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I. PHYSICS

Astrophysics (Solar Corona)

KITT PEAK CORONAL VELOCITY EXPERIMENT

W. LIVINGSTON, J. HARVEY, L. A. DOE, B. GILLESPIE *and* G. LADD
Kitt Peak National Observatory, Tucson, Arizona, U.S.A.

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SLIT spectrograph observations of Doppler shifts of the coronal green line (Fe XIV 5303Å) were successfully obtained during the February eclipse at Japal-Rangapur. Supporting projects carried out included a 35mm cinema record of the eclipse sequence, in collaboration with Osmania University, Hyderabad, India, and an all-sky photographic record designed to show cloud cover and illumination change during the eclipse event. Our team was a part of the U.S. National Science Foundation field party.

Keywords: Kitt Peak Coronal Velocity; Coronal Green Line; Corona Corotation; Eclipse Spectra.

EQUIPMENT AND PURPOSE

The coronal velocity instrumental package is a veteran of three eclipses: Mexico, 1970; Africa, 1973; and now India, 1980. A 20cm (156cm FL) objective lens formed a 1.4cm image of the sun at the entrance slit. This slit consists actually of 5 slits giving rise to 5 spectra and thus sampling 5 sections through the corona. Fig. 1

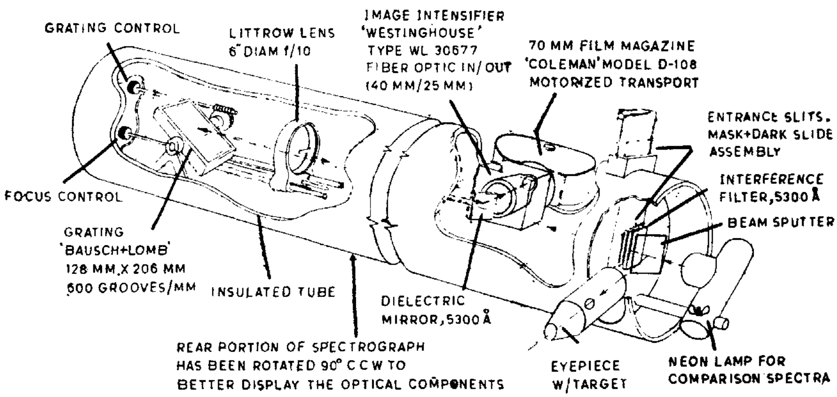

FIG. 1

is a schematic cross-section of the Littrow spectrograph. Dispersion is 1.2Å mm^{-1} at 5303Å in the fifth order. At the spectrograph focus an electrostatic fiber-optic image-intensifier demagnifies the image further (40mm to 25mm) with the final recording being on Kodak 2498, 70mm film. This intensifier tube (Westinghouse WL-30677) has the unique property of virtually no geometric distortion (Livingston, 1973).

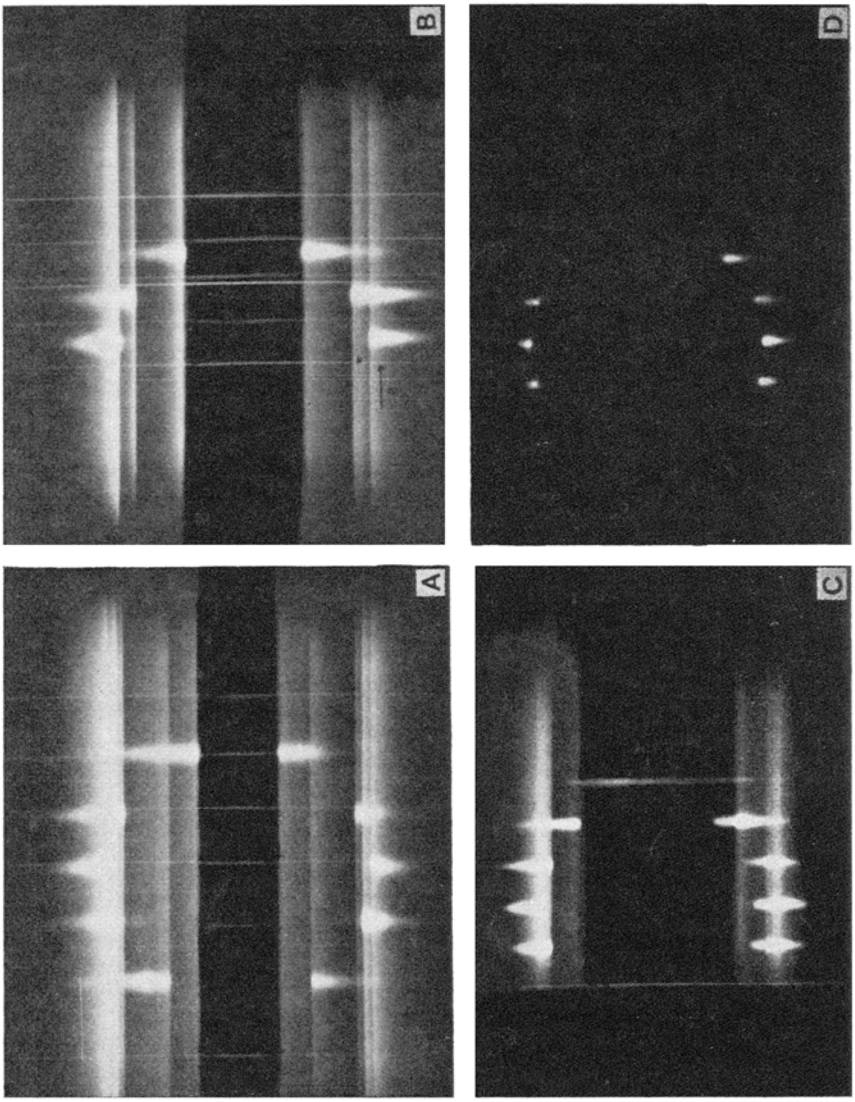

Fig. 2. (*A*) Five slit spectrogram of corona on March, 1970 in light of FeXIV 5303Å + neon comparison. (*B*) Same except June, 1973 with three slits. (*C*) Five slit spectrum for February, 1980. East is at bottom, south right. Exposure = 110 sec. (*D*) Same as (*C*) except exposure approx. 1 sec. and without neon.

Besides the coronal exposure, each frame has a superposed neon comparison consisting of the two lines at 5304 and 5298Å. The multislit spacing has been arranged (except in 1970) so that the array of 5303 and the neon lines are well separated. The spectrograph is physically contained in an aluminium tube rotatable about its input optical axis following the input slits to be positioned parallel to the heliographic equator at eclipse time. No rotational tracking is provided and some smear takes place during the exposure time, but this resolution loss is negligible.

RESULTS

The original purpose of the velocity experiment was to determine to what extent the corona corotates with the underlying photosphere as a function of height and latitude. Results from 1970 and 1973 gave essentially the photospheric rate of 13.6 ± 2.9 deg. day^{-1} sidereal but this large uncertainty precludes any conclusions of interest regarding departure from corotation. Evidently, large scale random motions in the corona mask the rotation component so that impossibly many eclipses would have to be observed to reduce this source of error. However, unexpected findings of even greater interest emerged. First, our spectra showed that within the resolution limit of $\sim 2(10^4)$ km the coronal gas is remarkably quiescent. Previous studies (e.g., Delone & Makarova, 1969) had indicated a wide spread strong turbulence of 10–40 km sec^{-1} but we found 0.5 km sec^{-1}. Secondly, our measurements indicate that the majority of systematic flows are directed *toward* the sun. Admittedly, outside-eclipse coronal condensations related to loops invariably flow downward. But in tenuous regions far above the surface (0.3 R_0) one might expect to see an overall outward motion, perhaps as the origin of the solar wind. Instead, our sample indicates a preponderance of down flow at 3–15 km sec^{-1}. A desire to enlarge our sample and confirm this general infall pattern led us to repeat this experiment by observing the 1980 eclipse.

Fig. 2 compares eclipse spectra from 1970, 1973 and 1980. Outwardly, the spectra are comparable although differences are notable at least on the negatives. In Yautepec, Mexico, the sky was particularly free of haze and, although near solar maximum, the corona displayed several prominent fans or rays. At Lake Rudolph in Africa, the sky was relatively poor so we reduced the number of slits to three in order to minimize the scattered light background. However, the solar minimum corona was very extended, again with strong, well developed rays. The borrowed image tube for 1973 was plainly more sensitive than the 1970 tube as shown by the strength of the neon lines. At Hyderabad, India, we were again using the 1970 image tube and now the neon lines are very weak indicating an additional loss of sensitivity. This loss, combined with the compact nature of the solar maximum corona, restricted the radial extent of 5303 for this eclipse. The southernmost slit was purposely placed outside the disk to better study motions in a coronal hole residing then at the south pole.

Reduction and analysis of the 1980 spectra is an involved process and will take several months. First, the entire spectrum must be scanned with a densitometer and converted to digital form. Then, by spectral synthesis, assuming the line profiles are gaussian, for each resolution element along each slit, four parameters are deduced:

line width, amplitude, position, and continuum intensity. The neon spectra are similarly measured to yield line curvature information and to place the wavelengths on an absolute scale. Finally, to decide the sense of motion with respect to the sun, synoptic *K*-corona data will be employed to construct a rough three dimensional model of the corona for February 16, 1980. Thus for example, a red shift originating in a streamer lying earthward of the plane of the sky indicates downflow.

Circumstances and the status of the secondary projects are as follows: Dr N. Sanwal (Osmania University) and Mr B. Gillespie mounted an Arriflex 35mm stop-motion movie camera with a 500mm objective on the side of the Hyderabad, 48 inch telescope. The emulsion was Eastman 5247, a colour negative film. Controlled by an intervelometer, 400 frames were exposed centred on totality but including some of the adjacent partial phase. Exposures were taken every second, $1/3^s$ duration, with the aperture set between f/3.5 and f/22, more or less continually varied between 2nd and 3rd contact. This negative film has an exceptional latitude and the exposures appear excellent.

As an exercise in serendipity, we photographed the entire sky and part of the landscape, a 220° field of view, at 2^s intervals again centered on totality. Change of horizon illumination due to the eclipse shadow was an objective. A preliminary inspection of the film shows that in accord with expectations the cloud coverage was perceptibly reduced by totality.

Location

Japal-Rangapur Observatory, Andhra Pradesh.

Acknowledgements

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