THE STRUCTURE OF THE TAURID, GEMINID AND QUADRANTID METEOR STREAMS

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The Taurids, Geminids and Quadrantids represent meteor streams existing at different stages of stream evolution. This can be inferred from the duration of their activity, more than a month for Taurids, a few days for Geminids and only a few hours for Quadrantids. The structure of the streams can be deduced from a study of the variations in incident flux of shower meteors and their mass exponents as a function of solar longitude. This paper is an attempt to deduce such structure from recent observations in India combined with data available for these showers from the early years of this century (Lovell 1954, Olivier 1960, Rao et al. 1975,1976, Webster et al. 1966).

THE TAURID STREAM

The Taurid stream is attributed to debris associated with the short-period Comet Encke (Whipple 1940). Strong displays are recorded as early as the 11th century with both northern and southern branches, the northern branch apparently at least twice as active as the southern Taurids (Astapovic and Terenteve 1968).

Figure 1, curve (a) shows mean hourly rates for the Taurids derived from visual observations at latitude 17°N between 1961 and 1976. In contrast to the ancient observations, the southern branch of the stream dominates although the activity is only moderate. The radiant position is complex with mean positions for the two branches at $\alpha = 58°$, $\delta = +14°$ for southern Taurids and $\alpha = 55°$, $\delta = +25°$ for northern Taurids.

Curve (b) in figure 1 is based on observed rates of bright photographic meteors and visual fireballs (Hindley 1972). The single peak at longitude 226.5° coincides well with the ascending node of Comet Encke, implying that the stream is uniformly rich in larger meteoroids producing fireballs. The average value of the mass exponent (s) determined from the magnitudes of the observed Taurids is 2.0, the same as that found for sporadic meteors.

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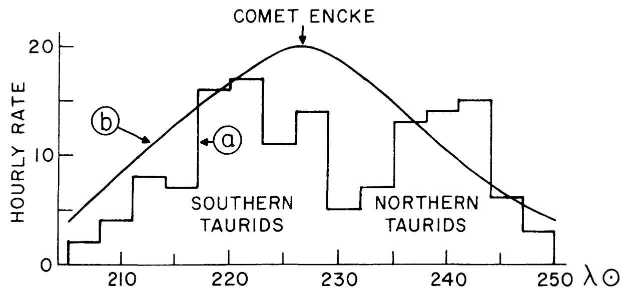

Fig. 1. The activity of the Taurid shower as a function of solar longitude. (a) visual observations in India, (b) photographic and fireballs.

THE GEMINID STREAM

The very stable Geminid meteor stream has provided a consistent display for at least nine centuries with peak activity near December 13-14 each year (Lovell 1954). Figure 2 represents the activity of the Geminid shower, where curve (a) shows the visual hourly rates of all meteors derived by Olivier (1960) during the first half of this century and curve (b) shows the rates of visual Geminids from 1962-76. Shower maximum occurs near $\lambda_{\odot}261.5°$. For comparison, curves (c), (d) and (e) show the activity derived from radar echo rates. Curve (c) shows data from Ottawa for 1958-62 where all echos are included while (d) shows only those echos lasting 8 seconds or more. Curve (e) shows forward scatter rates observed in India in 1974 (Rao et al. 1975). The faint radar echos peak near $\lambda_{\odot}261°$ but the longer echos, associated with larger meteoroids, are concentrated to the outer edge of the stream and are observed mainly during the last three days of the shower, whereas the faint echos endure for about seven days.

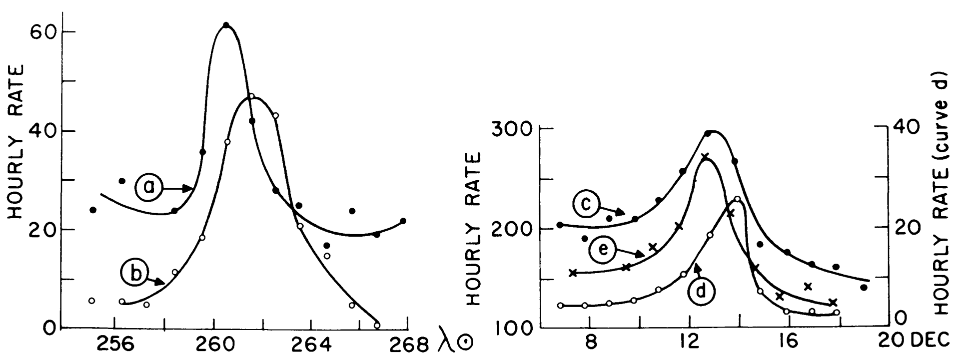

Fig. 2. Variation of mean hourly rates during the Geminid shower.

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Analysis of the mean hourly rates throughout the active nights of the Geminid shower shows two peaks during the night for the visual data, both for the meteors studies by Olivier and for the observations from India. A minor peak before midnight is followed by the main maximum near 0200 hours, local time. A similar trend has been observed in the radio meteor rates by Webster et al. (1966) who also found two distinct radiants. The present observations indicate the main shower radiant is at $\alpha = 110°$, $\delta = +33°$ and the lesser shower at $\alpha = 95°$, $\delta = +33°$, suggesting the possible development of two separate branches in the Geminid stream.

THE QUADRANTID STREAM

The Quadrantid shower is an intense annual shower with a sharp maximum over a period of a few hours between January 2-4. Figure 3 presents the variation of hourly rates of the Quadrantid shower. Curve (a) is derived from the visual observations of 1961-76 where rates after 0600 hours are estimated from the data of other stations (Hindley 1970) since observations in India were prevented by daylight. The shower maximum occurs at $\lambda_\odot 282.83°$ and the width of the shower is about 0.25°. Curves (b) and (c) show (on an arbitrary ordinate scale) the variation of radio meteor rates (Rao et al. 1976) and visual rates obtained by Prentice between 1921 and 1940 (Prentice 1940). All curves exhibit the same type of sharp maximum but the solar longitude at maximum has decreased somewhat during the four decades. This is attributed to regression of the nodes caused by Jovian perturbations, estimated at 3×10^{-3} ° yr^{-1}. There is evidence that secular perturbations modify the orbit sufficiently to alter the conditions of encounter with the earth, which sometimes crosses the main core of the stream but may encounter only the dispersed edges on other occasions. The visual observations suggest a 5-year periodicity in the rates, close to the value of 5.2 years found by Jacchia and Whipple (1961) for the orbital period.

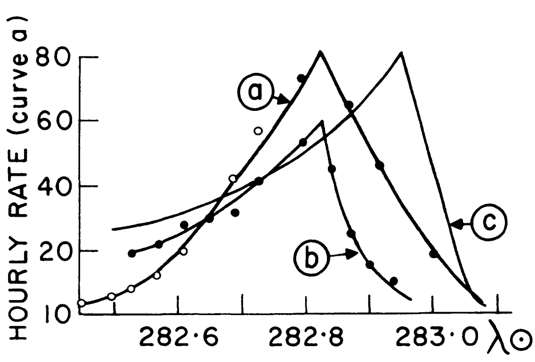

Fig. 3. Variation of mean hourly rates of the Quadrantid shower.

CONCLUSIONS

From the observational results it is seen that low-inclination meteor streams such as the Taurids and Geminids are gradually dispersed by planetary perturbations, especially those of Jupiter. The Taurids show a pronounced splitting and a wide spread in their orbits with advancing age, suggesting that the stream may disappear into the sporadic background. The Geminid stream is more stable although the secondary radiant indicates a tendency for the stream to split. The observations show a sorting of meteoroids in the stream due to the Poynting-Robertson effect, with the smaller meteoroids shifted to the inner orbits of the stream. The Quadrantid stream is much younger and is affected by strong Jovian perturbations giving rise to irregular changes in its activity. The Poynting-Robertson effect appears to deplete the smaller meteoroids from a stream so that old streams such as the Taurids are composed of larger meteoroids.

REFERENCES

Astapovic, I.S. and Terenteva, A.K: 1968, in Physics and Dynamics of Meteors, ed. L. Kresak and P.M. Millman, D. Reidel Pub. Co., 308.

Hindley, K.B.: 1970, J. British Astron. Assoc., 80, 479.

Hindley, K.B.: 1972, ibid., 82, 287.

Jacchia, L.G. and Shipple, F.L.: 1961, Smithson. Contr. Astrophys., 4, 97.

Lovell, A.C.B.: 1954, Meteor Astronomy, Oxford University Press.

Olivier, C.P.: 1960, Smithson. Contr. Astrophys., 4, No. 1.

Prentice, J.P.M.: 1940, J. British Astron. Assoc., 51, 19.

Rao, B.R., Rao, M.S., Rajaratnam, S., Rao, D.A.V.K. and Rao, E.B.: 1975, 1976, Indian J. Radio Space Phys., 4, 99 and 5, 103.

Webster, A.R., Kaiser, T.R. and Poole, L.M.G.: 1966, Monthly Notices Roy. Astron. Soc., 133, 309.

Whipple, F.L.: 1940, Proc. American Phil. Soc., 83, 711.

DISCUSSION

Lindblad: The activity of the Quadrantid shower peaks sharply about $\lambda_\odot 282.8°$. If this value of solar longitude occurs during daylight then visual observers will report a very low Quadrantid rate. I believe, therefore, that the variation in visual rates mentioned represents a variation with solar longitude rather than a variation along the orbit of the stream.

Hughes: I agree that the Quadrantid flux varies from year to year due to non-uniform distribution of meteoroids and by the effect mentioned by Lindblad. No specific periodicities seem to be echoed in the overall variability of the observed flux.

Lokanadham: A definite increase in Quadrantid rates was noticed after 1974 which must be examined further for such periodicities.

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