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Plume-like structures of extinction clouds at 19 Saturn radii

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Abstract : Observations of the occultation of the star SAO 158763 by Saturn's magnetospheric region around 19 R_s on 1984 May 12 are compared with the observations by Mahra *et al.* of the same event. Certain disparities between the Naini Tal and Kavalur data suggest that the extinction signatures are more likely to be caused by irregular density enhancements of ion, charged dust grain, or gas rather than regular ring systems confined to equatorial plane.

Key words : Saturn—ring system

Using Pioneer XI and Voyager ion counter results, Lazarus, Hasegawa & Bagenal (1983) suggested the presence of particulate or gaseous matter around Saturn at about 14 and 19 planetary radii (R_S). The occultation of the star SAO 158913 on 1984 March 24 (immersion) and March 25 (emersion) showed clear indication of absorption features on either side of Saturn at 12.5 R_s (Vasundhara *et al.* 1984; Bhattacharyya & Vasundhara 1985). On the basis of observations of another occultation event on 1984 May 12, Mahra *et al.* (1985) reported the detection of a ring system at 19 R_S. This second event was recorded also by using the 1m telescope at Kavalur, and the record confirms the existence of some extinction material out in the magnetosphere of Saturn. Some additional features of this possible ring system are discussed in this paper, and a plausible origin for the extinction cloud is suggested.

Observations of the star SAO 158763 were made on 1984 May 12, with the 1m reflector telescope at Vainu Bappu Observatory, Kavalur (lat. + 12° 34′.58, long. $-5^h\ 15^m\ 19^s.6$). The star was monitored through a standard B filter using dry-ice-cooled EMI 9658 photomultiplier. The photomultiplier output was fed simultaneously to a pulse counting unit with an integration time of 5s and to a strip-chart recorder with a time constant of 1s. Observations commenced at 19 : 47 UT and continued till 22 : 00 UT.

Figure 1a shows variation of stellar light between 19 : 58 : 00 UT and 20:52:00 UT. The planetocentric distances in units of Saturn radii marked in figure were calculated using the method described by Elliot *et al.* (1978). Figure 2 shows the direction of the occultation track as seen from Kavalur Projection of an equatorial

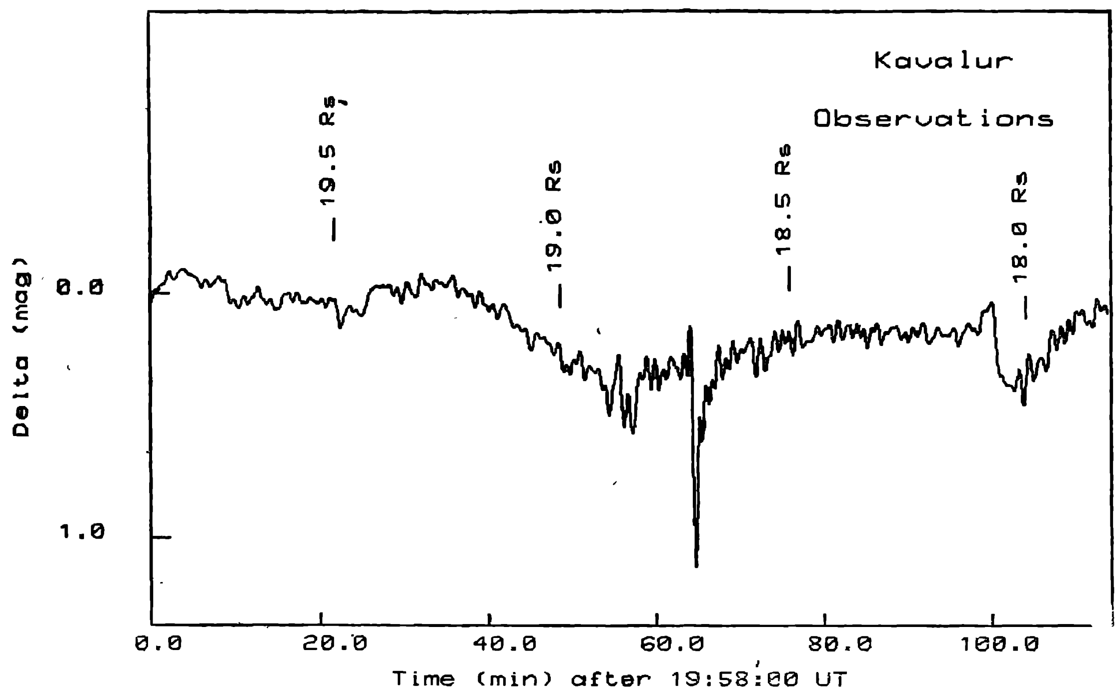

Figure 1a. Light curve obtained at Kavalur on 1986 May between 19 : 58 : 00 and 20 : 52 : 00 UT. The planetocentric distances are indicated in terms of Saturn radii.

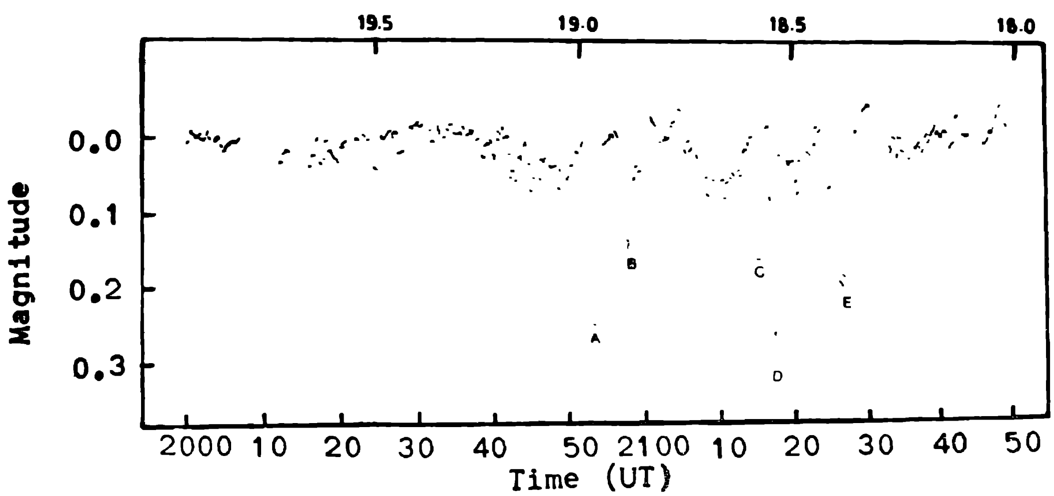

Figure 1b. Light curve obtained at Naini Tal on 1984 May 12 between 20 : 00: 00 and 21 : 50 : 00 UT. The planetocentric distances in Saturn radii are shown at the top (Mahra *et al.* 1985).

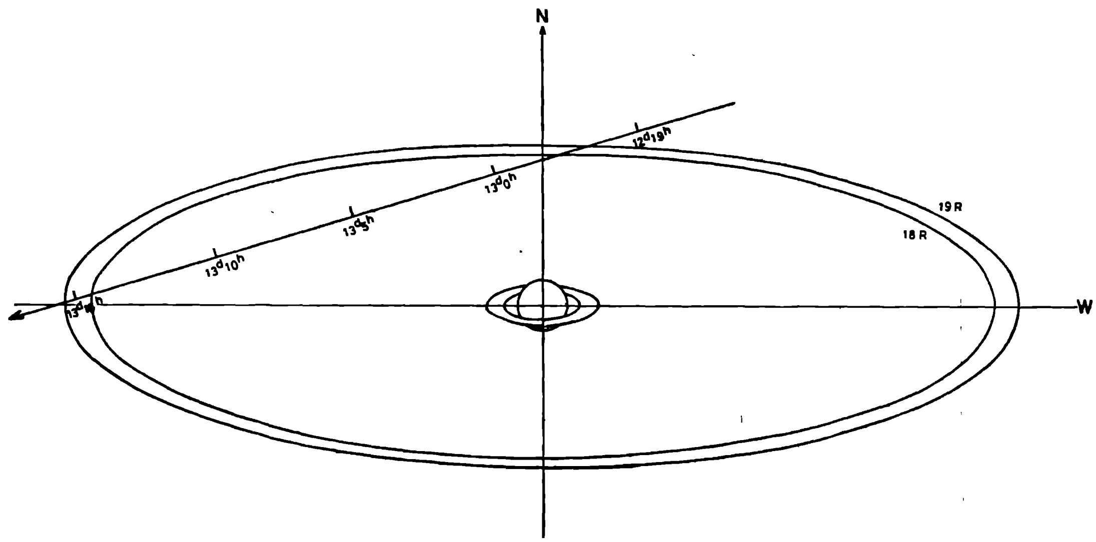

Figure 2. Path of the star relative to Saturn. Projection of an equatorial annular region between 18 R_S and 19 R_S on the sky plane is shown along with the visible inner rings.

annular region between 18 R_S and 19 R_S on the sky plane is also shown. Figure 1b shows the light curve obtained by Mahra *et al.* (1985) at Naini Tal. The planetocentric distances at various intervals are shown at the top of the figure to enable direct comparison of the features in the two light curves. The two light curves have similar form between 19.5 and 18.6 R_S except that feature A is missing in figure 1a and feature B is deeper. Below 18.6 R_S however there seems to be hardly anything in common between the two light curves.

As Naini Tal observations were made under photometric sky conditions and sky transparancy was monitored at several other telescopes, there can be little doubt about the reality of the extinction features. Absence of similar features in observations made from a site 2000 km away at Kavalur seems to suggest that these extinction signatures are more likely to be caused by irregular density enhancements of ion, dust grains, or gas, rather than regular ring systems confined to the equatorial plane. Absence of similar absorption features on 1984 May 13 during emersion across the same region supports this explanation.

These dips may be associated with low energy plasma density enhancement observed by Voyager 1 on either side of Titan (Bridge *et al.* 1981; Sittler, Scudder & Bridge 1981). Sittler, Scuddler & Bridge suggested that neutral absorbing material in the vicinity of Saturn can be sensed by studying the spectral modification of the speed distribution of low energy electrons. Using this technique they were able to delineate E ring on either side of the planet. They also identified certain similar features at and around Titan's orbit. These regions, which are now called plumes, comprise of electrons cooler than the surrounding magnetospheric electrons. Eviatar *et al.* (1982) analysed the enhancement of low energy plasma density in this region and found that they can be understood as multiple encounters with a single plume of plasma emitted by Titan and wrapped around Saturn several times by corotation. They have also related the radial motion of the plume to the observed bow shock motions. Though the main constituents of the plumes from Titan are considered to be hydrogen and heavier ions, submicron sized aerosols called tholins (Khare *et al.* 1981), charged by photoelectric effect (Toon, Turco & Pollack 1980), can also be ejected from the exobase of Titan.

The disparity between Naini Tal and Kavalur observations can be understood if the occulting matter consists of such plumes of sizes comparable to or smaller than the baseline of 2000 km between the two observatories. The nature and hence the source of the absorbing material can be traced if multicolour extinction measurements are made during future occultations.

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