Reflecting Echelle Spectrograph (RES) For the Multi-Application Solar Telescope

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Science Goals: We propose to have a spectrograph as a back-end instrument for the MAST telescope to be installed at USO.

Our main scientific goals are to study the

- Dynamics of small-scale magnetic flux elements
- Evolution of magnetic flux (emergence and cancellation)
- Temperature structure of the chromosphere
- Spatial distribution of hot and cool material in the chromosphere
- Heating of the upper atmosphere

This can be achieved if

1. One is able to measure the velocity flows of the order of 0.5 km/s in the solar atmosphere at differents height in the solar atmosphere.
2. Large wavelength range is covered so that more than two spectral lines can be chosen for spectroscopy. In fact, simultaneous spectropolarimetry in photospheric and chromospheric lines would be highly desirable
3. High linear dispersion of 5mA/pixel can be achieved.

Choice of spectral lines: Our choice of two spectral lines is on the following basis

a. High Lande factor
b. Formation heights in photosphere and chromosphere respectively so that simultaneous measurements in each line can be made.
c. The two lines should be chosen such that their wavelength separation is optimum to allow the dispersed light through the focusing lens.

Design considerations: The availability of particular diffraction gratings of specific blazing angles guides the designing of the spectrograph for the MAST. Our goal of wavelength diversity, i.e., observing at more than two wavelengths requires a longer focal length of the spectrograph which is not difficult as the spectrograph will be installed on a stationary platform. The choice of pixel size matching the littrow condition for the spectrograph will minimize the overall spectrograph size and is a significant factor to be considered in the design.

Further, the design of the spectrograph should be taken into consideration the coupling of the spectrograph to the main telescope.

Optical design Components: For designing such a high dispersion spectrograph, the chief components i.e. the entrance slit, collimator, grating and camera have to be suitably selected. There are different configurations for the arrangement of these components. The simplest of these is the Littrow arrangement that uses the same optics as a camera and collimator.

Selected Lines: Suggested pair of lines are, (i) 6173-8542A and (ii) 6302-8542 A

(i) 6173-8542A

1 --> Grating specifications:

Grating constant : 79 lines/mm
Blaze angle : 63.46 deg
Grating size : 408 x 204 mm

2 --> Order calculation

Assuming Littrow condition
Order for line 854.210 nm = 26
Order for line 617.334 nm = 37
Angle of incidence for the line 854.210 nm : 61.32^0
Fixing the above angle of incidence for the grating,
the angle of diffraction for the 617.334 nm line : 68.00^0
Spectral resolution 854.210 nm = 21.24 mA
Resolving power 854.210 nm = 402247.40
Spectral resolution 617.334 nm = 10.78 mA
Resolving power 617.334 nm = 572428.99

3 --> Littrow mirror focal length calculation

Focal length calculation assuming 13 (PIXIS 1024B) micron pixel size
taking 630.25 nm as the base line
Assumed pixel size : 26 microns
Sampling size half of (Nyquist criteria) the spectral resolution : 5.39 mA/pixel
Then, linear dispersion : 4.82 mm/A
Focal length of the Littrow mirror : 7.92 m
Assuming the final beam is f/40, the size of the Littrow mirror
should be ; 158.36 mm
Total spectral range covered by the 1024 CCD @ 630.25 nm 5.52Å
For 8542 A line ----------
Linear dispersion = 3.39 mm/A
Spectral sampling = 5.90 mA/pixel
Total spectral range covered = 6.04 A

(ii) 6302-8542 A

1 --> Grating specifications:

Grating constant : 79 lines/mm
Blaze angle : 63.46 deg
Grating size : 408 x 204 mm

2 --> Order calculation

Assuming Littrow condition
Order for line 854.210 nm = 26
Order for line 630.250 nm = 36
Angle of incidence for the line 854.210 nm : 61.32^0
Fixing the above angle of incidence for the grating,
the angle of diffraction for the 630.250 nm line : 66.23^0
Spectral resolution 854.210 nm = 21.24 mA
Resolving power 854.210 nm = 402247.40
Spectral resolution 630.250 nm = 11.32 mA
Resolving power 630.250 nm = 556957.93

3 --> Littrow mirror focal length calculation

Focal length calculation assuming 13 (PIXIS 1024B) micron pixel size
taking 630.25 nm as the base line
Assumed pixel size : 26 microns
Sampling size half of (Nyquist criteria) the spectral resolution : 5.66 mA/pixel
Then, linear dispersion : 4.595 mm/A
Focal length of the Littrow mirror : 7.756 m
Assuming the final beam is f/40, the size of the Littrow mirror
should be ; 155.11 mm
Total spectral range covered by the 1024 CCD @ 630.25 nm 5.79Å
For 8542 A line ----------
Linear dispersion = 3.32 mm/A
Spectral sampling = 6.03 mA/pixel
Total spectral range covered = 6.17 A

Optical Design is being finalized now.