L-DOT:73-99 August 28, 1973

LA-UR-73-1304

TEMPORAL OBSERVATIONS OF THE λ5303 EMISSION LINE PROFILE DURING THE 74 MINUTE TOTALITY FROM THE CONCORDE SST AT THE 30 JUNE 1973 TOTAL SOLAR ECLIPSE: PRELIMINARY INTENSITY VARIATIONS ABOVE AN ACTIVE REGION*

by

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ABSTRACT

Apparatus was designed for installation on the Concorde SST to provide high resolution emission line profiles at the 30 June 1973 total solar eclipse. A prime objective was to obtain profiles that could be used to detect the coronal response to the 5 min periodicities observed in the solar photosphere. Stability of the sky scattered light, drastic reduction of seeing affects enhanced the value of the exceptional opportunity. Preliminary results are discussed for a single region on the limb, above an active sunspot group.

INTRODUCTION

A current question in coronal physics relates to the heating mechanisms; does the photospheric periodicity of 300 sec propagate into the corona with observable amplitude and coherences? Good coronagraphic results require that seeing is stable and that atmospheric effects are properly eliminated so that the few attempts have led to inconclusive results. Moreover, theories have not been decisive in determining whether such a coronal response is expected.

* Work performed under the auspices of the US Atomic Energy Commission.

This question seemed uniquely appropriate for investigation aboard the French Concorde 001 at the 30 June 1973 total solar eclipse. At the altitude of 50,000 ft seeing conditions are very stable and no detectable atmospheric changes were expected. The great speed of the Concorde, over 1200 mph at Mach 2.05, gave a computed maximum of totality of nearly 80 minutes so that some 15 periods of a 300 sec wave could be determined. The dark sky background would improve the signal to noise ratio for detecting small intensity changes and the absence of any significant F corona component near the limb during eclipse reduces the perturbation on the Fe XIV coronal emission line profile introduced by the Fraunhofer absorption line at 5302.3 Å. Our previous experiences with high resolution Fabry-Perot spectroscopy which one of us has used at solar eclipse studies since 1954 (DHL) and the high resolution and high light gain video recording that was adapted to these studies in 1970 (MMH) made possible a rapidly designed instrument to use the remarkable capabilities of the French Concorde 001.

INSTRUMENTATION

On the Concorde a platform for the instrument was prepared and the 12 cm diameter fused silica window was installed looking vertical from the aircraft. The Los Alamos equipment was mounted to this platform and the telescope mirror tracker adjusted for a wide field view of the sky. The apparent position of the sun during eclipse varied from a 65 degree altitude nearly directly forward along the aircraft axis to a 70° altitude looking aft, the sun passing within 5 degrees of directly overhead at mid totality. The mirror tracker was located close to the window to avoid vignetting.

Light passed from the mirror tracker to an 8 cm diameter lens of 101.4 cm focal length and was turned downward along the optical bench as shown in Fig. 1. A beam splitter turned 10 percent of the beam into the photo-electric tracker focal plane and view finder. Four photosensors were used to develop error signals to activate the large bandwidth servo controlled mirror tracker. Visual observations of the corona were possible at this location with an image size of 1 cm.

The main beam was recollimated and passed through a dispersion interference filter and a pressure scanned Fabry-Perot interferometer. This beam was refocussed with unit magnification onto the image intensifier that was optically bonded to the vidicon with coherent fiber optics. The resulting image was scanned off and recorded each 16.7 msec via a video recording.

The Concorde departed Las Palmas, Canary Islands at 10^h 08^m UT on 30 June 1973. The eclipse intercept was accomplished within 1 sec of the previously computed optimum track.[2] Both before second and after third contact a continuation of the path was flown to provide observers with an opportunity to study the lower corona, chromosphere and photospheric layers. The flight was completed with landing at Ft. Lamy, Chad 2 hr 43 min after takeoff. Some 2400 nautical miles were traveled.

Operation of the interferometer and video equipment was entirely satisfactory during the entire 74 minutes of totality. Difficulties with the tracker will complicate the data analysis but the full program of search for periodicities in the coronal emission line will be possible.

RESULTS

The preliminary results discussed in this report have been extracted from the data tapes without benefit of direct digitization of the video

fields that will be used later. A direct recording of the monitor phosphor brightness has been made with a small diameter fiber optics and photomultiplier tube. The relative brightness change in the λ5303 emission line is determined satisfactorily for this temporal study. Furthermore, we have previous experience in using this technique to determine emission line profiles. Since slow residual image motions remained data were taken only at congruent image locations. The fiber was fixed with respect to the interferometer fringe system.

Several playbacks of the data tape were made, coincidences averaged four per minute of totality over a fifteen minute interval. In Fig. 2 data for a single playback are shown and averages over one minute intervals have been made for an initial time t_o and t_o + 30 sec. The results indicate no change in the main features of the temporal intensity variations from this shift in time base. The background intensity subtracted off is 0.05 on the arbitrary intensity scale. Thus, the variations in green line intensity shown here are significantly large and are strongly suggestive of a temporal variation with a 6 $\pm$ 1 minute period.

The main features of this time history intensity variation are unchanged with subsequent playbacks. An extension of these data to the first 39 minutes of totality indicate support for this large intensity variation with about a 6 minute period. Other coronal regions are under study with this preliminary technique but substantiation of these results must await the detailed planned analysis.

These data indicate an even greater amplitude modulation than was reported by Noxon[3] on the basis of coronagraphic studies. The more recent work by Morel[4] specifically excluded green line intensity variation while noting an intensity variation that was ascribed to difficulties in correcting

for the Fraunhofer absorption line. The measurements by Noxon were corrected for these seeing problems and a modulation of green line intensity of 50 percent with a period of 8 minutes was reported although no association with coronal features was made. Nor did he report the presence of the fluctuations as clearly established. The measurements presented here are entirely free of the Fraunhofer line absorption. The exactness of image coincidence is equivalent to tracking errors in coronagraph guidance and the more careful assessment from these data will await the detailed analysis.

There is another aspect to the present observations that has not been treated in this paper. The detailed spectral line profile was recorded as a function of time and may be expected to yield correlative information regarding the presence of the wave motion observed for the line peak intensities. A compressional wave moving through the corona would be expected to produce a line broadening in phase with intensity fluctuations for a temperature less than the ionization equilibrium temperature.

Transverse magnetic waves - Alphen-type in the corona would be expected to propagate horizontally in the base streamer region and the detection of intensity fluctuations along the line of sight would be difficult, although some additional line broadening might be expected. These possibilities are under investigation.

The authors thank Mr. R. Lang, LASL for his diligent effort in readying this equipment on a short time scale and Mr. E. Brown for his work with the design of the photoelectric tracker. M. Andre' Turcat of Aerospatiale is to be commended for the splendid eclipse flight. We are indebted to Dr. P. Charvin, Institute de Astronomie et du Geophysique, France, and Dr. A. Cox, LASL in

addition to the financial support we received from the U. S. AEC-LASL, the National Science Foundation Grant AG-433 and the Delegation General for Scientific and Technical Research of France.

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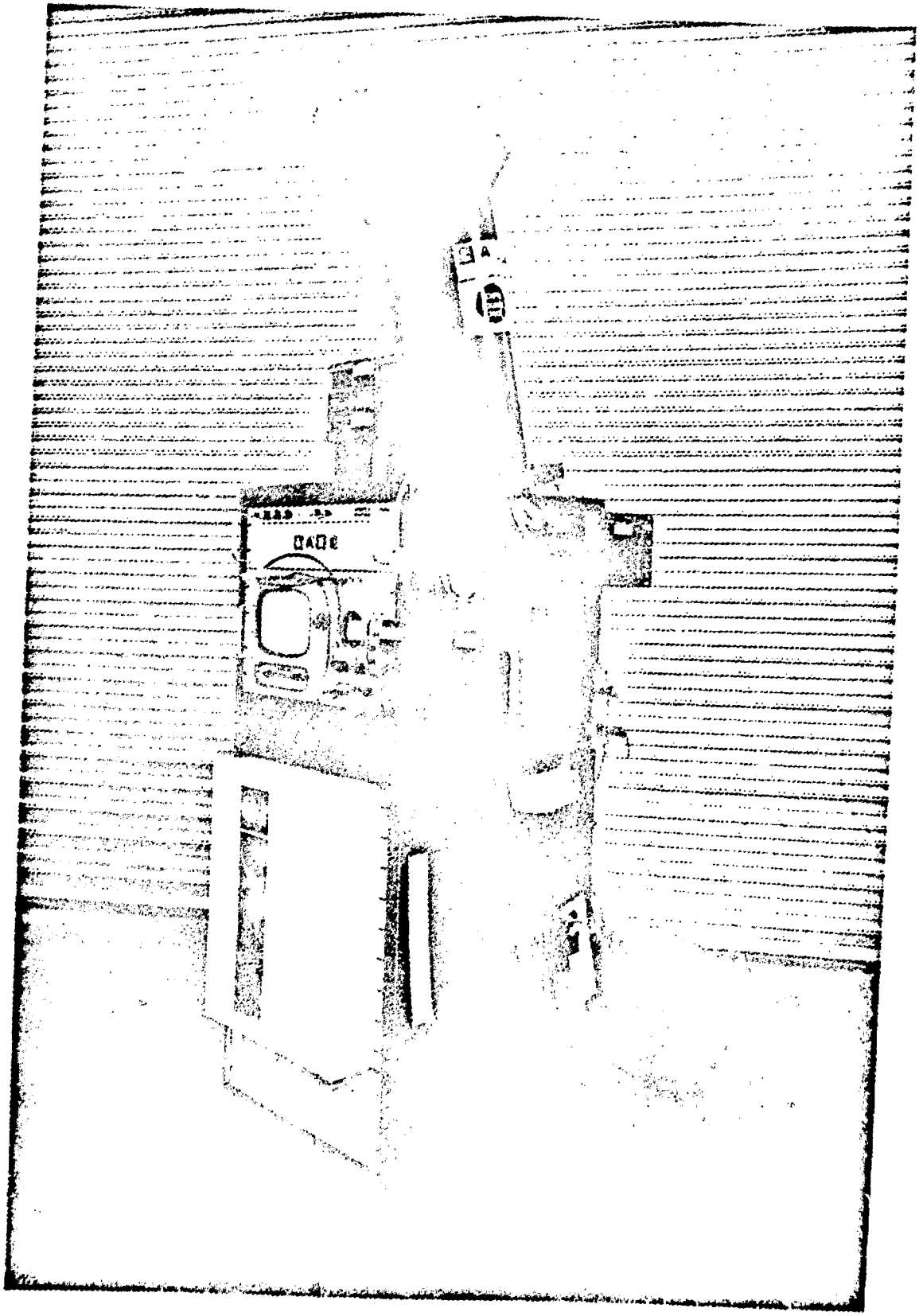

Fig. 1

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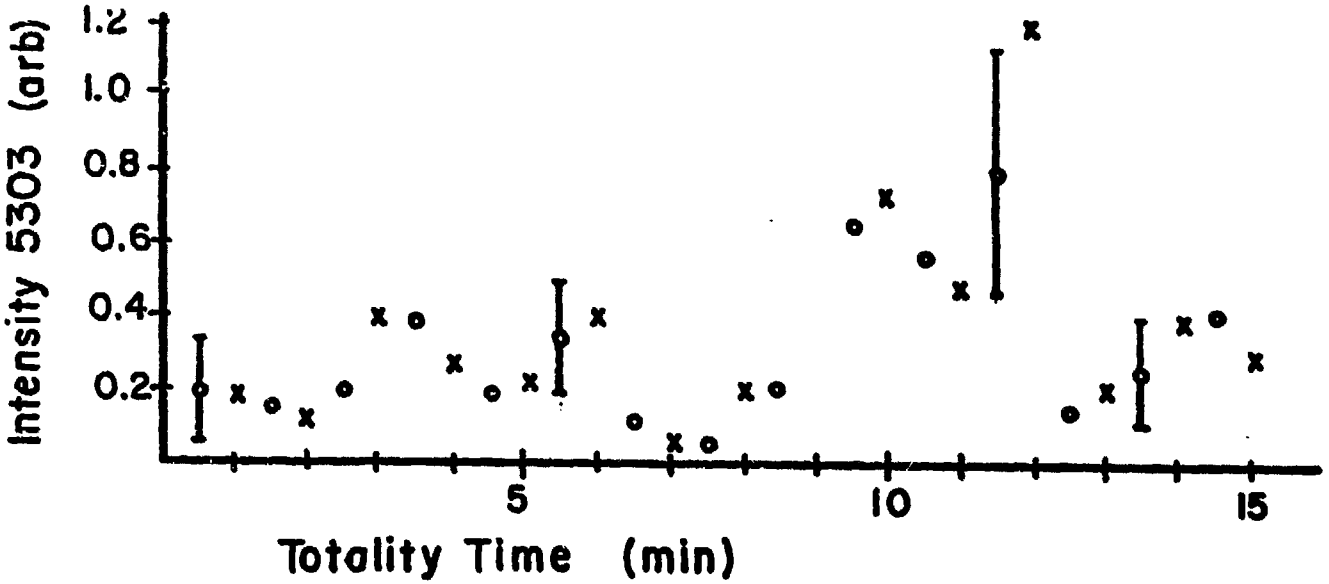

Fig. 2

FIGURE CAPTIONS

Fig. 1.

Emission Line High Resolution Video Telescope as designed for the French Concorde. A two axis mirror tracker is photoelectrically driven. The Fabry-Perot pressure scanned interferometer is followed by the image intensified vidicon camera. Electronic equipment is conveniently all contained in the adjacent rack that provide support to the optical bench.

Fig. 2.

Time variations of λ5303 peak intensity. The same data from one 15 min period of totality is shown for a time base t_o (o) and a time base shifted t_o + 30 sec (x). One minute averages are computed to indicate the presence or absence of the fluctuations in the solar corona material.