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Coronal Heating Experiments of the Williams College Group at Mukandgarh Fort, Rajasthan

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Abstract

We report on the Williams College expedition to Mukandgarh Fort, Rajasthan, for the total solar eclipse of 24 October 1995. The main experiments were a search for 1Hz oscillations in coronal loops as an indication of magnetohydrodynamic theories of coronal heating and a mapping of the coronal temperature through comparison of images at specific ultraviolet wavelengths, measuring the difference between the photospheric and coronal continuum. We also obtained a variety of coronal images.

Key Words : Coronal heating, Coronal temperature, Solar eclipse

Introduction

We are studying the coronal oscillation spectrum and its implications on the heating of the solar corona. The observations provide tests of proposed mechanisms to explain the heating of the solar corona via weakly compressive magnetohydrodynamic waves (Pasachoff, 1991). The heating is generated along magnetic field lines in closed loops in the lower corona, at the same heights at which open fields form the solar wind. We found indications of excess Fourier power near 1 Hz in the 1980 earlier version (Pasachoff and Landman, 1984) and again found excess power in the 1983 observations (Pasachoff and Ladd, 1987). These versions used fiber-optics to study single points; the multiplex advantages in using CCDs in both 1994 in Chile and

1995 in India are substantial. The 1994 data were taken through substantial cloud cover, diminishing their usefulness (Pasachoff, *et al.*, 1995; Pasachoff, *et al.*, 1996).

Experimental Details

The basic experiment is to observe the corona in two different wavelengths in order to detect coronal intensity fluctuations while eliminating terrestrial atmospheric effects. The main optical beam from the telescope is divided into two separate channels. A dichroic beamsplitter was used for this purpose. One beam passes through a DayStar [Fe XIV] 5303Å, temperature-tuned interference filter, with a 3Å FWHM passband. The other beam goes through a 100Å wide continuum filter at a nearby wavelength band that has been selected to be as free as possible for other known coronal emission lines. After passing through the filters, the beams are imaged on a thermoelectrically cooled Princeton Instruments CCD. The image scale is approximately 2.0 x 2.0 $arcseconds^2$ per pixel, with a total field of view of 3 x 5 $arcminutes^2$. The image data are digitized and recorded on hard disk. The specific CCD detector was selected to avoid any spurious effects from chip nonuniformities, especially from sub-pixel quantum efficiency variations. We binned 2 x 2 to minimize quantum-efficiency variations.

Our preliminary view of the 1995 data showed peak count rates of better than 4000 adc/bin in the coronal line spectrum, corresponding to more than 14,000 photons/bin. This value is in reasonably good agreement with expectations based on the factor of 3 from our use of a larger objective, 2 from the 5-Hz exposure rates instead of our earlier 10-Hz rate, and 2-3 from clearer skies compared with the Chile data. We thus achieved the 1% level we need.

We successfully observed coronal loops in the [Fe XIV] green line with the CCD imaging at 5 frames per second from the eclipse site in Mukandgarh, Rajasthan, though for computer reasons we have data for only the last 10 second of totality and for only higher loops on the limb of the sun we were observing. The prior observations we made at single points in the corona at the total solar eclipses of 1980 and 1983 indicated excess power in the Fourier power spectra between 0.5 and 2 Hz; our expedition was clouded out of observing the 11 July 1991 total solar eclipse and affected by clouds at the 3 November 1994 eclipse. The new observations improve on the previously published observations in a variety of ways, especially by providing a 200 x 300 arcsec field of view instead of only a single point, which allows us to distinguish between standing and propagating waves.

Data reduction for the oscillation experiment includes flat-fielding and taking account of bias in the series of CCD observations, which we plan to carry out in IDL. We will also measure the position of the solar limb and align the series of images, taking out periodic and atmospheric variations and any drift. We will calculate Fourier transforms for various intervals and for various parts of the image, comparing on-band and off-band images. Any signs of excess power in the 1Hz range will be interpreted, in collaboration with Prof. Joseph Hollweg of the University of New Hampshire, in terms of loop models and their adjustable parameters.

We also carried out a coronal-temperature-mapping experiment, using a slow-scan CCD. This experiment was based on photometric comparison of the corona at different ultraviolet wavelengths chosen for their sensitivity to thermal smearing of the solar spectrum reflected by coronal electrons.

The data from both experiments are available for reduction by my students and me starting during the summer of 1996. We will work on the data from the 1995 eclipse during the summer of 1996 with Williams College student Sebastian Diaz'98 and Colgate University student Matthew Pickard '98 (on a Keck Northeast Astronomy Consortium summer exchange), and during the following academic year as part of the senior thesis of Christian Reynolds'97.

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