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AN IMAGING VECTOR MAGNETOGRAPH FOR THE NEXT SOLAR MAXIMUM

Richard C. Canfield and Donald L. Mickey
Institute for Astronomy, University of Hawaii
Honolulu, Hawaii 96822

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.

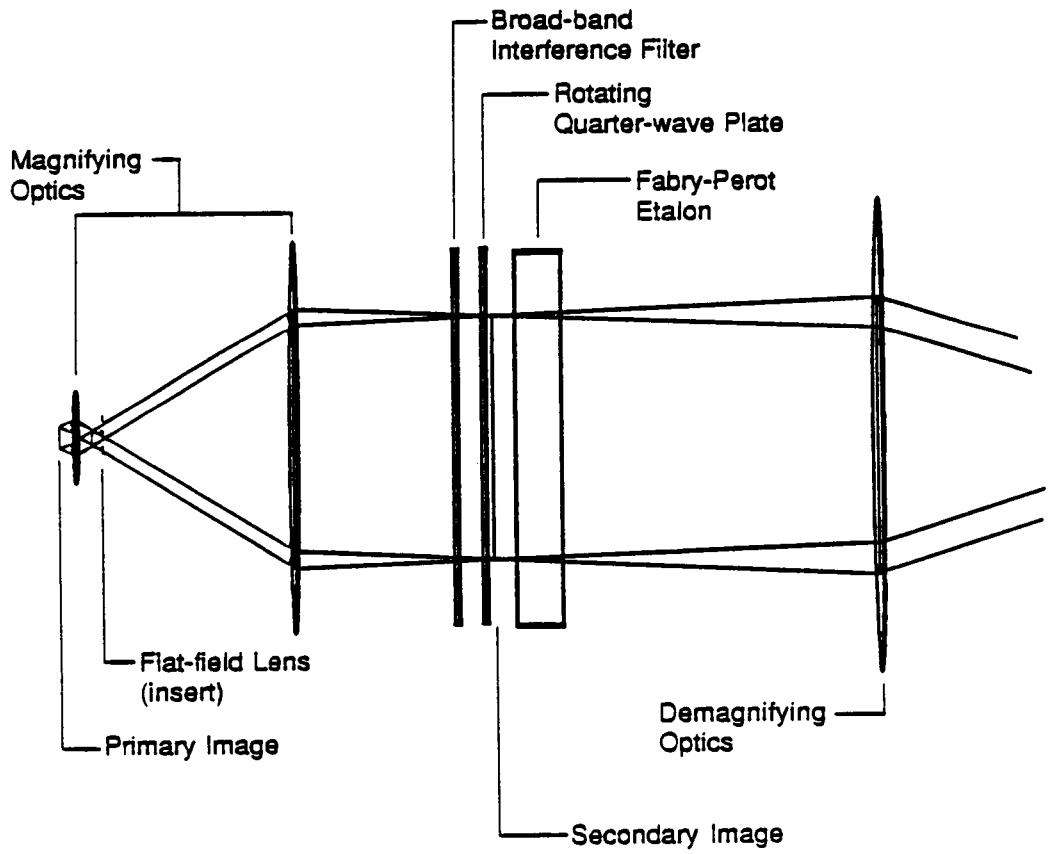

Figure 1. The modulator section of the Imaging Vector Magnetograph. Vertical exaggeration is 5:1.

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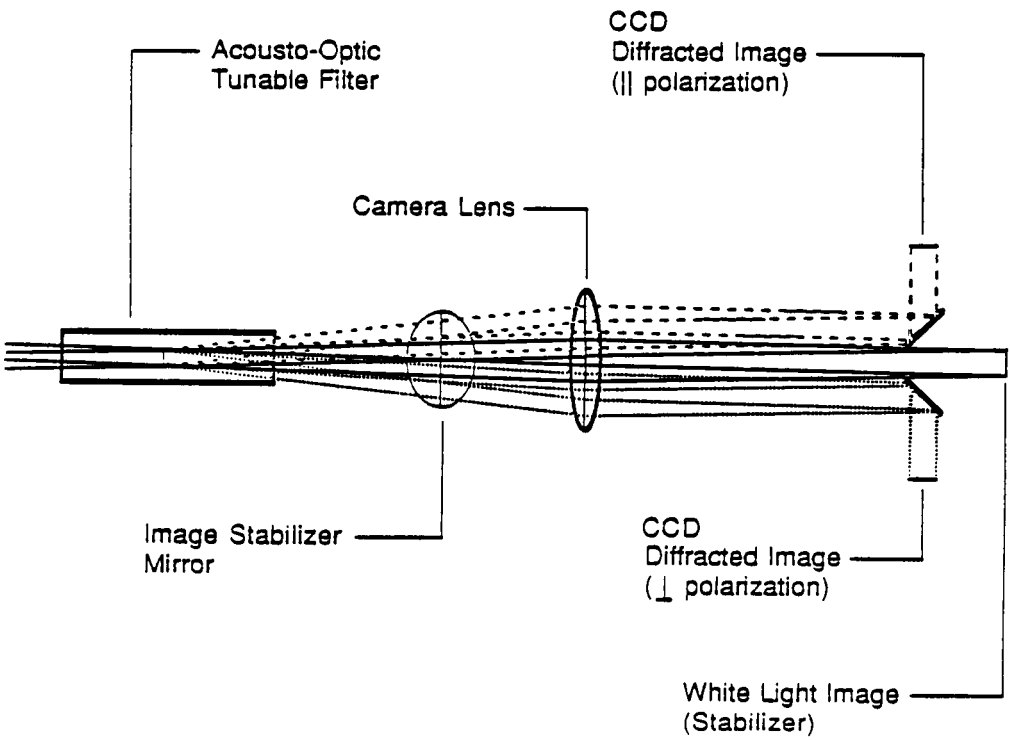

Figure 2. The analyzer section of the Imaging Vector Magnetograph.