Imaging Dynamic Solar Activity in Hydrogen-Alpha Light

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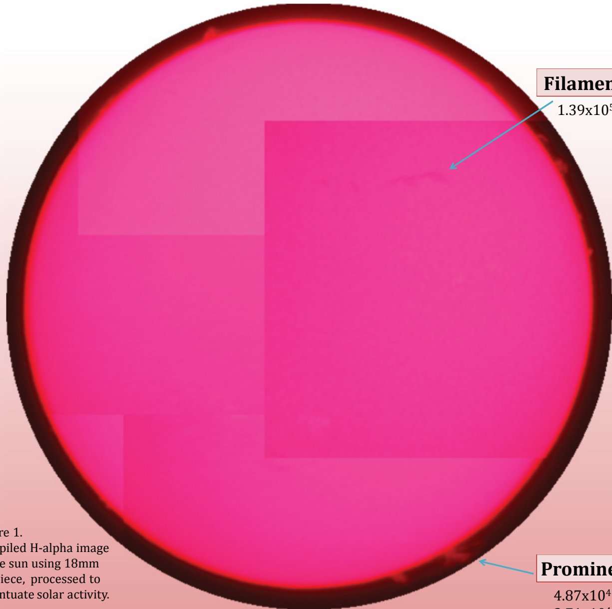


Filament
1.39×10^5 km in length

Prominence
4.87×10^4 km in height
3.71×10^4 km base width

Figure 1.
Compiled H-alpha image of the sun using 18mm eyepiece, processed to accentuate solar activity.

Abstract

In this project, we monitor the evolution of solar features, including prominences and filaments, as they travel across the solar surface. To do this, we take images by attaching a single lens reflex camera to a Coronado Hydrogen-alpha solar telescope, with the sensor plane at the focal plane. By recording a wavelength of high solar opacity, H-alpha images of the sun accentuate the activity on the solar surface. We have worked to refine techniques to achieve the best focus, exposure, and imaging cadence. We bracket the exposure times over a wide range to emphasize activity both on the disk and above the limb of the sun. Different magnifications are also being used; we create both an image of the full sun which contextualizes features, and zoomed-in views of regions of interest showing more detail. When the best exposure times are determined, we take a series of photographs over a time frame chosen to best capture the evolution of the features and create a time series of the images taken. These images allow us to observe these solar features as they develop and change. The images are processed using Adobe Photoshop.

Feature Measurement Using Prime Focus Photography

Light from the sun enters the objective lens. Each point on the solar surface corresponds to one point on the image plane.[1] When viewing the image, these points are displayed as pixels. By calculating the arcseconds per pixel and the kilometers per pixel, we can determine the size of the solar features observed.

$$\text{Plate Scale} = \frac{206265 \text{ (arcseconds in a radian)}}{\text{Focal Length}}$$

The plate scale is the number of arcseconds each pixel of the sensor spans.[3] With a focal length of 400mm, our plate scale equals *515.7"/mm*. The Canon 450D has a 22.2 x 14.8 millimeter, 12.2 megapixel CMOS sensor with a maximum resolution of 4272 x 2848 pixels. Dividing the px width by the mm width, we find *192.4px/mm*. Dividing our plate scale by this value, we determine the arcseconds per pixel to be ***2.68"/px***. Relating this to what we know about the sun, being 1.38 million kilometers in diameter, and what we know of our images, solar diameter of 1473px at prime focus, we conclude ***937 km/px***.

Hydrogen-Alpha Light

White light images of the sun depict how the sun appears to the naked eye, white light being the collection of all visible wavelengths of light. Some features of the sun become lost in white light images, but if a filter is used to select which wavelengths are observed, this is no longer an issue. The Coronado H-alpha telescope is specifically designed to view red light of 393.4 nanometers. With this particular wavelength, we are able to see solar activities such as ribbon-like structures called "filaments" on the solar disk and "prominences" when seen extending off the solar limb.[2]

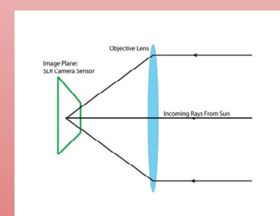


Fig. 2. Prime Focus Photography.

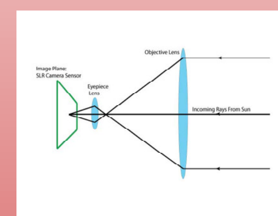


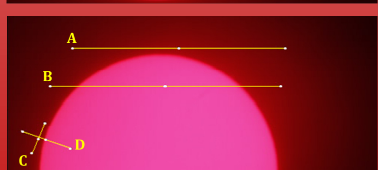
Fig. 3. Eyepiece Projection Photography.

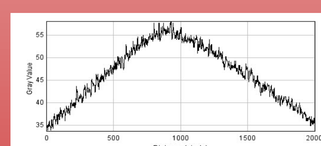
Feature Measurement Using Eyepiece Projection Photography

This is comparable to prime focus photography with the addition of an eyepiece.[1] We find the "/px and the km/px following calculation methods used with prime focus, and now take magnification into account. In Fig 1., the total image is compiled of separate images taken with 18mm eyepiece.

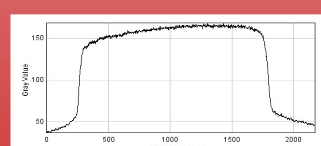
$$\text{Magnification} = \frac{\text{Objective Lens Focal Length}}{\text{Eyepiece Focal Length}}$$

Using the equation to the left, we find our magnification to be *22.2*. Dividing our results from our prime focus calculation by this magnification, for this eyepiece we find ***0.121"/px*** and ***42.2 km/px***.

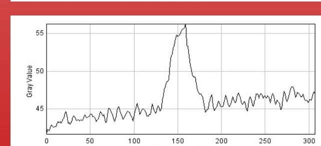




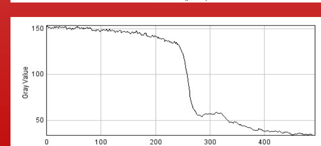
A
Fig. 4. Cut showing radiation near the solar disk.



B
Fig. 5. Cut across the solar disk, showing limb darkening.



C
Fig. 6. Cut across the base of a prominence.



D
Fig. 7. Cut along the radial extension of a prominence.

Monitoring Brightness

Using pixel brightness values, we can monitor the brightness of a desired region (see fig. 4-7). An increasing value corresponds to a brightening region and a decreasing value to a dimming.

Fig. 8. Exposure time of 0.004 s.

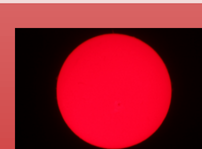


Fig. 9. Exposure time of 0.025 s.

Fig. 10. Exposure time of 0.25 s.

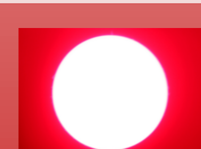


Fig. 11. Exposure time of 2.5 s.

Exposure Times

We find exposure times 0.004-0.01 seconds accentuate certain aspects of disk activity, while exposure times 0.025-0.1s bring out different aspects as well as better shown activity on the limb. Exposure times below 0.004s become too dark, while times between these two ranges listed blend most activity with the rest of the solar surface. Above 0.1s, the increased light begins to wash out the image making it difficult to distinguish any activity. (See fig. 8-11 above)

References

[1] J. Jenkins & R. Tatum (Eds.). January 2010. *Guidelines for the Observation of Monochromatic Solar Phenomena* (3rd ed.). Retrieved from http://www.alpo-astronomy.org/solarblog/wp-content/uploads/mono_2010.pdf

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[3] Hands On Universe. (n.d.). *Calculating plate scale.* Retrieved from http://www.handsonuniverse.org/for_teachers/course/teacher_course/size2/size23.html

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