OBSERVATIONS OF THE 7 MARCH, 1970 TOTAL SOLAR ECLIPSE AT WAVELENGTHS OF 3.2 AND 8.3 mm

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Abstract. The 7 March, 1970 total solar eclipse was observed at wavelengths of 3.2 and 8.3 mm; the object being to use the knife edge of the Moon as it passed across the Sun to improve angular resolution on the Sun. This in turn would provide a radial brightness distribution of the Sun with an angular resolution of a few seconds of arc.

Excellent eclipse curves were obtained at 3 mm; however, some external interference marred the 8 mm record near totality.

The 8 mm brightness distribution is subject to some uncertainty, but tends to show limb brightening. The 3 mm brightness distribution shows a well defined complex limb brightening within about 1 arc min of the optical limb. The maximum brightening is approximately 30% above the average disc temperature.

1. Introduction

A. RADIAL BRIGHTNESS DISTRIBUTION OF THE SUN AND THE SOLAR ATMOSPHERE

The purpose of the eclipse observation was to determine an accurate radial brightness distribution for the Sun at wavelengths of 3.2 mm and 8.3 mm using the occurrence of a total solar eclipse to increase the obtainable angular resolution.

The radiation originating from any position on the Sun can be said to come from an elevation above the photosphere determined by the total integrated absorption along the line of sight looking into the point where optical depth, $\tau$, becomes approximately unity. This height ($\tau = 1$) above the photosphere, for a specific wavelength, is lower on the disc than at the limb since optical depth becomes unity more quickly for the longer path looking in toward the limb of the Sun. Whether the limb appears at a higher or lower temperature than the disc depends upon the temperature vs height distribution in the solar chromosphere. In general, the chromospheric temperature increases with height in the region where microwave radio emission originates. This results in limb brightening for most short radio wavelengths. The temperature gradient is negative in the photosphere, producing limb darkening at optical wavelengths. In the far infrared and very short (millimeter) radio wavelength region, it is not known with certainty whether limb brightening or limb darkening occurs. An accurate determination of the radial brightness distribution at millimeter wavelengths is, therefore, necessary to determine the temperature and density distribution in the middle chromosphere.

B. PREVIOUS EXPERIMENTS

The first successful determination of the millimeter radial brightness distribution of
the Sun was made from observations at 8.6 mm of the total solar eclipse of 20 June, 1954, observed by Coates et al. (1958) in Oskarshamn, Sweden. The Sun was found to have a slight limb brightening within about 1 arc min of the limb and a smaller, unexpected central brightening.

During the 12 November, 1966 total solar eclipse in Peru, Noyes et al. (1967) found no limb brightening at 22 \mu; however, with direct scans of the Sun at \( \lambda = 1.2 \) mm and a half power beamwidth of 4 arc min, he found some limb brightening, after effects of instrumental smoothing had been removed.

Other attempts to determine the brightness distribution at millimeter wavelengths have been inconclusive or show little or no limb brightening. The general problem is discussed by Simon and Zirin (1969).

2. Description of Experiment

An outline of the experimental procedure is given below.

A. RADIO TELESCOPES

The 3.2 mm wavelength (93 GHz) receiver was a Dicke switched, crystal mixing radiometer using Schottky barrier diodes and a 500 MHz IF bandwidth which gave an rms sensitivity of 0.5 K. The antenna was a parabolic cylinder, 6 ft long by 1 ft wide, fed by a modified hog-horn line feed positioned across the narrow dimension of the reflector. The half power beamwidth was approximately 2° by 6'.

The 8.3 mm (36 GHz) receiver was a Dicke switched, crystal mixing radiometer, also using Schottky barrier diodes, with a 100 MHz bandwidth which gave an rms sensitivity of 0.5 K. The antenna was a parabola, one foot in diameter fed by a pyramidal horn. The half power beamwidth was 2°. The radiometers and antennas are shown in Figure 1.

B. CALIBRATION

Calibration of both radiometers was accomplished by using the output of a discharge (noise) tube and ambient temperature for the two calibration points. The noise tubes were compared with hot loads at the antenna terminals to provide an absolute calibration. Time marks, from a chronometer, were placed on the record every minute. The chronometer was periodically checked against WWV. Calibrations were placed on the record approximately every half hour.

C. EQUIPMENT VAN

All equipment was mounted in a surplus SCR-584 radar van. The altitude-azimuth radar mount was converted to an equatorial mount by tilting the azimuth axis to correspond to the latitude of the site in Mexico. Power was provided by a gasoline powered motor generator.

D. ECLIPSE GEOMETRY

The eclipse path projected onto the celestial sphere was inclined approximately 45°