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Occultations by Possible Material in Saturn's Outer Magnetosphere

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Abstract. Results of a search for occultations of stars in the SAO catalogue by Saturn's outer magnetosphere during 1988 are presented.

Key words: occultations—Saturn—magnetosphere

Anomalous dips in low energy plasma ion density in regions of Saturn's magnetosphere around 14 and 19 Saturn radii (R) were measured by Voyager 1, 2 and Pioneer 11 spacecrafts. Lazarus, Hasegawa & Bagenal (1983) suggested that these density dips may be arising due to absorption by long-lived particulate or gaseous material in the equatorial plane of the planet. Baron & Elliot (1983), from their CCD imaging of the region of magnetosphere between 10–35R, set an upper limit of $+22$ mag arcsec^{-2} for material distributed over a region larger than the 3 arcsec seeing disc in the I band. However such an imaging needs to be repeated at the time of ring plane crossings and with proper masks to ensure that the diffraction effects do not corrupt the frame.

Following predictions by Mink (1983), occultations of the star SAO 158913 (1984 March 24–26 and SAO 158763 (1984 May 12–13) were observed from Vainu Bappu Observatory at Kavalur and Uttar Pradesh State Observatory at Naini Tal. The 1984 March observations indicate radially symmetric distributions of absorbing matter probably in the form of a ring at 12.5R, although there was no evidence of any material at 14R. (Vasundhara *et al.* 1984; Bhattacharyya & Vasundhara 1985; Vasundhara & Bhattacharyya 1987). The May 1984 occultations were observable from India when Saturn's magnetosphere at 19R occulted the star. A comparative study of the observations from the two stations in India indicate fragmented or clumpy matter in this region, rather than a continuous ring system (Mahra *et al.* 1985, Vasundhara, Bhattacharyya & Rozario 1986).

Cheng, Lanzerotti & Maclennan (1985) raised serious doubts on the existence of any absorbing matter in Saturn's magnetosphere, their main argument being lack of substantial evidence from Voyager 2 LECP data in the energy range 30–1,000 keV. It is interesting to note that even for the E ring, whose existence is now well established, there exist discrepancies in the spacecraft measurements (Burns, Showalter & Morfill 1984 and references therein).

Further occultation observations will help in understanding this part of Saturn's magnetosphere. Therefore search was carried out in the SAO catalogue for occultations of stars by Saturn's magnetosphere occurring during 1988. In the search program, instantaneous apparent position of the star, angle of inclination of the ring plane to the line of sight, and position angle of the projection of the north pole of the planet on the sky plane were used. The planet coordinates were obtained from the Astronomical Almanac 1988 (DE 200). The apparent position of the stars were

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Table 1. Predicted occultations by Saturn's magnetosphere during 1988.

Date (UT) 1988	mag	SAO no.	sp. type	Position (1950.0) R.A. Dec.			Geocentric impact parameter (arcsec) Sky plane velocity ($km\,s^{-1}$)	Event*		UT	Position angle N–E	Distance from Saturn (arcsec)
1. Feb. 17–18		186141		17^h	59^m	$17^s.445$	18	19R	Imm	22:59	96°	150
	9.0		M0	−22°	19′	49.91	+25.09	12.5R	Imm	03:27	100	98
								12.5R	Em	18:24	257	83
								19R	Em	22:56	262	136
2. May 10–11		186344		18	05	40.073	33	19R	Imm	00:21	256	140
	9.3		B5	−22	16	52.39	−12.74	12.5R	Imm	10:25	244	76
								12.5R	Em	10:42	108	103
								19R	Em	20:23	101	168
3. May 12–14		186335		18	05	08.281	33	19R	Imm	16:02	256	141
	8.5		B5	−22	16	55.19	−13.63	12.5R	Imm	01:20	244	77
								12.5R	Em	00:23	108	104
								19R	Em	09:23	100	169
4. Nov. 10–11		186063		17	56	46.029	49	19R	Imm	01:31	61	98
	9.1		K5	−22	37	50.18	+31.88	19R	Em	14:57	295	123
5. Nov. 10–11		186064		17	56	48.979	38	19R	Imm	01:19	107	136
	8.9		A0	−22	39	18.30	+31.89	12.5R	Imm	06:10	124	70
								12.5R	Em	12:44	226	53
								19R	Em	17:34	252	115

* R = 60 300 km; Imm: immersion; Em: emersion.

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computed from SAO 1950.0 positions using the software package developed by A. V. Raveendran (1984, personal communication). The program uses the rigorous method for precession till the beginning of the year and computes the Besselian day numbers to correct for the precession for the fraction of the year, nutation and aberration. As the origin of the DE 200 reference frame is the mean equator and dynamical equinox of J2000.0, the apparent stellar positions were corrected for the zero point shift of

$$\Delta\alpha = 0^{s}.035 + 0^{s}.085(T - 19.50)$$

where T is counted in centuries (Fricke 1982).

Table 1 gives the UT date, the star's SAO catalogue number, its visual magnitude, spectral type and its 1950.0 position with proper motion up to the time of event added. The geocentric impact parameter is the closest approach of the planet to the star, measured in arcsec as would be seen from the centre of earth. In all the cases this distance is more than 18 arcsec, therefore the disc and the visible rings will not be occulting the star. Star 5 will only be occulted by the $19R$ region. The sky plane velocity is positive when the planet is in prograde motion and it is negative when it is in retrograde motion. For each star, the predicted universal time, position angle and distance of the star from the planet's centre in the sky plane at the time of the event are given for occultations at $12.5R$ and $19R$. The May events occurring near planet's opposition have good observing conditions whereas February and November events are observable only along a narrow longitude belt and that too at large zenith distances.

A two-star multichannel photometer would be an ideal instrument to observe these events. Multicolour extinction measurements would directly lead to an estimation of the average size of the grains. Continuous monitoring of the star centred around the time of prediction is essential. In case of a single-channel photometer, simultaneous monitoring of a nearby star from an adjacent telescope (Mahra *et al.* 1985) would help in estimating sky transparency changes.

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