SOME FURTHER MEASUREMENTS OF URANIAN RING CONDENSATIONS

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Abstract. The results of photometric observations of the occultation of BD–19° 4222 by Uranus on April 26, 1981 from two stations in India conform with the model proposed by Elliot *et al.* (1981).

We have utilised the occultation of BD –19° 4222 by Uranus on April 26, 1981 for obtaining further information of the Uranian ring system. Observations were attempted from three stations in India viz. Kavalur Observatory (Lat: + 12° 34′.58, Long: $-5^h 15^m 19^s.6$), Japal-Rangapur Observatory, Hyderabad (Lat: + 17° 05′.9, Long: $-5^h 14^m 54^s.8$) and the Uttar Pradesh State Observatory, Nainital (Lat: +29° 21′.65, Long: $-5^h 17^m 49^s.71$). The observation at Japal-Rangapur Observatory was unsuccessful due to clouds interfering at the time of observation. At Kavalur, the observations were made with two telescopes (Bappu and Liller, 1981) of 102 and 76 cm aperture reflectors in adjacent domes. On the 76 cm reflector telescope the photometer employed was a dry ice cooled EMI 9558 phototube with Wratten 89B filter. On the 102 cm telescope, the detector system of Harvard College Observatory employing a two channel photometer with RG 695 filter was used. At Kavalur, presence of cirrus clouds and poor seeing conditions made identification of the ring occultations during pre immersion difficult; however conditions improved during post emersion phase and dips in light curves due to occultation by ϵ, δ, and γ rings were recorded on both the chart records. At Nainital, a long stretch of undisturbed record clearly showed the occultations by the planet body as well as the dip due to ring occultations. Some precise measurements of the widths and extinctions due to ring segments could be obtained from these records.

Positions of the occulting segments in the ring plane as viewed from the two stations were calculated following the method described by Elliot *et al.* (1978). For greater accuracy, times of all events were referred to the mid-planetary occultation instant, which could be precisely determined from Nainital records (Pande, 1981). The orientation of the ring plane as seen from the earth was calculated using the pole of Elliot *et al.* (1981) given by

$$\alpha(1950) = 5^h 06^m 26^s.1 \pm 10^s.7,$$
$$\delta(1950) = 15^\circ 13' 15'' \pm 3' 13''.$$

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TABLE I

Station	Ring	Event	Mid-time of ring occultation (UT)[a]	Planeto-centric distance R (km)[b]	Azimuth of occulting point $(\theta)^c$	Radial width W (km)[d]	Relative extinction	Planetocentric distance calculated from Elliot's parameters *Rc* (km)[e]
Kavalur	γ	Em	20:25:47.8	47 661	157°.198	–	1	47 656
Kavalur	δ	Em	20:26: 22.45	48 330	157°.613	–	0.72	48 330
Kavalur	ϵ	Em	20:28:35.64	50 922	159°.106	40.1	1	50 911
Nainital	ϵ	Im	19:18:42.0	51 099	32°.223	48.1	1	51 094
Nainital	ϵ	Em	20:28:15.0	50 931	157°.365	39.5	1	50 903

[a] ± 0.25 sec.
[b] ± 5 km.
[c] ± 0.003 deg.
[d] ± 5 km.
[e] ± 33 km.

The coordinates were reduced to the epoch JD 2 444 721.33 (April 26, 1981 at 20 hr UT) by using formulae given by Davies *et al.* (1980).

Residual errors due to uncertainties in planet's ephemerides and star position were almost totally eliminated by linking the known physical dimensions of planet Uranus to the timing of two events of immersion and emersion by the planet's body. The refractive deviation in the planet's atmosphere was taken care of by measuring half-intensity points (Baum and Code, 1953), and the value of planet's radius taken as 26 200 km (Elliot *et al.*, 1978), the relative shift of the shadow centres from their respective calculated positions was found to be

$$\Delta\xi = -4874 \pm 5\,\text{km},$$

$$\Delta\eta = -1853 \pm 5\,\text{km}.$$

The uncertainties are assumed to be determined by the accuracy of timing the events. The radial distances of the occulting ring segments are thus determined to the resolution limit of our measuring system.

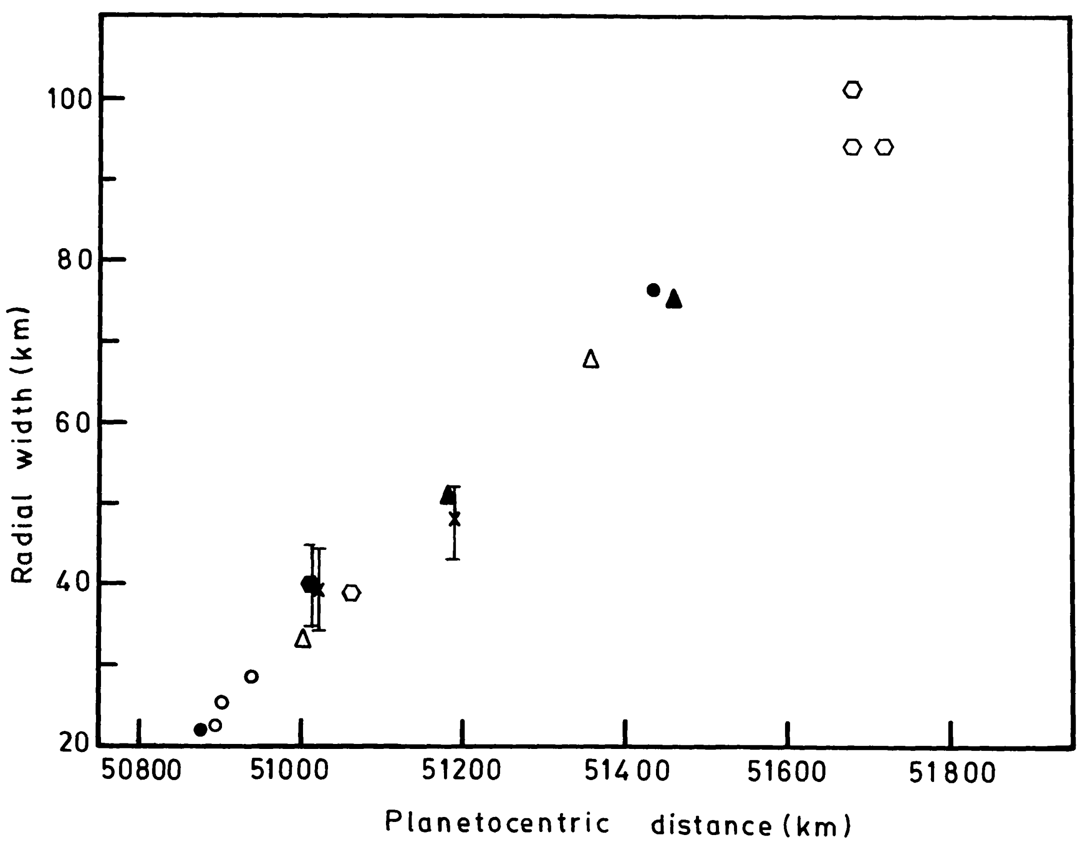

Fig. 1. Relation between the radial width and planetocentric distance for the ϵ ring. Various observations are denoted by the following symbols. Open hexagons – March 10, 1977 (KAO, Kavalur and Perth), filled circles – April 10, 1978 (Las Campanas), filled triangles – June 10, 1979 (Las Campanas), Open Circles – March 20, 1980 (Cerro Tololo and Sutherland), open triangles – August 15, 1980 (Las Campanas), filled hexagon – April 26, 1981 (Kavalur), Crosses – April 26, 1981 (Nainital).

Table I gives the position of the occulting ring segments expressed in polar coordinates (R, θ), where R is the planetocentric distance and θ the azimuth measured from the ascending node of the ring plane on the Earth's equator of date. Radial width (FWHM) of the ϵ ring and extinction of γ and δ rings relative to that of the ϵ ring are also given in Table I. The last column in the table gives Rc, the expected planetocentric distance corresponding to azimuth θ, for all the events, calculated using the fitted model parameters of Elliots *et al.* (1981).

Figure 1 gives the relation between radial width (FWHM) and radius in the ring plane for the ϵ ring. The radii calculated by Nicholson, *et al.* (1982) for August 15, 1980 event and our results are based on Elliot's pole, whereas all the other published radii are based on the pole of Dunham (1971). For comparison we have increased the radii of these two events by 90 km (Elliot *et al.*, 1981) to bring them into agreement with the pole of Dunham.

Dimensions and extinctions of segment of the three rings detected during this experiment confirm measurements of earlier occultation events. A comparison of the observed and calculated planetocentric distances R and Rc in Table I shows that, for almost all the events there is close agreement. Nainital ϵ ring emersion event shows maximum deviation of 28 km, but it is still less than the uncertainty of ± 33 km caused by the uncertainty in the ring plane position. Thus the present results conform with the model drawn by Elliot *et al.* (1981).

The extinction caused by γ ring is measured to be larger than that due to δ ring. Such variabilities of extinction along the longitudinal direction were shown to be present earlier (Bhattacharyya and Bappu, 1977) as judged from unequal extinctions at different parts of the rings.

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