Team Project 2

Sun Prominence Imaging

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Image Intent:

The purpose of this image is to visualize a plasma flow created by on the surface of the sun. In these photos one can see two different prominences of the surface of the sun that create very beautiful and powerful images. The sun is one of the largest visible fluid flows from the earth because it is essentially a huge ball of plasma. The sun goes through different, periodic, levels of surface activity and the purpose of the images is to capture the current state of the suns activity.

Flow Phenomenon:

The suns is composed mainly of Hydrogen and some Helium as well as very small percentages of Oxygen, Carbon, Nitrogen, Silicon, Magnesium, Neon, Iron and Sulfur. These elements exist in a plasma state with a surface temperature of about 6,000 degrees Kelvin. The portion of the sun that is visible is the photosphere. This portion of the sun is the outermost layers of the sun. The core and the corona of the sun on the other hand, are not visible because they are opaque and do not allow light to pass through them. The photosphere of the sun is where the majority of solar activity occurs, such as the prominences visible in the photos. The sun yields energy to the solar system by fusion, which is where a proton and a neutron bond, forming a deuteron. [i]

The majority of the suns activity is the result of magnetic fields which reduce the convection rate between the corona and the photosphere. The reduced convection then leads to an increase in thermal energy in the area that results in active spots on the sun, which lead to sun spots, solar flares, coronal mass ejections and prominences. The suns activity tends to exist in 11 year cycles. During solar minimums there are very small amounts of activity, while large amounts of activity exist in the maximums. According to the 11 year cycle, the Sun should currently be experiencing a solar maximum, but this does not appear to be the case.

A solar prominence is a bright projection extending from the surface of the sun. Prominences vary widely in their shape and size and exist in 2 different varieties, active and quiescent. Active prominences are generally very bright and last for only a few minutes, up to a few hours. Quiescent prominences appear much more smoothly and can last several months. The prominences pictured are Quiescent, which is known because they were there over a period of many days. [ii]

The size of the prominence on the top left is determined to be approximately 2.5*10^7m wide and 1.59*10^7m high. This is equivalent to 1.5*10^4 mi by 9.8*10^3 mi. This gives the prominence an area of approximately 3.97*10^14 m^2. This was determined by finding the ratio of the number of pixels in the solar flare to the number of pixels across the radius of the sun and multiplying this ratio by the known radius of the sun in meters. See Equation 1.

Equation 1:
Pixel Dimension of prmoinence = P_flare
Pixel Dimension of Solar Radius = P_Sun
Radius of the Sun = r_sun

$P\_flare := 82$ pixels $\quad$ $P\_Sun := 2292$ pixels

$$Ratio := \frac{P\_flare}{P\_Sun} \qquad r\_sun := 6.995 \cdot 10^{8}\ \mathrm{r}$$

$$Flare := Ratio \cdot r\_sun \qquad Flare = 2.503 \times 10^{7}\ \mathrm{r}$$

Visualization & Photographic Technique:

The sun is one Astronomical Unit away from Earth and yet, it is one of the most powerful sources of light and heat (caused by nuclear fusion) that reaches Earth. However, from our planet this fusion reaction remains unnoticed except for heat and light emissions. So what is the best way to visualize this magnificent plasma phenomenon from a distance of approximately 149 million kilometers? Using a Nikkon D90 SLR, 12.3 megapixle digital camera, Fabio Mezzalira, an SBO Assistant and Computer Specialist, helped out group attached a quarter-inch telescope adaptor to a Coronado SolarMax Telescope containing an Hydrogen-alpha filter. The Coronado has an aperture of 44mm and a focal length of 400mm. The f/ratio of f/10, and alteration of the ISO based on the natural light conditions (sunny, cloudy, snowy…) focused the area for our project to the edges of the solar image surface. This is because there is a larger atmosphere on the outside of the sphere of the sun causing it to appear darker, and therefore allowing the visualization of more solar sun texture.

The H-alpha filter is an optical filter that allows for the wavelength specific transmission of the H-alpha. This narrow bandwidth of light is the only wavelength that is transmitted through the filter allowing for spectacular photos of this specific red emission line. This H-alpha that radiates from the Sun is basically a 6562.8 Angstrom wavelength of hydrogen, which occurs when the hydrogen is ionized. This particular H-alpha filter came with a "< 0.7 angstrom bandpass, which results in increased surface detail across the disk." [iii] The Nikkon D90 SLR camera and the Coronado SolarMax Telescope were then placed on top of an 18-Inch DFM Telescope in the Sommers Bausch Observatory. This telescope has a PC-based control system that is linked to an auxiliary computer, which runs computer software that allows for an operator to select a star from the display, and the computer will move the telescope to the correction position where the object is visible in the viewfinder. By mounting our setup to this 18-Inch DFM computer-telescope system, we managed to keep the sun in the frame as it moved across the sky allowing for little to no adjustment when tracking the sun's movement. [iv]

My Image:

The photo is taken with a Nikon D90 digital camera. The shutter speed of the camera is set to 10/600 seconds. The pixel dimensions of the cropped image 1404 pixels horizontally and 884 pixels vertically. The unedited image is 4288 pixels horizontally and 2848 pixels vertically. The field of view is approximately 6.995*10^8 m (radius of the sun) horizontally and 4.401*10^8 m vertically. The image distance is approximately 1.5*10^11 m. The resolution is 300 by 300. The photo was edited by rendering it into black and white in Photoshop with an increased influence of red on the black and white image. Black and white was chosen because it made the prominence stand out better. This image was cropped to show only the upper left half of the sun in order to focus the image on the prominence and not the entire sun.

Future Work

Given the opportunity I would like to take similar images when the sun is much more active than it was during the time of this photograph. I would also like to do this with a higher resolution camera, or a telescope with a higher level of zoom. Both of these item will probably prove very difficult for me to come by, but I have seen very amazing photos of other prominences on the sun that show much more detail than we were able to achieve.

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[i] "Solar Fusion." 31 March 2009. Online. Available at: <http://facultystaff.richmond.edu/~ggilfoyl/qm/homework/fusion/fusion.html>.

[ii] "Solar Prominence." Encyclopædia Britannica. 2009. Encyclopædia Britannica Online. 30 March 2009. Online. Available at: <http://www.britannica.com/EBchecked/topic/552973/solar-prominence>.

[iii] "MaxScope 40 Product Description." Coronado. Online. Available at: <http://www.coronadofilters.com/Maxscope_40.html>.

[iv] "18 – Inch DFM Telescope." SBO Observing Deck. Online. Available at: <http://lyra.colorado.edu/sbo/telescopes/18inch/18inch.html>.