Search for Optical Modulation of the Solar Corona During the February 16, 1980 Total Solar Eclipse*

E. J. Seykora

Department of Physics, East Carolina University, Greenville, North Carolina, U. S. A.

(Received May 5, 1980)

Abstract

The optical modulation and solar scintillations in the frequency range from 20 Hz—15 k Hz and 5 — 15 MHz were recorded during the February 16, 1980 total solar eclipse. Preliminary results are discussed concerning both the coronal modulation and atmospheric modulation of the light. Recordings of the shadow band phenomena are presented.

Important data on solar flares, and on their influence on the solar corona have been obtained from studies in the radio frequency spectrum. Transient radio frequency radiations have been studied in the centimeter, decameter, and meter ranges. Specifically, type II and type III bursts of radio noise in the decameter range have been associated with "puffs" of high speed particles that move through the coronal gas and excite plasma oscillations. The existence of harmonics in the radio-frequency noise suggests a macroscopic non-linear oscillation of the coronal gas in a region above a flare location (Aller 1963). The continuity and force equations of electrodynamics can also be shown to yield a wave equation for the plasma, or density fluctuations, of the form (Jackson 1975)

$$\frac{d^2n}{dt^2} + \frac{4\pi e^2 n_O}{m} n = 0,$$

where n is the charge density and $\frac{4\pi e^2 n_O}{m}$ is the plasma frequency ω_p. As a result of the form of this equation the charge density, velocity and electric field all oscillate with the plasma frequency ω_p.

The objective of this project was to search for and record the modulation of the light intensity emitted by the plasma oscillations in the solar corona. That is, the light emitted from an oscillating plasma in the solar corona follows the density fluctuations which oscillate at the plasma frequency. Because of the low level of the light intensity fluctuations, at radio frequencies, expected from the corona, the search for such fluctuations is possible only during a total solar eclipse.

The instrumentation used in the search for the optical modulation of the solar corona included:

(1) A photomultiplier detector and radio receiver system capable of detecting modulation of the solar corona in a band from 5 MHz to 15 MHz. The radio receiver frequency was swept, in time, (1 MHz/sec) and the output recorded on both magnetic tape and paper chart. The resultant recordings represent the light modulation intensity vs. frequency.

(2) Three solid state photodetector systems with high gain AC coupled amplifiers used to detect light modulation and fluctuations in the frequency range from 20 Hz to 15,000 Hz. The detector - amplifier outputs were recorded directly on magnetic tape.

The light modulation detection system for frequencies from 20 Hz to 15 k Hz is capable of detecting and recording light fluctuations from atmospheric turbuelence and wave phenomena. That is, atmospheric striae resulting from wave phenomena, or turbulent mixing of regions of warm and cold air refract light from the Sun and give rise to small but detectable light fluctuations at the surface of the earth. Previous measurements in this low frequency range (Seykora 1979) have indicated a turbulent atmospheric change following a solar eclipse.

Because the light fluctuations from atmospheric turbulence is spatially local (several metres), the fluctuations resulting from the solar corona would be coincident at three widely separated detectors (~10 metres).

Preliminary results of the observations carried out at the Rangapur-Japal Observatory indicate that no coronal modulation was observed in the frequency range from 5-15 MHz. An upper limit on the luminous flux of the optical fluctuation in this frequency range can be placed at 10 picolumens as calculated by the photomultiplier current, and shot noise recorded at the receiver.

A recording of one of the three solid state detectors (20 Hz to 15 k Hz) is shown in Figure 1. The majority of the fluctuations and scintillations recorded are of atmospheric origin. The numerous spikes recorded which form a background on all recordings have been

*This material is based upon work supported by the National Science Foundation.

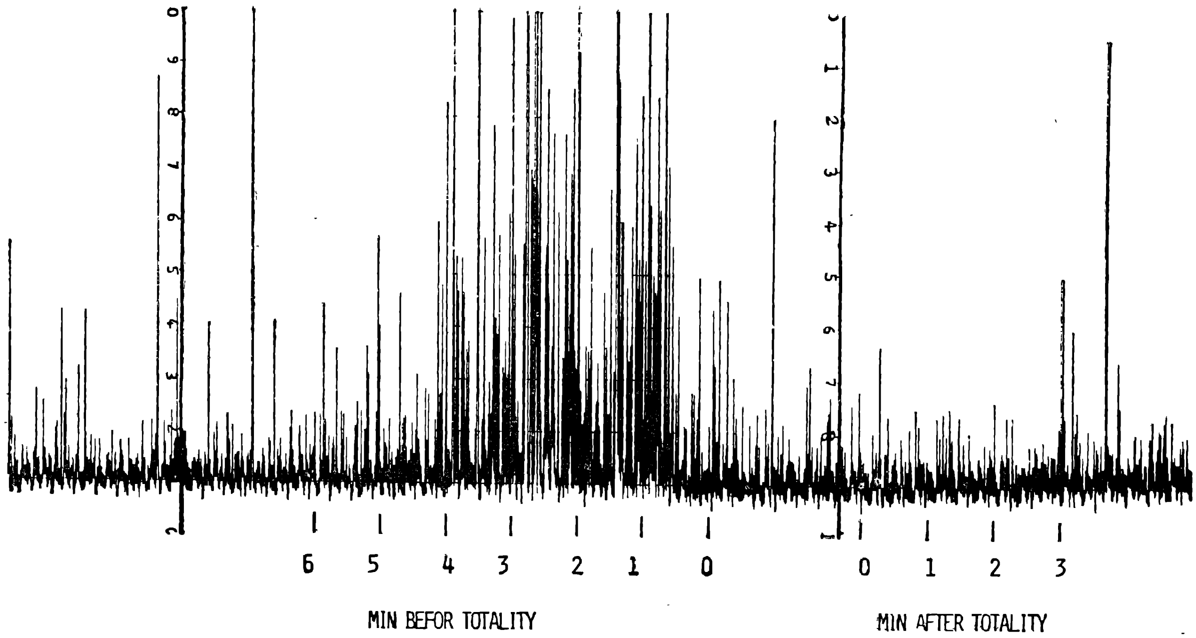

Fig. 1. Solar scintillations recorded during the 16 February 1980 total solar eclipse. Full-scale amplitude $10^{-5}\times$ static background illumination.

shown to be high flying insects crossing the solar disc. Each signal can be heard on reviewing the tape as an insect which modulates the background light by the beat frequency of the insects' wings. Because the detectors and recording equipment record changes in light intensity amounting to a one part per million variation in background illumination, individual insects at altitudes in the kilometer range can be recorded. The large number of scintillations recorded from four minutes before totality to totality were a result of the shadow bands seen during some total solar eclipses (Seykora 1979). During this time period shadow bands were seen visually and no bands were seen or recorded after totality at the location of the detectors.

Several preliminary conclusions can be drawn from the shadow band recordings we have analyzed. First, they do appear as true atmospheric scintillations. The correlation from one scintillation to the next is random in time and amplitude. Furthermore, a large variation in the intensity of the shadow band phenomena was seen at the three detectors separated by 10 metres.

Further analysis of the scintillation data is continuing along with an analysis of coincident events which may be of solar origin.

The author would like to thank the National Science Foundation Field Support Team for their help, and the Indian Government for their hospitality.

REFERENCES

Aller, L. H. 1963, *Astrophysics — The Atmospheres of the Sun and Stars,* The Ronald Press Company, New York

Jackson, J. D. 1975, *Classical Electrodynamics,* John. Wiley & Sons, Inc., New York.

Seykora, E. J. 1979. *Applied Optics,* **18,** 3538.