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I. PHYSICS

Astrophysics (Ionosphere)

PHASE AND FIELD MEASUREMENTS IN VLF, LF AND HF REGIONS DURING THE SOLAR ECLIPSE OF 16 FEBRUARY 1980—PRELIMINARY RESULTS

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THE effect of the eclipse at VHF frequencies over short paths (upto about 600km) and long paths (upto 11000 km) have been studied in some detail during the total and partial eclipses between 1949 and 1965 (Bracewell, 1952; Craryar & Schnaible, 1965; and Albee & Bates, 1965). The aim of our experiment was to study the effect of eclipse inVHF and HP region at medium path lengths from 1700km to about 8000km by monitoring frequency and time signals transmitted by distant stations.

Keywords: VLF, RF and HF Regions; Phase and Field Measurements; Partial Eclipse

EXPERIMENT

Equipment and Observation

The phase and field strength measurements were carried out from Kavalur (12° 34'N, 78° 49'E) at 16 KHz by monitoring GBR (52° 22'N, 01° 11'W) and at 10 MHz by monitoring ATA (28° 34'N, 77° 19'E) during the solar eclipse of February 16, 1980. Field strength measurements were recorded at 164 KHz at Ahmedabad using Radio Tashkent transmission.

VLF 16 KHz signal transmitted by GBR (Rugby) was received at Kavalur using a loop antenna oriented to receive maximum stability of the order of 1 part in 10^{11} and was phase-locked to the signal received from GBR. The local oscillator, the VLF receiver and the data recorder were run on battery supply throughout the experiment. The phase measurements were carried out seven days before eclipse and seven days after the eclipse as well. The data were recorded on a pressure sensitive strip-chart recorder.

The VLF receiver was Datum Inc., Model 9880 A, which is tunable between 10 KHz and 30 KHz in steps of 100 Hz. The image rejection is 50 dB or better. Overall gain of the system is 85 dB, at 16 KHz. This unit provides the means for developing precise information about the change in the phase relationship between a received VLF transmission and a local reference frequency source. The information provides the criteria for making appropriate adjustments to the local reference source so as to improve its accuracy.

The local oscillator was calibrated using VLF receiver so that the frequency of the oscillator was precisely tuned to the received signal. The phase matching accuracy was of the order of one microsecond which is the limit of the resolution of the strip chart recorder. VLF signal was tracked at tracking rate of 0.2 microsecond per second.

The HF signal at 10 MHz was monitored using transmissions from ATA (New Delhi). ATA transmissions were switched on round the clock from February 14, 1980 to February 18, 1980, on 5 MHz, 10 MHz and 15 MHz frequencies at the output power of about 8 kw. The received signals at 5 MHz and 15 MHz were found to be very noisy with very low signal to noise ratio throughout from February 14 to 18, and therefore data at these frequencies were not found useful. ATA transmits second pulses of 1 KHz modulation and with pulses of 100 milliseconds duration every minute in UTC system. The receiver used was USSR made allwave continuously tunable (10 KHz to 30 MHz) receiver (VOLNA-K) and a highly stable crystal oscillator (with a stability 1×10^{-10} per thousand) and a built-in phase shifter. During the eclipse, the measurements were carried out at every five minutes interval on a Tektronix storage oscilloscope (No. 466) having 100 MHz bandwidth.

Results

(1) *VLF (16 KHz)*

In Figure 1(*a*) is given the variations in the mean phase averaged over seven controlled days at every 15 minutes interval. Figure 1(*b*) gives the observed phase anomaly with the time scaled at every 2.5 minutes during the eclipse.

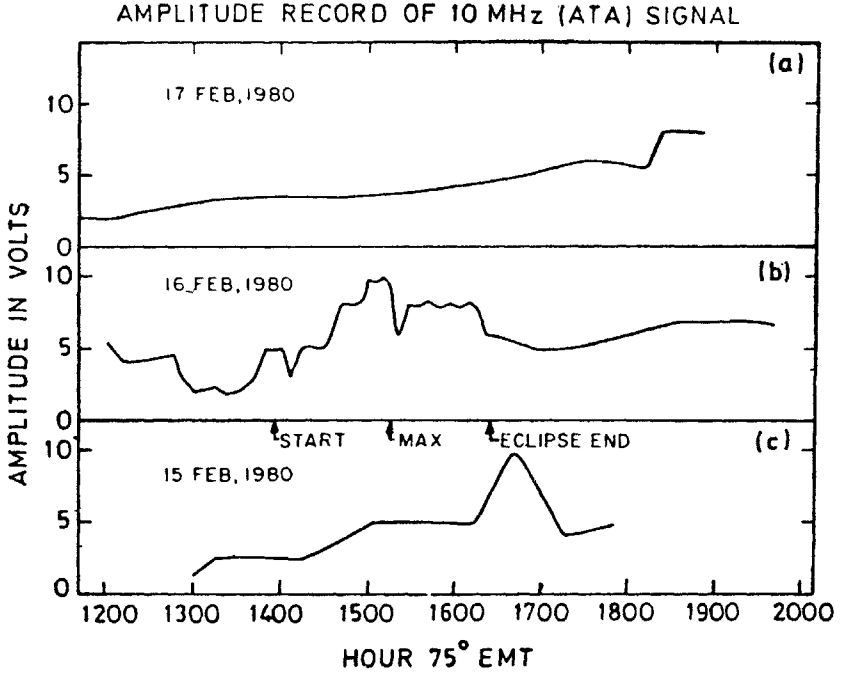

Fig. 1

It is seen from the Figure 1(*a*) that during normal days mean phase of the recorded signal is almost constant between1300hr and1530hr and increases gradually after 1545 hr to a constant value at night time.

At the start of the eclipse, the phase was observed to decrease by about 6° though this was not expected and then there was a gradual increase in phase. Similar decrease in phase has also been reported in the literature cited (Albee & Bates, 1965). The maximum phase anomaly was observed at the eclipse maximum which was of the order of 34°.5 $\pm$ 3°. This may be due to the fact that the D region concentration gradually decreases and tends to disappear as the Sun was gradually obscured by the Moon. As the D region ionisation decreased, the VLF reflection height increased causing an increase in the observed VLF phase. After the eclipse maximum, the phase decreased as expected until about 1545hr. No complete symmetry was observed in the phase variations with epoch during the eclipse and this may be due to the effect of the sun set on the D region interfacing with eclipse effect on VLF signals. After the end of eclipse, variation in the phase of the VLF signals with time was as observed during the normal days.

(2) *HF* (10 *MHz*)

In Fig. 2 is plotted the variation of the amplitude of 10 MHz signal measured during the eclipse and one day around it during the same time. The amplitude of the signal at 10 MHz was observed to increase during the eclipse period and there was a gradual fall in the amplitude as the eclipse reached its minimum. After the eclipse,

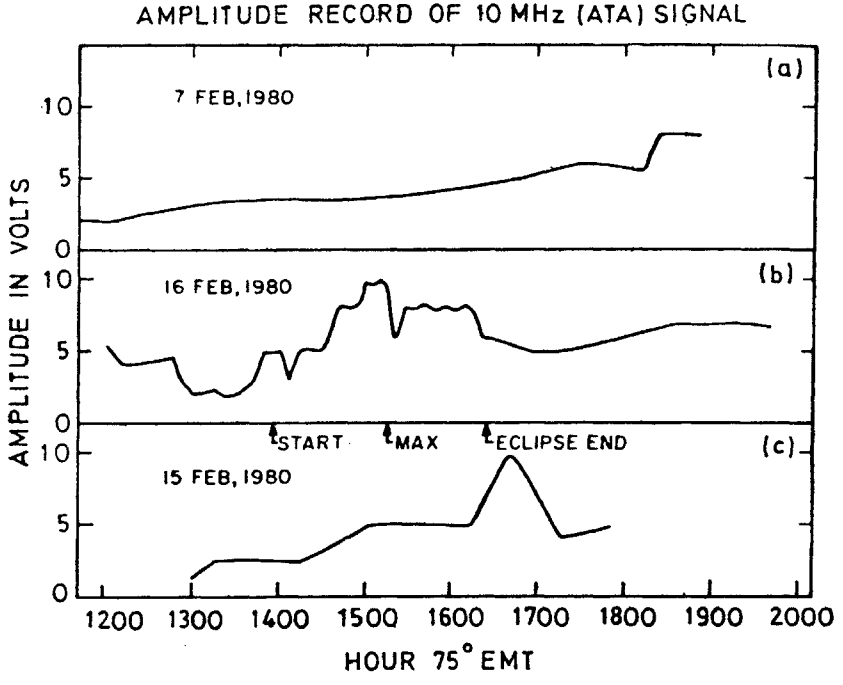

FIG. 2

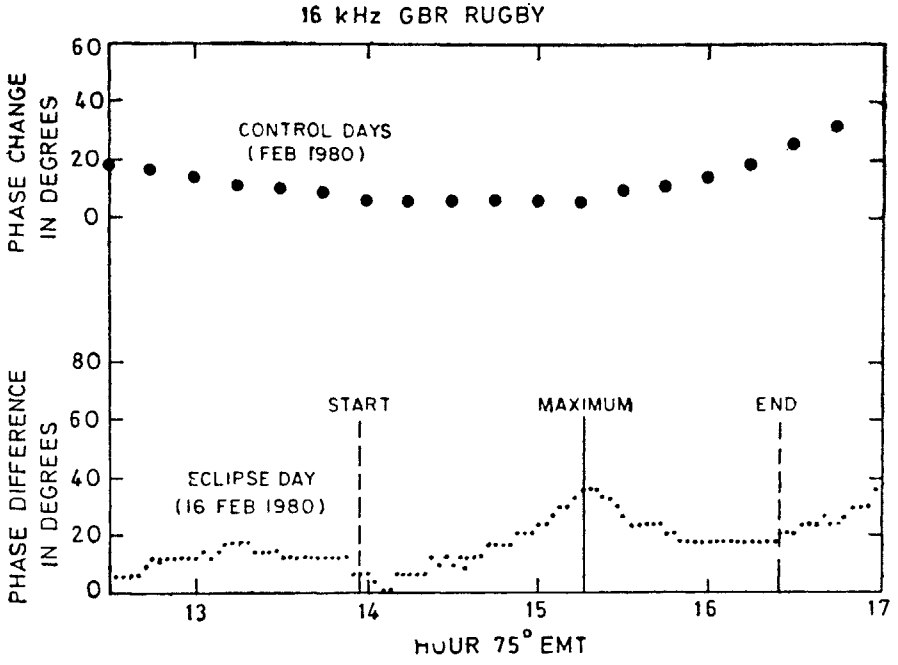

FIG. 3

the variation in amplitude of 10 MHz ATA signal was observed to be normal as any other day. Similar results are reported using different techniques in the literature cited (Lerftas *et al.*, 1963).

(3) *LF (164 KHZ)*

The field strength measurements were also made at Ahmedabad, on a few days before and after the eclipse. The variations of the relative field strength on a control day (February 17, 1980) and on eclipse day are shown in Fig. 3. On the eclipse day an increase is noted in the field strength from about 14 hr. The maximum field strength is noted around 16hr which is little after the time of total eclipse.

These results at VLF, LF and HF range are consistent with the eclipse time decrease in the ionisation resulting in the decreased absorption in D region and increase in the VLF reflection height as evidenced by the increase in phase associated with the eclipse.

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