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Multi-Frequency Observations of Radio Sun During Total Solar Eclipse of February 16, 1980

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Abstract

Measurements of radio flux of the Sun during the total eclipse on February 16, 1980 were made from the Japal-Rangapur Observatory near Hyderabad, at radio frequencies of 2.8, 10, 19 and 22.2 GHz. Observations for both ingress and egress are available. Residual fluxes at totality for 2.8, 10 and 19 GHz were 23, 3.5 and 3 per cent respectively. The minimum fluxes were observed from 2 to 7 minutes prior to the mid-eclipse.

INTRODUCTION

The radio astronomer has a distinct advantage over his optical counterpart because his measurements are not affected by the clouds in between the observer and the Sun.

The moon's razor sharp edge offers a unique high resolution scanning of a few arc seconds and makes possible, as the moon's edge covers and uncovers the solar disk, the dtermination of the source size of enhanced radio emission regions on the solar disk with a modest size antenna. Therefore, the eclipsing process can be used with advantage to reveal, with simple equipment, the angular size of active centres on the Sun associated with sunspots, plages and prominences. In addition, coronal electron densities and temperatures can be derived from the observed solar flux at different wavelengths (Castelli et al 1963; Hagen and Swanson 1975).

Another important aspect of making solar observations during eclipse is to find out the solar radio diameter, which is larger than its optical diameter, and which increases with wavelength. The radio diameters can be compared with those obtained earlier at different epochs of the sunspot cycle to give an idea of the changes taking place in the coronal plāsmā densities.

EXPERIMENTAL SET-UP

Multifrequency observations of radio emissions from the Sun were made at the Japal-Rangapur Observatory of the Osmania University, Hyderabad during the total solar eclipse of February 16, 1980. A 2.8 GHz radiometer was operated by the Physical Research Laboratory (PRL), and a 10 GHz radiometer was operated by the Astronomy Department, Osmania University in collaboration with PRL; 19 and 22.1 GHz radio meters were operated by the Space Applications Center (SAC), Ahmedabad in collaboration with PRL.

The microwave radiometers were Dicke-type and the basic receiver was built on superheterodyne principle. Some important specifications of the four radiometers are given in Table 1.

TABLE 1

Specifications of microwave radiometers.

Frequency (GHz)	..	2.8	10.0	19.35/22.235
Radiometer sensitivity (°K) ..	..	1.3	0.4	0.16/ 0.57
Integration time (sec)	..	1	1	1
Total receiver noise figure (db)	..	7.0	7.0	8/13
Antenna dish diameter (m) ..	..	1.5	3	1
Beamwidth	..	5°	0°.8	3°

The 2.8 and 19/22 GHz parabolic antenna dish were equatorially mounted, and tracked the Sun continuously with the help of a motor and a suitable reduction gear system. The 10GHz dish was manually

adjusted every 3 to 4 minutes to obtain the transit of the Sun.

Eclipse observations at a number of radio frequencies enable estimation of the relative levels, and one dimensional angular size of bright emitting regions on the Sun with an angular resolution of a few seconds of arc depending on the stability of the radio telescopes used. Recordings were made on strip charts.

OBSERVATIONS AND RESULTS

Just before the eclipse observations, all the four radiometers were calibrated by noting the deflections on their strip charts when the antennas were pointing to the earth, sky and the Sun. During the course of the eclipse, periodic transits of the Sun were taken on the 10 GHz radiometer, its reflector being manually advanced in right ascension by a few degrees ahead of the Sun and allowing it to transit through the antenna beam till the HPBN level was reached. Calibration points corresponding to the earth and sky were marked for all the radiometers at the end of the eclipse observations. Scaling of the data was done at time intervals of 0.5 and 5.0 minutes for 2.8 and 10 GHz;and at 1.0 minute interval for 19 and 22.2 GHz. These two sets of observations are important for partly removing the ambiguity in precisely locating bright radio regions on the solar disk.

Figure 1 shows the observed eclipse curves for 2.8, 10, 19 and 22.2 GHz. They represent solar radio flux (normalised to its uneclipsed value) as a function of time. The residual fluxes indicated by the minima of the curves were 23, 3.5 and 3 per cent at 2.8, 10 and 19 GHz respectively. Interestingly, these residual fluxes are seen to have occurred from about 2 to 7 minutes prior to the time of the mid-eclipse. Furthermore, the eclipse curves for 19 and 22.2 GHz after 1640 hrs IST show pronounced variations in the radio flux which are absent on the 2.8 and 10 GHz curves.

In figures 2 and 3, the observed eclipse curves at 2.8 and 10 GHz are compared with the eclipse curves obtained by artificially eclipsing uniformly bright radio disks of radii 18.2 and 16.7 arc minutes (Furst et al. 1979) respectively by the disk of the moon This comparison brings out the departures in the slope of the observed curves from those of the theoretical curves. Such changes in the slope are a result of the variations in the radio brightness of the solar disk in the presence of compact sources on the Sun. After correcting for atmospheric absorption, antenna beam pattern, cable attenuation, moon's temperatures, etc. these changes in the slope of the eclipse curve can be used for studying compact localised sources and limb brightening effects.

DISCUSSION AND CONCLUSION

Multifrequency radio observations were obtained for the first time in India in the path of totality during the total solar eclipse of February 16, 1980. Although such occasions have come but only rarely, there have been at most two dozen observations of such kind elsewhere in the world, but the conditions of solar activity have been different each time. The residual flux, which comes beyond the solar disk at the time of eclipse totality, are comparable with those obtained earlier (Castelli et al., 1963). The significance of this needs to be carefully examined. Similarly, once the radio diameters at each of the observed frequency are computed, they can be compared with the values observed by other workers (e.g. Castelli and Aarons, 1965; Furst et al., 1979). The changes of slope in the eclipse curves are due to discrete emissions from compact radio sources on the disk. Their scale sizes in one dimension can be compared with those obtained earlier by Straka and Castelli (1970).

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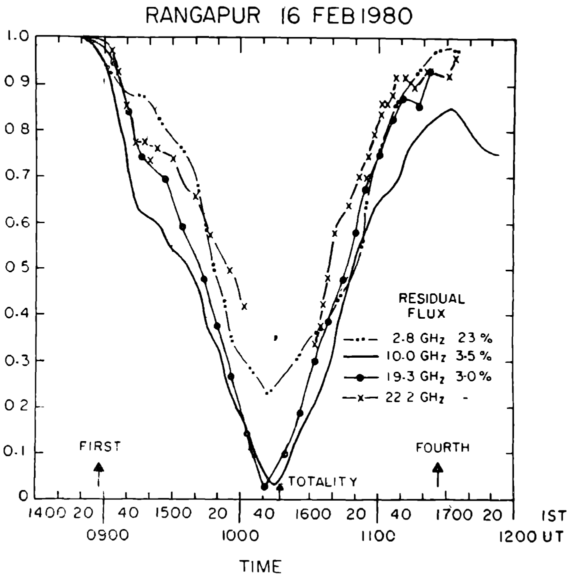

Fig. 1: Observed eclipse curves at 2.8, 10, 19 and 22.2 GHz for 16 February 1980 total solar eclipse. Arrows indicate times of 1st contact totality and 4th contact.

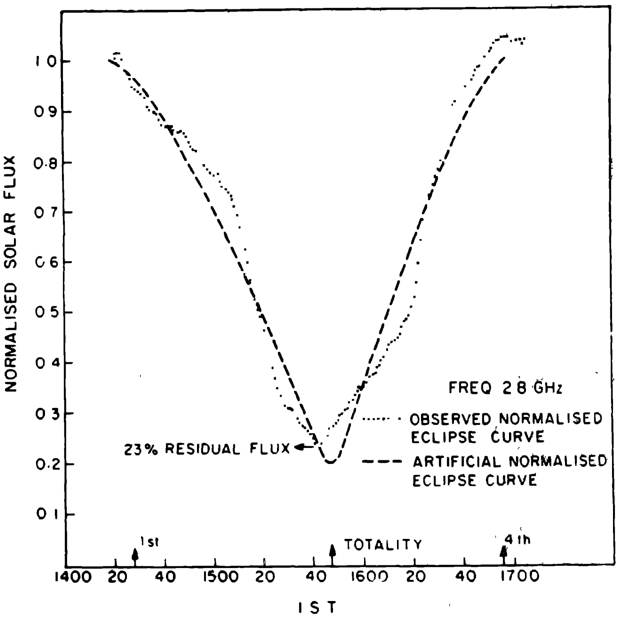

Fig. 2: Comparison of observed eclipse curve at 2.8 GHz with artificial eclipse curve for a uniformly bright radio sun with radius of 18.2 arc minutes.

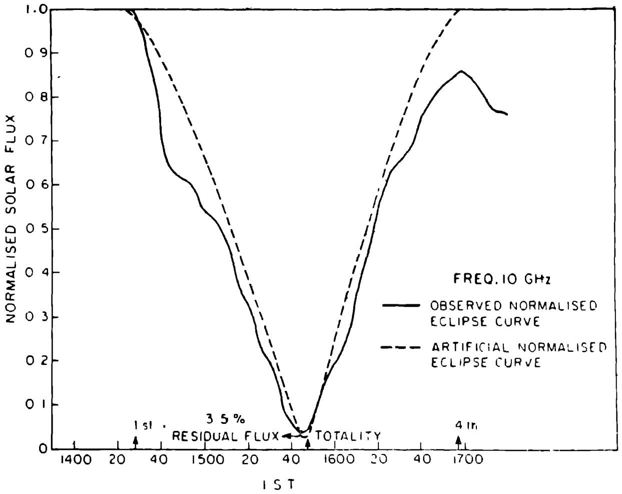

Fig. 3: Comparison of observed eclipse curve at 10 GHz with artificial eclipse curve for a uniformly bright radio sun with radius of 16.7 arc minutes.