Prominence Magnetometer Operations

This document was originally prepared to make sure we understand all aspects of observing with the Prominence Magnetometer (ProMag) and that all necessary controls are available. Refer to *ProMag_OpticsandControl_Revx* for details of the ProMag instrument. Use cases for observing and set up are examined for required controls.

Mechanisms:

More than just the ProMag computer is required to make solar observations. The ESF so called "chronograph" control panel contains push buttons and a hand box connected to the facility computer has numerous commands.

Telescope hand box coronagraph commands:

The handbox has a selector for a number or letter, a Hi/Low selector, and buttons for ±x and ±y (nomenclature when using Lo) or ±X and ±Y (nomenclature when using Hi).
0 : Coronagraph guider lens (x and y drive E-W and N-S respectively. X and Y are fast)
1 : coude mirror (same as guider)
2 : occulting/inverse disk position (same as guider)
4 x : occulting disk focus (X for fast)
4 y : O_2 lens focus (Y for fast)

"Chronograph" control panel push buttons

Lens cap: Close/Open
O_1 Lens: Disk/Coronal
O_1 Aperture: 16/12/8
Diffuser: Out/In

ProMag control computer

Details of mechanism units, rates, limits etc are in a separate document

Polarimeter rotation (0º to 360º and cannot cross 0º)
Calibration optics translation (in/dark/out)
Calibration polarizer angle (0º to 360º)
Calibration retarder angle (0º to 360º)
Image rotator angle (synchronized to polarimeter angle and telescope hour angle)
Slit translation (±158.5 arc seconds)
Collimator translation (synchronized to slit translation)
Visible light camera focus (microns)

ProMag manual adjustments

Grating rotation
IR camera focus
Visible camera pre-filter

Set up:

Refer to the Evans Solar Facility (ESF) observer's manual http://nsosp.nso.edu/esf/obsman/index.html for daily operation of the coronagraph, startup and shutdown.

Using the "Chronograph" panel push buttons select the O_1 aperture of 8 and disk lens. Open the lens cap. Use hand box commands to focus the telescope. Send the coronagraph beam to "ebc". If necessary adjust the coudé to place an image of the ProMag inverse occulter on the slit. Move the guider lens so that the solar limb is on the slit. Sharpen the limb with O_2 focus. Sharpen the image of the ProMag inverse occulter with occulting disk focus. The occulter translation needs to be centered. Drive the guider lens to the north limb and record the position. Drive to the south limb and record the position. Calculate the value where the limb should be and drive to that position. Use the occulter N-S translation to center the limb in the ProMag aperture. Repeat for the E-W limbs. From now on the occulter translation is to be fixed and any centering on the slit should be performed using the coudé hand box adjustment.

There will be a one time only TBD spectrograph alignment procedure involving slit rotation, grating β angle, camera rotation, and collimator focus position. This setup will establish the relative translations of the slit scan and collimator lens mechanisms that must remain synchronized.

There will be a one time adjustment to synchronize polarimeter angle to image rotator angle. From the ProMag computer drive the image rotator angle until the straight side of the inverse occulter is parallel to the slit. To align the edge of the inverse occulter to the edge of the slit, view the spectrograph image using ProMag camera(s) in video mode. Use the ProMag slit translation to move the slit just to the edge of the occulter. Carefully adjust rotation of the image rotator for equal illumination along the length of the slit. Once the rotator orientation has been set, the polarimeter rotation and image rotator angle are synchronized in software so that the image rotator always places the short axis of the inverse occulter parallel to the entrance slit of the spectrograph. The image rotator angle also continuously adjusts for image rotation due to the coudé feed.
Impact on ProMag control.

Video mode for cameras
Angle of image rotator selectable while viewing camera display
Angle of polarimeter adjustable while viewing image on Littrow spectrograph
Positioning of spectrograph slit/collimator while viewing camera display and then sending slit translation to an absolute position
Continuous motion of image rotator angle to correct for image rotation even when sending the polarimeter and image rotator to selectable angles
Synchronization of polarimeter angle and image rotator angle
Synchronization of slit translation and collimator lens translation

Daily:

As often as daily, there will be spectrum line selection that will involve manually positioning of the visible light camera and camera lens, to previously defined locations with mechanical stops. Prominence observations are conducted with the visible camera and camera lens aligned to the 587.6nm stops. Filament observations are conducted with the visible camera and camera lens aligned to the 656.3nm stops. The pre-filter screwed to the front of the visible light camera is selected for the particular observation. The IR camera only exceptionally will be used at a wavelength other than 1083.0nm so the camera, IR camera lens, camera pre-filter, and grating angle remain unchanged.

To set up on a prominence, use the 8" O_1 aperture and the disk lens, set from the "Chronograph" control panel. Use hand box #2 to direct the beam to the West Bench Littrow spectrograph slit. The reflected dual beam image off the slit is viewed through an ESF Hα Lyot filter and video monitor camera. Drive the spar to the limb using the hand box and look for a prominence (perhaps using the Hilltop Dome image for guidance). From the ProMag computer drive the polarimeter angle until the long concave side of the inverse occulter is tangent to the solar limb at the base of the prominence and blocking disk light. Drive the spar so that disk light just fills the inverse occulter field of view. Flip the beam back to the East Bench. Drive the slit translation back to the center of the inverse occulter image. Drive the spar until the disk is again occulted. Adjust the coudé to center the image on the slit if necessary. Change to the coronal objective lens and restore the full 16" aperture.
Impact on ProMag control.

Hα context imager on at the Littrow spectrograph

Observing:

Prominence Map:

Follow the procedure above to center a prominence on the ProMag spectrograph slit. Use the ProMag computer to select the modulation rate. Select the number of map steps, number of map repeats, and step size. Start a map. The map consists of Stokes observations at each of the map steps. On at least the visible light camera view Stokes parameters as they are collected. Adjust display gain of this Stokes parameter display so that the polarization signal can be seen. On the control computer monitor progress of the observation, pause it, end it, or abort it. The computer notifies the user when the observation is complete. Data are stored in FITS format using a file name that identify this observation as a prominence map.
Impact on ProMag control.

- *Set up observation parameters*
  - *Map steps*
  - *Step size*
  - *Repeats*
- *Control an observation*
  - *Start*
  - *Pause/Resume*
  - *Abort*

End
Show map progress
Control of the modulator
Modulation rate
Synchronize data collection
Tell cameras when to start data accumulation (TCP/IP to remote cameras)
Broadcast modulator status to remote cameras via parallel I/O
Send camera strobe signals to remote cameras via TTL
Internal and remote cameras
Accumulate frames into Stokes modulation states upon command
Remote cameras demodulate modulation states into Stokes parameters
Remote cameras display Stokes parameters with adjustable gain
All computers store data in FITS format
Modulator phase offset specified to remote computers

Filament Map:

A filament map is similar to a prominence map except a filament is on the solar disk. Orientation of the inverse occulter has the desired scan direction along desired axis of the filament. The coronagraph disk lens is used for filaments. Since the theoretical resolution of the 40-cm coronagraph is never used (0.3 arc seconds) reduction of the objective lens aperture diameter from 16” to 8” is used to reduce solar flux on the polarimeter. An additional factor of ~25 reduction in flux is achieved using a neutral density filter at the spectrograph slit. Data are stored using a file name that identifies the observation as a filament map.

Polarization Calibration:

Calibrations for disk observations and limb observations are performed separately since different optics are used. For the filament configuration (with 8” aperture) use the center of the solar disk for calibration. For the prominence configuration, insert the diffuser into the beam and drive the telescope to disk center. One must create a list of calibration optical configurations. These consist of at least

Dark
Clear
Linear polarizer at 0º, 45º, 90º, and 135º with the retarder set to 0º
Linear polarizer at 0º, 45º, 90º, and 135º with the retarder set to 45º

At least at first we will try many more configurations than these and then decide upon the actual set comprising the minimum number possible. Perform Stokes observations at each of these configurations with the observing program stepping through the list and changing configurations between each observation. At least at first calibrations will be performed at several slit translation positions. It may turn out that this is not needed but the capability must be available. Data are stored with a filename that identifies this as a filament or prominence polarization calibration.

Impact on ProMag control.

Configure the calibration optics to a pre-determined set of positions
Perform Stokes observations automatically sampling each configuration

The same control options as for a Map are available

Flat Field

Flat field consists of finding the detector gain and dark levels. For prominence observations, use the diffuser for the gain measurement. For filament observations it would be nice to be able to raster the solar guider to smooth out solar features. The flat field operation will be like a many step map but with no solar details. In addition to taking light observations, many darks are acquired. Data are stored in a format that identifies, a gain, or dark observation, prominence or filament.
Impact on ProMag control.

Automatically configure the telescope for gain or dark
Perform Stokes observations at these configurations
The same control options as for a Map are available

Data

The amount of data per day can vary widely. Assuming ten solar targets per day (prominences and filaments), maximum size maps of 120 steps, each of two cameras producing a pair of 256x256 images of four Stokes parameters and 2 bytes/pixel, there will be 1.2Gbytes of data per camera per day. This amount of data could easily be archived onto DVD or USB disk drive. For signal to noise better than 10^3 about 15 seconds per scan position is required, ½ hour per map, or 5 hours/day.

Conclusion

This document is expected to become much larger with inclusion of the detailed commands sent to the hand box, and ProMag computer. The impacts sections will be removed as these capabilities are made available. For reference this document will eventually be web accessible.

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