OBSERVED CORONAL TEMPERATURES AT 1.37R$_\odot$

IN THE REGION OF A HELMET STRUCTURE*

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(Received 24 June; in revised form 25 October, 1974)

Abstract. During the total solar eclipse, 1965 May 30, a 25 cm aperture f/8.0 telescope and Fabry-Perot interferometer were operated aboard the USAF-AEC aircraft. High resolution spectra of the Fe xiv emission line, 530.3 nm, were obtained. Deconvolved intensity vs wavelength profiles of the second order fringe overlay a helmet structure on the NM limb at out to 1.37 R$_\odot$. The profiles yield coronal temperatures, absolute intensities and Doppler velocities in regions of apparently open magnetic field structure and within the closed field lines of the helmet. Together with white light intensities the observations are interpreted to provide temperatures and turbulent velocities in and around this coronal structure. Comparison is made with a model by Billings and Roberts. We suggest a model with radial flow (solar wind) velocities of \sim 60\, km s$^{-1}$ satisfies the observations in the open field line region.

1. Introduction

During the 1965 May 30 total solar eclipse, the Los Alamos Scientific Laboratory (LASL) expedition obtained observations from a U.S. Air Force operated NC-135 aircraft as described by Cox et al. (1965). These observations were made at 38,500 ft above the cirrus clouds that extended over a wide region over the South Pacific Ocean and totality was extended to 4°47'. Our objectives were to obtain emission line intensity vs wavelength profiles and photometric intensities in several emission lines in order to compare methods for determining ion temperatures. Some preliminary results have already been reported by Liebenberg (1967) and by Robertson et al. (1965). In this report deconvolution techniques have been applied to the second order fringe of the photographic interferometer results and true emission line profiles obtained. The second order fringe crosses a region on the NW limb that included a coronal helmet structure and the line profiles are interpreted in terms of an ion kinetic temperature and turbulence. In addition, Doppler velocities are measured from the fringe shift and these are generally less than 5\, km s$^{-1}$ in this region. Absolute intensities are determined from standard lamp calibration and compare well with values extrapolated from measurements at lower coronal altitudes. The use of white light K corona intensities found by S. Smith et al. (1967) provides a relative measure of electron or total density. The data are combined to discuss the model for M regions proposed by

* Work performed under the auspices of the U.S. Atomic Energy Commission, and portions of the analysis at the National Center for Atmospheric Research, Boulder, Colo.
Billings and Roberts (1964) in which coronal isotherms were predicted to extend to greater altitudes outside a helmet-streamer structure than within the helmet. While consistent with the present observed temperatures in a usual interpretation of the line profiles, we suggest that a significant influence of a radial solar wind flow along the apparently magnetic open field lines should be included.

2. Instrumentation and Analysis

Since a detailed discussion of these instrumentation and analysis techniques is in preparation, a brief account is appropriate. A 25 cm aperture objective doublet lens was designed by Brixner (1966) for best spatial resolution in the coronal image. The objective lens provided light to a Fabry-Perot interferometer and predispersion dielectric interference filter located in the recollimated beam. A final image was formed on a glass plate camera. A two axis tracking mirror was controlled by feedback from a beam splitter in the main beam. Long term image stability was measured from a movie record to be 0.7' rms. The coronal image crossed with interferometer fringes was recorded on Kodak type 103a-G glass plates and a sequence was obtained with exposure times from 10 to 30 seconds. Plate reduction to densities was performed at the HAO digital microdensitometer with a 3" square slit.* The spectral dispersion on the plate in the second order fringe was 0.2 nm mm^{-1}.

Deconvolution techniques developed by two of the authors (RJB and BW) for this analysis provide true emission line profiles with a spectral resolution believed to be 0.005 nm (0.05 Å). The deconvolution was accomplished by fast Fourier transform techniques similar to those discussed by Brault and White (1971). The power spectrum of each observed line profile was fitted by the method of least squares to a two parameter Voigt function, which was then used in the construction of a spectral filter appropriate to that profile. The true profile was then obtained by deconvolution of the instrument function from that filtered profile. The high signal to noise ratio of the data and the relatively narrow instrument profile enable the profiles to be deconvolved with reasonable accuracy, as noted above.** Absolute intensities are obtained from calibration at LASL through a step wedge with a xenon flashlamp source and a calculation of the telescope transmission. Fringes up to 7th order and out to 1.8 R_⊙ were obtained with this instrument during this eclipse. True profiles of the second order fringe overlay an interesting solar structure and are treated in this report.

3. Results

The second order fringe crosses the corona in the NW quadrant and line profiles were determined at approximately 2 deg intervals in the heliographic coordinate system,

* One of us (DHL) acknowledges the use of the HAO-NCAR microdensitometer and a grant of CDC-6600 computing time from The National Center for Atmospheric Research to prepare the digital tapes for subsequent analysis. NCAR is operated by the National Science Foundation.
** Details of this procedure will be published in another paper.