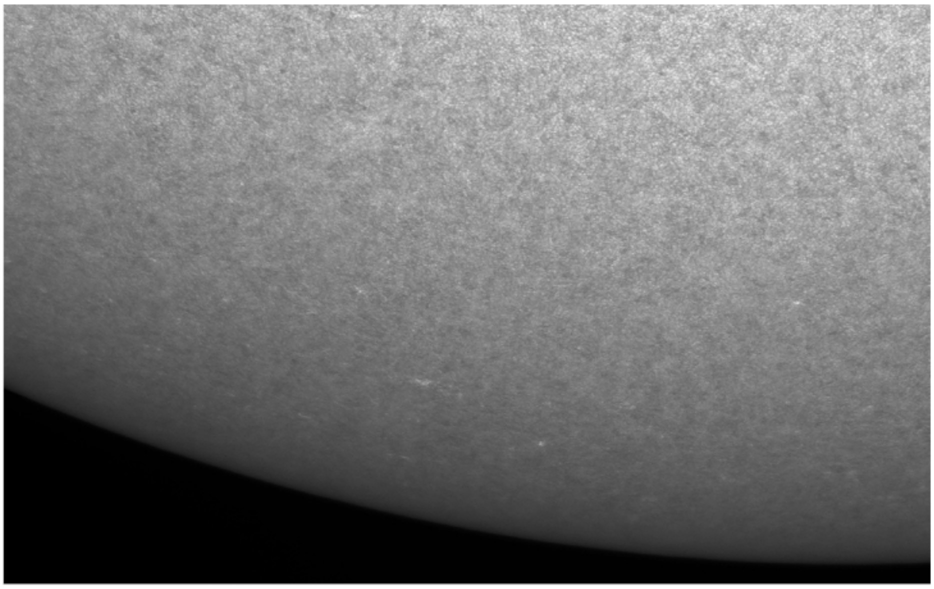

Figure 6. South polar faculae, 2019 Mar 29, 09:49 UT. *Alexandra Hart*

Your polar faculae observations, whether they be monthly MDF values or images, should be submitted to Solar Section Director Lyn Smith (**solar@britastro.org**).

1 Muñoz-Jaramillo A. *et al.*, 'Calibrating 100 years of polar faculae measurements: implications for the evolution of the heliospheric magnetic field', *Astrophys. J.*, 753:146 (14pp), 2012 Jul 10, doi:**10.1088/0004-637X/753/2/146**
2 Briden C., 'Observing polar faculae', *BAA Solar Section Newsletter*, 2019 February
3 *TiltingSun2* – **atoptics.co.uk/tiltsun.htm**
4 Sidgwick J. B., 'Amateur astronomer handbook', Faber & Faber Ltd., 1955, p.49: **archive.org/details/AmateurAstronomersHandbook/page/n27**
5 Wilmslow Astro, 'Useful Formulae': **wilmslowastro.com/software/formulae.htm**
6 *AutoStakkert!* – **autostakkert.com/**
7 *RegiStax* – **astronomie.be/registax/**
8 *Gimp* – **gimp.org/**