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PRISMA THE INSTRUMENTS

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INTRODUCTION

Our understanding of Solar structure has increased dramatically in the last couple of decades thanks mainly to the opening of new windows of observation providing high quality data to theoreticians with access to powerful computing facilities. Two of the new windows were UV and X-ray images of the Sun, allowing a detailed view of the upper solar atmosphere, and the development of very high resolution spectrometers allowing us to exploit the solar oscillations to probe the internal structure of the Sun. It is the goal of PRISMA to extend these techniques to other stars, which using the Sun as a calibration point will allow us to explore stellar structure and evolution in ways not possible now.

In this poster I will present a possible selection of instruments able to achieve this goal, and explain some of the rationale in their design. A more general overview is presented by T. Appouchaux also in these proceedings. It must be stressed that these are not the definitive instruments to be flown on PRISMA, but rather result from a study to show the feasibility of such a mission. Should PRISMA be chosen as the next ESA medium sized mission, an 'Announcement of Opportunity' will be issued by ESA and the responses of all people interested in constructing the instrument will be considered.

For more information about PRISMA please send an electronic mail request to:**prisma@obs.aau.dk [129.142.17.96]**

ASTEROSEISMOLOGY

There are two main techniques for measuring the solar oscillations, Doppler velocity measurements with very high stability and resolution spectrometers, and intensity measurements with photometers. For ground based observations the spectroscopic techniques are preferred, as the fluctuations in the transparency Earth's atmosphere are some 100 times larger than the solar intensity fluctuations. From space this problem disappears, and the relative simplicity of the photometric instruments lends itself to satellite operation. In the case of stellar measurements there are further factors in favour of using photometric techniques. The optical layout of the two photometers on PRISMA is very similar, as they both have to fulfil the stringent conditions of providing a wide field of view, and a flat image. At the same time it must be possible to achieve very good photometric precision for all stars in the field. In order to satisfy these requirements, a three mirror off axis design was chosen. Both photometers use simple active optics to stabilise the stellar image on the detector. This reduces the noise due to spacecraft jitter though recent calculations by British Aerospace show that the satellite platform may be very stable.

The rôle of the large photometer is to provide seismic data for many stars in a $1.5° \times 1.5°$ field. To monitor many stars at once a Charge Coupled Device (CCD) detector has been selected. As there is only a limited data transmission bandwidth, only the position and intensity of the stars is transmitted. We have proposed a parallel architecture for the onboard data reduction system, this has the twin advantages of high throughput, and increased redundancy.

The small photometer is dedicated to obtaining very high quality time series for bright stars. A coelostat allows the SP to point independently of the other instruments, so it can view the same star for many months. A photo diode detector is used as this provides a large dynamic range, and relatively simple electronics.

ACTIVITY MONITORING

Monitoring various lines in the stellar atmosphere gives a picture of the star above the photosphere, and allows us to trace the rotation, and magnetic flux. Simultaneous multi wavelength measurements allow us to track surface inhomogeneities such as star spots and plages, whilst the ability to perform Doppler imaging provides information on the position and area of individual active regions.

The UVS is a Cassegrain telescope feeding a cross dispersed echelle spectrometer. The telescope selects a star by rotation of the primary mirror about its focus. A slit jaw camera and actuated secondary stabilises the image. The spectrometer is a conventional design covering 120–285 nm with a resolving power of about 29000. An off-axis paraboloid collimates the beam onto a small echelle grating, whilst a concave grating is used both as a cross-disperser and camera objective. The echelle working in 41st.–94th. orders gives a dispersion range from 5.2 mm/nm at long wavelengths to 12 mm/nm at the short wavelength limit. A spiral anode detector with 1000×1000 pixels, and a centring accuracy of better than $20 \mu m$ record the spectrum.

The XUVT images the same $1.5° \times 1.5°$ field as the LP and UVS. This instrument has undergone several revisions since the publication of the PRISMA Assessment study report(Appourchaux et. al. 1991). The major change is to increase the collecting area by using a multi mirror design. The reason to use multiple mirrors rather than a single larger is driven by the current state of the art in x-ray multi layer mirrors. The reflectivity of the mirror is very sensitive to the surface smoothness, and the ability to control the thickness of the multi layers. Currently this limits the maximum diameter of such mirrors to about $25 - 30\ cm$, whilst still maintaining a reflectivity of about 30% at 17 nm. The current design uses four 20 cm diameter mirrors, though we have also thought about substituting objective gratings to disperse the image, if this technology proves to be sufficiently mature. A 'Solar Blind' 256×256 anode mesh MCP detector with 50 μm square pixels is planned. This arrangement will allow the detection of solar type activity on stars to 7th. magnitude.

DISCUSSION

The question of whether we need to go to space to make these measurements needs to be asked. For the UV and X-ray measurements the answer is obvious in that the Earth's atmosphere is not transparent at these wavelengths. However, we have just said above that in the case of the Sun we can make measurements from the ground. This is also to some extent true for stellar measurements. There is currently intense work on both Doppler velocity and photometric searches for solar type oscillations on other stars, but in the foreseeable future these techniques show little sign of producing more than an indication that such oscillations exist, rather than providing a tool to probe stellar structure. In the last 6 months the first decisive evidence for solar type oscillations has emerged from velocity observations of α Cen A (Pottasch et. al. 1992). For the first time the results seem to show a resolved spectrum of oscillations above the noise. Unfortunately the Doppler techniques are limited to slowly rotating stars with sharp, unblended absorption lines.

In January 1992 a multi telescope CCD photometric campaign was conducted to study a field in the M67 open cluster. The results of these observations are still being analysed, but it appears that an ultimate noise level of less than 10 μmag. can be achieved for a 5 night 7 telescope campaign. This is indeed exciting, however, it exposes many of the problems of ground based, multi site precision photometry. The measurements of brighter stars are not photon noise limited, but rather scintillation sets the noise limit. The problems of obtaining a good duty cycle are also apparent, as is demonstrated in a separate presentation by Søren Frandsen at this meeting.

On PRISMA the photometers are designed to achieve a precision of 1 ppm in 1 month on 8th and 6th magnitude stars for the LP and SP respectively .For brighter objects this level is reached faster. Thus, very high quality oscillations spectra will be obtained on many objects sampling the HR diagram, and allowing an extensive exploration of the physics of stellar interiors.

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