Proc. Indian Acad. Sci. (Earth Planet. Sci.), Vol. 89, Number 2, July 1980, pp. 153–157.

On the effect of the partial solar eclipse of 29 April 1976 on electron content

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MS received 17 January 1979 ; revised 9 April 1980

Abstract. Faraday rotation measurements made at a chain of stations and group delay measurements made at Ootacamund from ATS-6 are examined for the partial solar eclipse event of 29 April 1976. There is no evidence of eclipse-induced gravity waves in these measurements extending from Ootacamund near dip equator to Patiala (dip 45° N). Eclipse-induced fluctuations were however reported at Trivandrum, about 300 km south of Ootacamund.

Keywords. Solar eclipse ; total electron content ; gravity waves ; travelling ionospheric disturbance.

1. Inroduction

Gravity waves generated by the shadow of moon as it moves supersonically across the earth's atmosphere had been predicted by Chimonas and Hines (1970) and Chimonas (1970a, b). Total electron content observations at four stations in Western United States during the solar eclipse of 7 March 1970 detected travelling disturbances which implied a possible confirmation of the Chimonas and Hine's suggestion (Davis and da Rosa 1970; Chimonas and Hines 1971). However, TIDs observed in a number of ionospheric experiments in United States during same period were not conclusively attributed to the eclipse effect (Carlson *et a-* 1970; Larford *et al* 1972; Arendt 1972 and Sears 1972). This was due to the fact that the magnetic storms prevailed during the period 6–9 March 1970 and large scale TIDs are in general generated during magnetic storms (Georges 1968). Faraday rotation measurements made at a chain of stations in Africa (1° S to 22° S geog. lat, about 20° S to 50° S dip) exclusively to study the effect of solar eclipse of 30 June 1973 did not show any eclipse-induced gravity waves (Hunter *et al* 1974; Schodel *et al* 1973) though the theoretical calculations had expected perturbations in total electron content of atleast 15% (Frost and Clarke 1973). Results have been recently reported for the total solar eclipse of 23 October 1976 from the Faraday rotation measurements made in Australia. Absence of any wave activity as reported by Morton and Essex (1978) from the observations made in the path of totality while observations at a station away from the path of totality showed presence of TIDs (Hajkowicz 1977).

Faraday rotation measurements at 140 MHz were made at a number of locations in India during the period October 1975 to July 1976, when the geostationary satellite ATS–6 was positioned at 35° E. In addition Faraday rotation and group delay measurements at 40 and 140 MHz were made at Ootacamund. The dip latitude coverage by the chain of stations is about 2° N to 26° N. The stations with their sub-ionospheric points are shown in figure 1. During the period of these measurements, an annular solar eclipse occurred on 29 April 1976. The geometry of the eclipse is shown in figure 1. This eclipse was visible as a partial solar eclipse at all the stations of the chain. In view of the conflicting reports about the detection of TIDs in the Faraday rotation measurements, due to eclipse-induced gravity waves, an attempt is made to examine the excellent coverage of data available for this eclipse from all the stations. Recently Vaidyanathan *et al* (1978) had reported quasi-periodic fluctuations of about 10 min periodicities in the Faraday rotation and group delay measurements at 40 MHz, using radio beacons from ATS–6 at Trivandrum (dip 0·6° S). The amplitude of the fluctuations is estimated to be of the order of $0 \cdot 5 \times 10^{16}$ el m^{-2}. The location and the sub-ionospheric point for Trivandrum to ATS–6 ray path is also shown in figure 1.

2. Results

The geometry of the annular eclipse and its beginning times are shown in figure 1. The beginning times of the eclipse for the chain of stations are around 1600–1630 hr

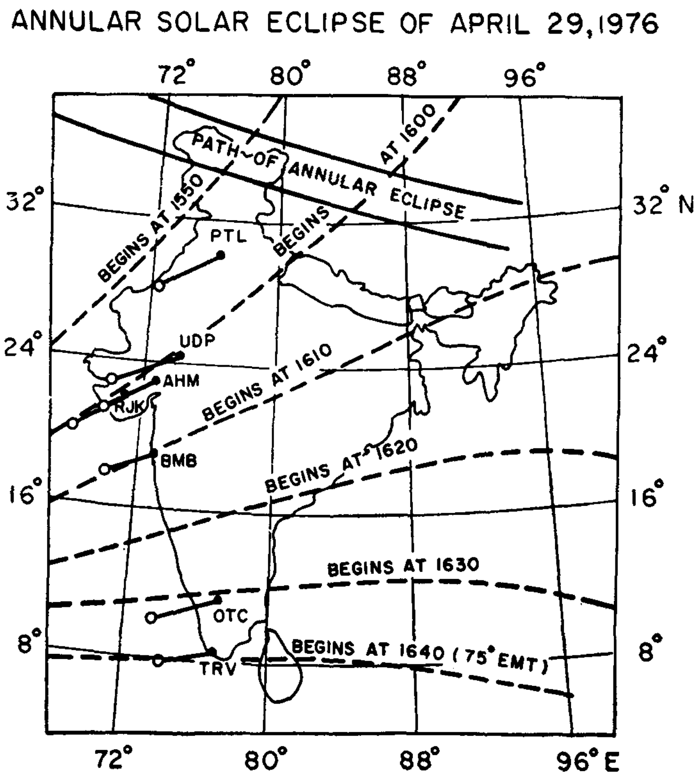

Figure 1. Geometry of the eclipse and the locations of the different stations. The subionospheric points are shown by open circles.

(75° EMT). The Faraday rotation angle Ω at 140 MHz is traced from the original charts for nearly 3 hours duration around the eclipse and shown in figure 2 for different stations (excluding Ootacamund). The angle Ω can be converted into TEC using some specified constants which depend upon the geometry of the ray path (Iyer *et al* 1976; Singh *et al* 1978). It is to be noted that the eclipse-induced fluctuations observed in TEC are of the order of $0{\cdot}5 \times 10^{16}$ el m^{-2} (Davis and da Rosa 1970; Vaidyanathan *et al* 1978) which is equivalent to about 9°, 11°, 12° and 16° of Faraday rotation angle at 140 MHz for Bombay, Ahmedabad, Udaipur and Patiala respectively. To examine the absence or the presence of the expected fluctuations, the 180° jumps in the original data have been removed and replotted in the upper part of figure 3. The large time constant of the pen recorder at Ahmedabad has produced two bumps in the curve. The original records have been scaled every 2 min and the difference between data and 10 min moving averages is obtained in the same way as followed by Vaidyanathan *et al* (1978). The resultant curves for all the four stations are shown in the lower part of figure 3. The arrows show the eclipse starting time at different stations. It is noted that the fluctuations of the order of ± 3° are observed at all the stations not only during

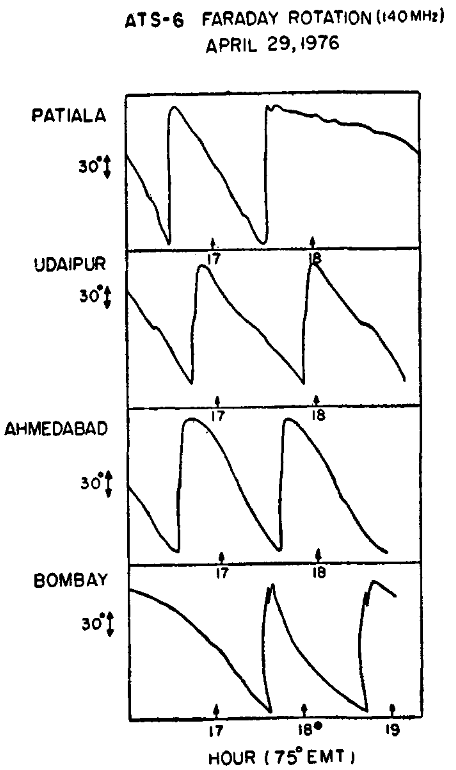

Figure 2. Plots of the Faraday rotation angle (Ω) from the actual charts for different stations.

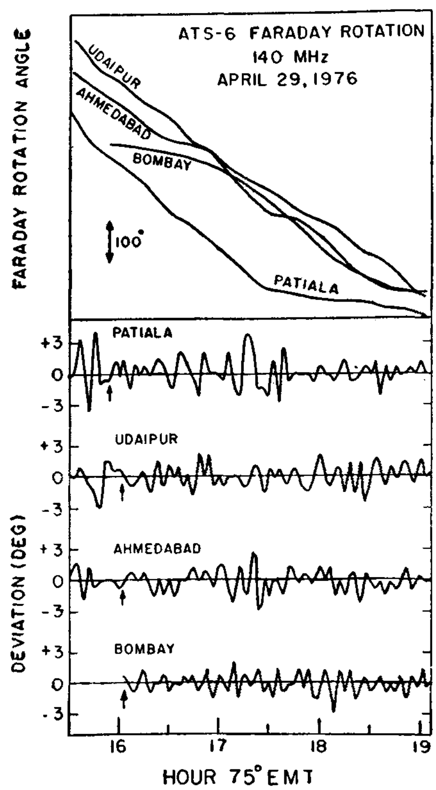

Figure 3. Upper part of the figure shows the continuous plots of Ω, removing 180° jumps from the original charts. The lower part of the figure shows the detrended fluctuations in Ω for different stations.

or after the eclipse but also before the eclipse. The scaling accuracy from the records is not better than 2–3°, hence the fluctuations are not much of significance.

At Ootacamund, Faraday rotation and group delay measurements were made at 40 MHz as well as at 140 MHz. The lower frequency being more sensitive to TEC changes, further analysis was done using measurements made at 40 MHz, in the same way as followed by Vaidyanathan *et al* (1978). Similar analysis was done for a day previous to the eclipse day also and the fluctuations are shown in figure 4 along with the times of first contact, the maximum phase and the last contact. For comparison the results of Vaidyanathan *et al* (1978) are also included in figure 4. The eclipse start time for Ootacamund is about 10 min earlier than the start time at Trivandrum (figure 1). It is noticed that for Ootacamund, a wavy structure throughout the period 1600–1800 hr is observed on the eclipse day as well as on the non-eclipse day. The eclipse-induced fluctuations of the order of 33° and 140° in Faraday rotation angle and group delay angle respectively are expected but no such fluctuations are noticed for Ootacamund. On the contrary Trivandrum data do show fluctuations which can be attributed to the eclipse.

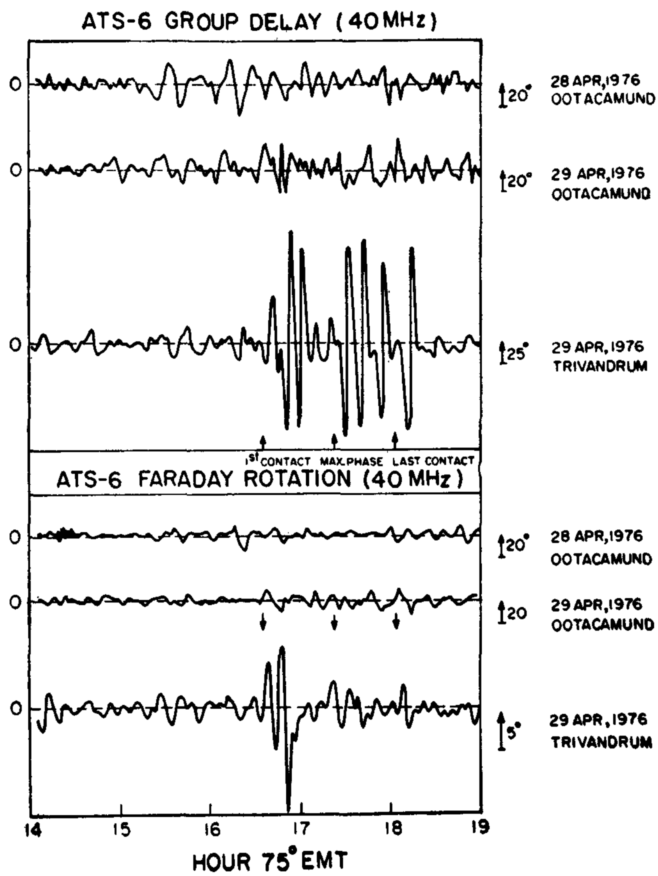

Figure 4. Detrended fluctuations in Faraday rotation angle and group delay angle measured at Ootacamund and Trivandrum. The eclipse day is 29 April 1976.

3. Discussion

Davis and da Rosa (1970) detected the TIDs induced by the solar eclipse of 7 March 1970 at widely separated chain of stations; the separations being as large as 600–1000 km. The stations were situated away from the path of totality but were within penumbra. In the present case both Trivandrum and Ootacamund are within penumbra and are quite close to each other compared to their distances of the order of 3000 km from the path of the annular eclipse. It looks rather surprising that the eclipse-induced gravity waves should have escaped being observed at all the other stations except at Trivandrum.

Acknowledgements

The ATS–6 Ootacamund project was a joint undertaking of the Physical Research Laboratory, Ahmedabad, India and NOAA, Boulder, USA. This project was partially supported by DOS and NASA. Authors are grateful to Profs R G Rastogi and R P Kane for helpful discussions. Thanks are due to Mr K C Patel and Miss Chhaya Shah for the computational help.

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