Solar Hα filter commissioning, calibration and imaging from the University of North Dakota Observatory, Grand Forks, North Dakota

R. Nath[1](rakesh.nathrakeshr@my.und.edu), P.S. Hardersen (hardersen@space.edu)[1]
[1] University of North Dakota
Clifford Hall, 512, 4149 University Avenue, Grand Forks, ND-58203

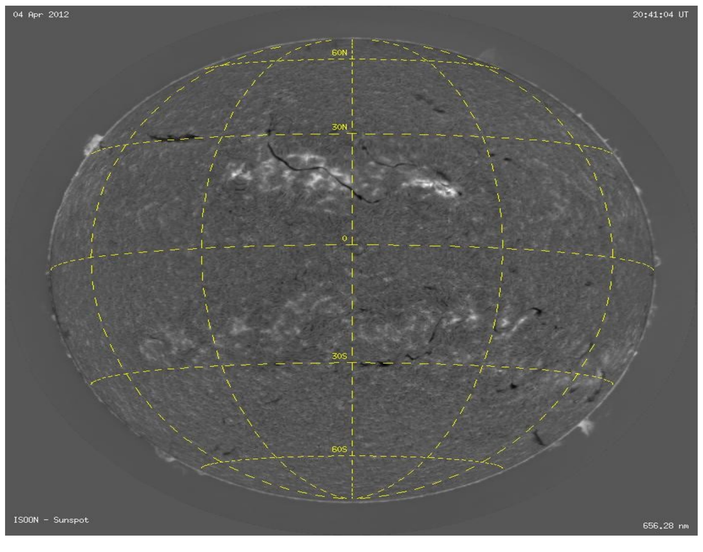
1.Chromospheric Hα Imaging

The UND Observatory aims to image the full disk sun to detect features in the Hα.Full disk imaging in the Hα will reveal full disk features such as the chromospheric network, plages, prominences and filaments. The aim of the thesis is to quantify what kind of features are visible in full disk images of the sun taken from the UND observatory with the changing seeing conditions and specifically suggest probable features as scientific targets for future observers using the facility. A part of this project is to also quantify the variability in the seeing in a place like North Dakota and suggest the correlation between imaging targets on the disk and limb and the seeing. The thesis also aims to isolate image processing algorithms which would help enhance the scientific usability of the data from the observatory. The attempt is to isolate IDL procedures which can be used for image processing. This poster will describe the probable features that can be imaged in §2 and the instruments used for the thesis in §3.

2.Hα features

This thesis intends to image the following features in the full disk image of the sun:

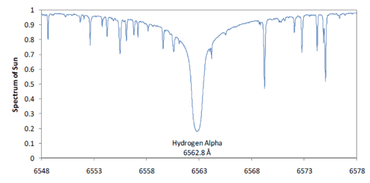
- **Prominences: Prominences should be visible as a feature on the limb quite clearly [1].The study of prominences should provide an insight into their temporal evolution and supporting magnetic field. Various types of prominences including quiescent and eruptive prominences should be visible on the full disk image.**
- **Filaments: Filaments are on-disk equivalents of prominences. Therefore they appear as absorption bands. Full-disk observations of filaments have shown mini-filaments and eruptions. Mini-filament eruptions has known to contribute to coronal heating.[1]**
- **Plages: Plages seem to be chromospheric equivalents of sunspots. Plages in Hα imaging show up as bright patches. Since they occur at the edges of filaments it would be interesting to contrast them with the magnetogram data for the corresponding dates.**
- **Chromospheric network: The chromospheric magnetic network is evident in the Hα as a bright pattern. The network brightness should indicate density and temperature. The edges of the network where the material deposition happens tends to brighter than the core, this will be interesting to image and document.**
- **Below is a classic full disk Hα image that we hope to achieve at the observatory[3]**



3.Instrumentation

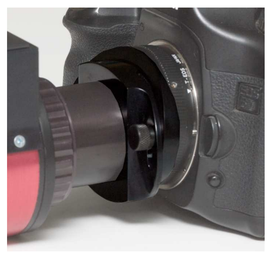
Hα Fabry-Perot etalon

The Daystar Quantum bandpass filter will be used for this thesis at the UND observatory under the supervision of Dr. Paul S. Hardersen. The filter is a Fabry-Perot etalon that uses the principle of interference to produce an accurate central band frequency of the 6562.8 A by blocking all other frequency bands to an accuracy of 0.2 A.[2] The filter is applied to the back of an Schmidt-Cassegrain telescope at the observatory with a focal length of F/30 in a focal plane imaging set up. The narrow FWHM is designed to reveal details even in faint prominences . The filter has the ability to image the wings of the Hα as well by changing the central wavelength using the buttons shown in the figure.



Interference Eliminator

Fringes are caused in the in the Fabry-Perot etalon because of the optical axis tilting and causing destructive and constructive interference patterns known as Newton's rings. The solution to this is by slightly changing the path lengths so that interference occurs at different frequencies . The interference eliminator does this by tilting the camera slightly off normal while keeping the center of the image stationary. The interference eliminator is placed directly in front of the camera in the optical train. The optimum tilt has to be decided by trial and error.



Energy Rejection filter

The energy rejection filter is used to reduce the overall heat load entering the telescope by reducing the aperture and absorbing the heat through high grade optical windows. This thesis uses an off-axis reduced aperture filter of approximately 2 inches diameter. This also serves to reduce the telescope aperture to achieve a higher focal ratio of F/30. In addition to this the equipment set up also uses a neutral density filter to reduce the overall light intensity but this is situated in a filter wheel at the back of the telescope

Finger Lakes Instrumentation front illuminated CCD camera

This thesis uses the Finger Lakes Instrumentation (FLI) ProLine series of CCDs to image the sun in the Hα spectrum. The CCD has a chip size of 4096x4096 pixels, with a pixel size of 9µm. The CCD produces a field of view 49.8'x49.8' on both axes with the telescope and Energy rejection filter combination. The FLI CCD can go down to an integration time of 0.2 seconds which is low enough to acquire enough data without completely saturating the CCD.

LX200 GPS Schmidt-Cassegrain 10" telescope

This thesis uses a SCT telescope with a LX200 GPS motorized fork mount that is controlled with a key pad. The telescope has a focal length of 2540 mm and aperture of 10 inches. However due to the energy rejection filter the aperture is reduced to a little over 2 inches with a focal ratio becoming f/30. The guided fork mount will be used to track the sun through the day and it is a future goal that unguided tracking will be feasible in the future. The telescope is remotely controllable using ACP and is internet controlled. More information is available at http:// observatory.space.edu.

Image processing techniques planned to be implemented through IDL

- **Unsharp masking: The technique is used to highlight sharp features in the images. This can be used to detect quiescent prominences etc which are not very evident directly from the data.**
- **Sobel transform This is a transform which can be used in unsharp masking and is typically used to detect the edge between filaments and prominences.**
- **Robert's Cross operator This is used for edge detection, similar to the Sobel transform, a qualitative choice has to be made based on multiple image processing runs.**
- **This thesis will also attempt to use fast fourier transforms and deconvolution as additional techniques to improve the scientific accuracy of the images taken.**
- **The learning and understanding of IDL routines to perform the image processing operations is intended. This will ensure that the I, as student, have a good understanding not only of the image processing techniques but also of IDL syntax.**

References:

[1]DENKER, C. et al., 199. Synoptic H-alpha observations of the sun from the big bear solar observatory. Solar physics, pp. 87-102.

[2]Daystar Filters, 2000. Quantum Hydrogen alpha filter, s.l.: Daystar Filters .

[3]AURA inc., 2011. ISOON. [Online] Available at: http://nsosp.nso.edu/info [Accessed 22 March 2012].

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