Mem. S.A.It. Vol. 74, 835

Memorie della Società Astronomica Italiana

The ASCE EUV Polarimeter

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Abstract. The SOHO mission has achieved important results in the physics of solar wind and coronal mass ejection acceleration, but most of the processes that drive this acceleration have not yet been explained. The Advanced Spectroscopic and Coronagraphic Explorer (ASCE) mission will carry on-board spectroscopic and polarimetric instrumentation of new generation that is designed to address the fundamental questions on this processes. Following a brief description of ASCE scientific objectives and instrumentation, the EUV polarimetric channel is described. The EUV Polarimeter (EUVP) is designed to measure for the first time the magnetic field vector in the extended corona through the Hanle effect, and the anisotropy of the ion velocity. The EUVP represents the contribution of the Italian solar physics community to the ASCE mission.

Key words. EUV spectropolarimetry – solar corona – solar wind and CME acceleration

1. Introduction

The energy that heats the corona and accelerates the solar wind and the coronal mass ejections (CMEs) originates in the sub-photospheric convective motions, but how this energy is transported into the solar corona and converted in thermal, kinetic, and magnetic energy is not known. The Solar Heliospheric Observatory (SOHO) has greatly advanced our knowledge about coronal heating, solar wind acceleration, and CMEs (Fleck & Svestka (1997)) but many key questions remain unanswered.

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The proposed Advanced Spectroscopic and Coronagraphic Explorer (ASCE) (Gardner et al. (2002)) will address fundamental questions on how the primary and secondary plasma components of the fast and slow solar wind are heated and accelerated, and on how the CMEs are heated and accelarated, and which is their role in the evolution of the solar magnetic field. Spectroscopy and polarimetry provide the empirical description of the plasma that is needed to identify the basic physical processes. Also, a detailed understanding of the physical processes is fundamental to learn how and when to perform space weather predictions. ASCE payload consists of three instruments, a EUV coronagraph spectrometer (AUVCS), a visible light coronagraph (ALASCO), and a solar disk spectrometer (ASDS), which derive their optical design from the SOHO instruments but with greatly improved performances. These instruments will provide:

- intensities of EUV spectral lines, in chromosphere, transition region and low corona, with high spatial resolution (1") and high cadence (10s) (ASDS);
- spectroscopic and polarimetric diagnostics of the extended corona (1.15-10$R_\odot$), with performances up to 400 times better that those of SOHO/UVCS, through the measurement of intensities and profiles of EUV spectral lines, including, for the first time, the HeII 30.4nm line (AUVCS);
- visible light imaging and polarimetry of the solar corona (1.15-10$R_\odot$) with high cadence (1s) (ALASCO).

The most important feature that will enhance the performances of the coronagraphs will be a 13 m deployable boom that will bring the external occulter 14.7 m away from the telescope mirrors, providing an increased mirror area, decreased stray light, and allowing observations at lower heliocentric heights.

The Italian solar physics community will contribute to ASCE with a EUV Polarimeter (EUVP) that will be mounted on the focal plane of the EUV coronagraph spectrometer (EUVSP) forming the EUV Polarimetric Path (EUVPP). The EUVP is designed to measure the linearly polarized brightness and the orientation of the polarization vector of the EUV lines from the Lyman continuum to Lyα in the outer solar corona ($r > 1.2 R_\odot$).

2. EUVP scientific objectives

The EUVP is designed to perform spectropolarimetry in the 90 - 130 nm wavelength range where many of the brightest coronal lines lies. The major objective of the EUVPis the determination of the magnetic field intensity in the outer corona through the measurement of the Hanle effect, that produces depolarization and rotation of the polarization vector in the HI lines. The magnetic field diagnostics, described in Fineschi et al. (1999), is based on the measurement of the linear polarization and the intensity of the hydrogen Lyman series lines (Lyα 121.6 nm, Lyβ 102.5 nm, and Lyδ 95.1 nm, obtained with EUVP) and of the FeXIV 530.3 nm (observed by ALASCO). This technique will be applied between 1.2 and 1.5 $R_\odot$ and will be able to determine magnetic fields intensities above 1 gauss. The secondary objective is the measurement of the polarization state of the atomic and ion lines (among the brightest the O^{+5} lines). The polarization of the spectral lines gives an additional piece of information for the understanding of the solar wind velocity field, and the ion kinetic velocity distribution. This represents the first attempt to measure the polarization state of spectral lines in the outer corona. The velocity vector and the velocity distribution anisotropy will be determined for the ion O^{+5} from the measurement of the intensity, and the linear polarization of the OVI 103.2/103.7 nm doublet (Fineschi (2001)).

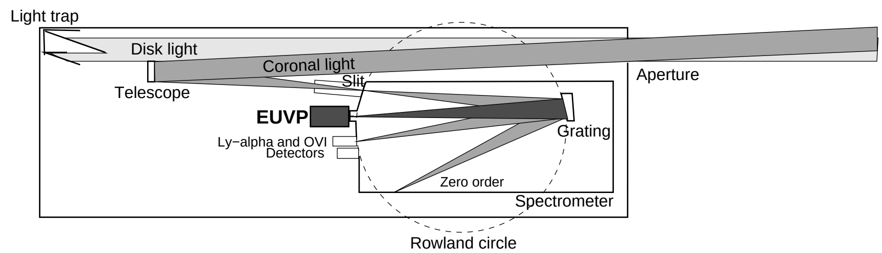

Fig. 1. EUVPP optical diagram.

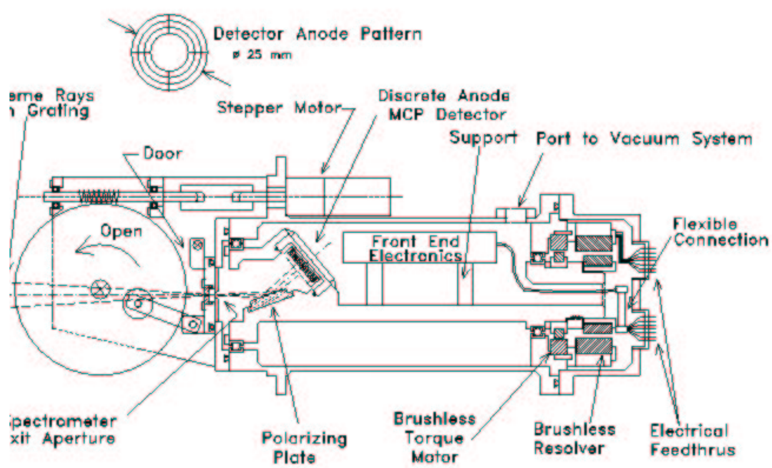

Fig. 2. EUVP mechanical and optical layout.

3. EUVP technical description

The EUVP is designed to perform spectropolarimetry in the 90 - 130 nm wavelength range. Since no transmission polarizers are available in the 90-130 nm spectral range, a single reflecting surface placed at about the pseudo-Brewster angle with respect to the incidence beam will perform the best in terms of efficiency and polarization properties. The EUVP is mounted on the focal plane of the spectrometer of the AUVCS EUV spectroscopic path (EUVSP) forming with the EUVSP the EUVP (Fig.1). The radiation from the selected line is focused by the EUV spectrometer grating onto the EUVP entrance pinhole. The EUV polarimetry path (EUVPP) is selected by adjusting the rotation of the EUV grating to focus the desired wavelength onto the entrance pinhole. The EUVP optical assembly consists of a rectangular pinhole, a rotating polarizer, and a detector (Fig.2), whose specifications are given in Tab.1. The polarizer is a CaF_2 reflecting flat. A preliminary study (Corti & Romoli (2003)) based on the reflectance properties and the polarization properties of several materials (metals, semiconductors, and dielectrics), and on a laboratory characterization of selected materials have returned the CaF_2 as the best candidate. The front and back surfaces of the fluoride polarizer form a wedge to prevent the back surface reflection of Lyα radiation from illuminating the detec-

Table 1. EUVP specifications.

Entrance pinhole:		Rectangular: $300\mu m \times 2.9mm (\pm 20\mu m)$
	Spectral resolution	0.2 nm
	Spatial resolution	24" (radial) x 84" (tangential)
Distance pinhole - detector:		60 mm
Polarizer:	Size (diameter)	$25.0mm \pm 0.1mm$
	Thickness (center)	$7.0mm \pm 0.1mm$
	Wedge angle	$17^\circ \pm 0.5^\circ$
	Substrate	CaF_2 (uncoated)
	Surface figure and finish	Flat $\lambda/10$
	Surface microroughness	0.8 nm rms
Polarizer angle of incidence:		$70^\circ \pm 0.5^\circ$
Rotation mechanism:	Step size	$1^\circ \pm 0.1^\circ$
	Range	$\pm 100^\circ$
	Coalignment with optical axis	$\pm 0.5^\circ$
Detector:	Microchannel plate	Z-stack MCP
	Photocathode	KBr ($>$ 35% at HI Lyman lines)
	Read-out	Discrete anode array in bull's eye pattern
	Size of anode array	$25.0mm \pm 0.1mm$
	Size of central anode	$12.5mm \pm 0.1mm$

tor surface. Lyα is the only line in the wavelength range of interest that is transmitted through the material. The detector is a KBr coated MCP with discrete anodes. The polarizer and the detector are assembled on a rigid mount that rotates around an axis that is co-aligned with the optical axis of the incident beam. The entire polarimeter is enclosed in a housing that can be evacuated to preserve the functionality and the performances of the detector. An aperture door, which will be opened at the beginning of the mission and closed at the end, seals the subsystem. A EUV transmissive window is incorporated into the door to allow alignment verifications on the ground while the system is in vacuum.

4. Conclusions

ASCE has been selected by NASA for the feasibility study within the MIDEX (Medium Class Explorer) program and will undergo final selection in the spring 2003. ASCE is scheduled for launch at the beginning of 2007.

Acknowledgements. We are thankful to Galileo Avionica, Firenze, and Laben, Milano, for the fundamental technical support. This work has been partially supported by ASI (Italian Space Agency).

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