AN IMAGING VECTOR MAGNETOGRAPH FOR THE NEXT SOLAR MAXIMUM

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ABSTRACT.

Measurements of the vector magnetic field in the sun's atmosphere with high spatial and temporal resolution over a large field of view are critical to understanding the nature and evolution of currents in active regions. Such measurements, when combined with the thermal and nonthermal X-ray images from the upcoming Solar-A mission, will reveal the large-scale relationship between these currents and sites of heating and particle acceleration in flaring coronal magnetic flux tubes.

We describe the conceptual design of a new imaging vector magnetograph that combines a modest solar telescope with a rotating quarter-wave plate, an acousto-optical tunable prefilter as a blocker for a servo-controlled Fabry-Perot etalon, CCD cameras, and a rapid digital tape recorder. Its high spatial resolution (1/2 arcsec pixel size) over a large field of view (4 by 5 arcmin) will be sufficient to significantly measure, for the first time, the magnetic energy dissipated in major solar flares. Its millisecond tunability and wide spectral range (5000 - 8000 Å) enable nearly simultaneous vector magnetic field measurements in the gas-pressure-dominated photosphere and magnetically-dominated chromosphere, as well as effective co-alignment with Solar-A's X-ray images.

PERFORMANCE CHARACTERISTICS

- **Spatial resolution: one arcsec.** Detector pixel spacing of approximately 0.5 arcsec over a 4 x 5 arcmin field of view. This high resolution will critically sample the high quality image typical at Mees early in the day.

- **Spectral resolution: 70 mÅ at 6000Å.** This resolution is marginal for the narrowest lines; at least three spectral samples will be required in the simplest cases, and probably quite a few more will be used for the standard program.

- **Spectral range: 5000 - 6500 Å.** This range includes both photospheric (e.g. Fe I λ6302) and chromospheric (e.g. Mg I λ5173) lines whose use for vector magnetic field measurement is well understood.

- **Temporal resolution: A complete magnetogram in a single line in 15 seconds.** This resolution is determined primarily by the data recording speed; better resolution can be achieved over a smaller field of view.

- **Sensitivity: 10 Gauss longitudinal fields and 200 Gauss transverse fields in a few seconds.** Simultaneous velocity measurements to 10 m/s. Temporal resolution can be traded for increased sensitivity.

- **Co-alignment: A simultaneous photospheric white-light image of the full field of view,** for precise co-alignment with Solar-A images and Max'91 ground and balloon-borne experiments.

DESIGN FEATURES

- **Telescope: 20-cm refractor.** On-axis, as shown in the Figures 4 and 5. On the spar at Mees Solar Observatory, Haleakala, Maui.

- **Monochromator: Air-spaced tunable Fabry-Perot, 70mÅ bandpass.** Order-sorting using an acousto-optic tunable filter (AOTF) with bandpass of 2 Å, a contrast of 1000:1, a large field of view, rapidly tunable over the full wavelength range.

- **Polarization Modulator: Rotating quarter-wave plate.** The AOTF will double as a beam-splitting analyzer.

- **Detectors: High-resolution commercial CCD cameras.** No mechanical shutter is necessary; turning off the radio-frequency signal to the AOTF turns off the diffracted beams imaged on the cameras. 754 x 488 pixel detector arrays.

- **Data Acquisition: 68020-based computer in a VME-bus chassis.** A minimum modulation sequence consists of a half-rotation of the wave plate, i.e. eight camera reads, which are combined to derive Stokes parameters. Recording on 8mm digital video cassettes.

- **Analysis and Archiving**: Off-line analysis on a Sun workstation. Archival medium is the original 8mm video cassette. Digital optical disk for archiving working datasets. Video disk recorder for time-dependence studies.

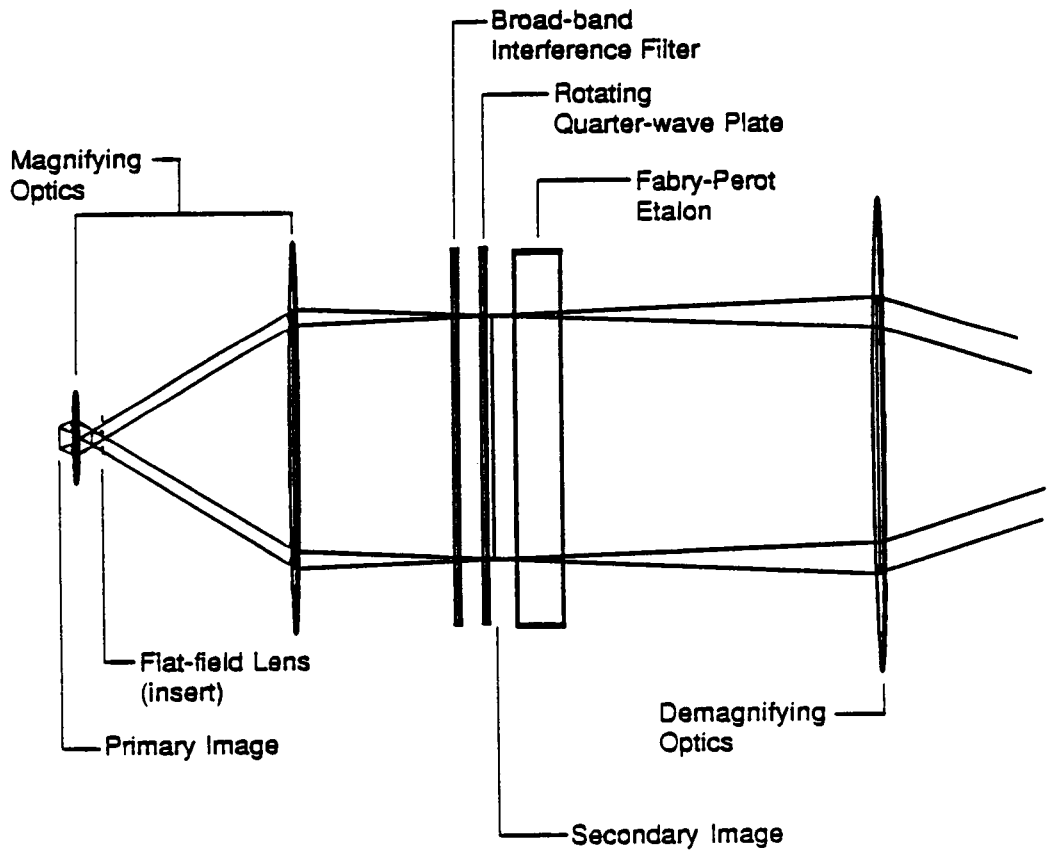

Figure 1. The modulator section of the Imaging Vector Magnetograph. Vertical exaggeration is 5:1.

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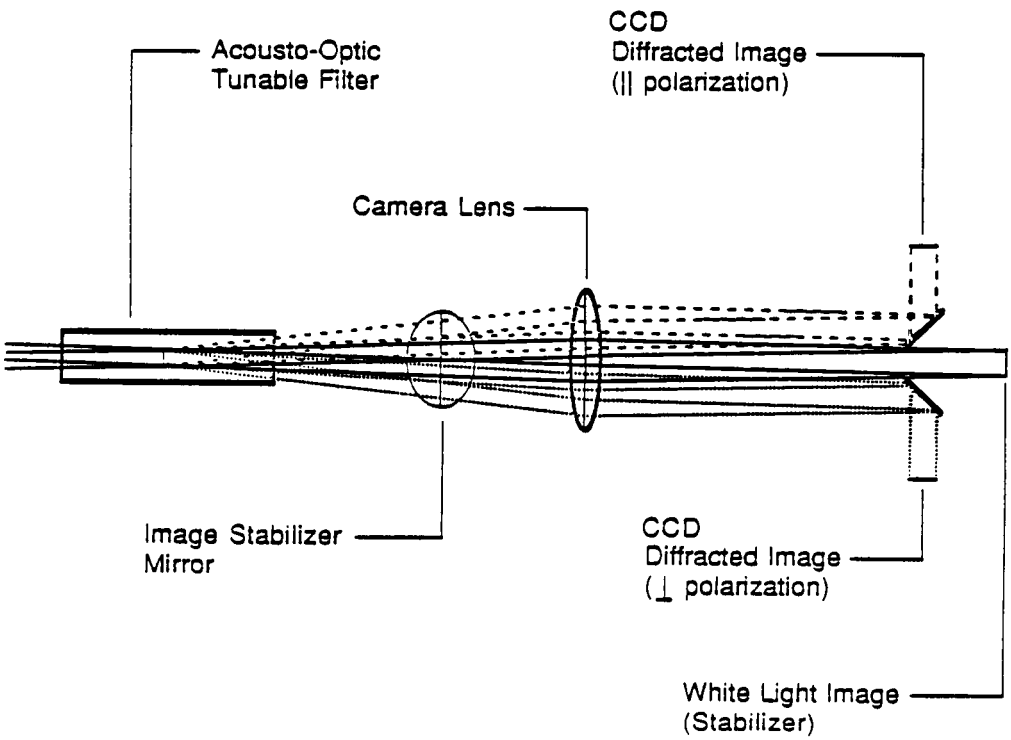

Figure 2. The analyzer section of the Imaging Vector Magnetograph.