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METEOR SHOWERS

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Photographic, Radar, and Theoretical Studies

In the period 1969–72 ,several lists of northern-hemisphere, photographic, and radar meteor streams have been published. Lindblad (06.104.042) has listed 75 photographic stream radiants. Cook *et al.* (1973) have further analyzed the photographic data. Cook (*Coll.***13**) gives a list of stream radiants and orbital elements. Sekanina (05.104.009, 10) has discussed streams detected in the Harvard Radio Meteor data. Several new southern-hemisphere radar streams and associations have been reported by Gartrell (1971). The so-called 'toroidal' type of meteor stream (short period, high inclination, low eccentricity) is confirmed in the southern-hemisphere radar data.

Progress in identifying new streams has been made mainly through the use of computer techniques. The *D*-criterion of Southworth and Hawkins directly compares different sets of orbital elements and is easily adapted for computer searches. This method has been used by Gartrell (ibid.), Lindblad (06.104.076, 7), and Sekanina (op. cit.). A search by Lindblad among 2401 graphically reduced Super-Schmidt orbits revealed 15 new photographic streams for which identifications with visual radiants were proposed. Several streams were split into a northern and a southern branch. The so-called σ Leonid stream appears to be identical with the visual Virginid stream reported by Hoffmeister.

The precise photographic-data samples now available have made possible a detailed study of the orbital scatter within meteor streams. For meteor streams of short period this problem has been discussed by Lindblad (1972; *Coll.* **22**). A progressive increase in the scatter of the orbital elements within a given stream is found as the mean period is reduced, indicating that the spatial motions of individual stream members differ increasingly from the average motion of stream members as the short-period streams drift inward toward the Sun. A systematic increase in mean meteoroid density with decreasing period is also noted.

The age of meteor streams has been discussed by Astapovich (1972) .The determination of radiant positions and the radiation area of meteor streams was made by Chebotarev (06.104.009). Structural peculiarities and perturbations in the Perseid stream have been investigated by Kramer and Musiy (02.104.055) and by Kramer and Pavlenko (06.104.008). The evolution of a hypothetical meteor stream under the influence of Jupiter and Saturn has been studied by Sherbaum (06.104.027, 33). The orbital elements of photographic Leonids have been reported by Babadzhanov and Getman (03.104.022). Radar observations of the 1957–68 Leonids have been studied by McIntosh and Millman (03.104.029).

Comet-meteor stream associations. The problem of ejection from a parent comet and the early evolution of a meteor stream have been studied by Sekanina (1972, see reference, preceding Section). Lists of theoretical radiant positions derived from comet orbits have been published by Zentsev (03.102.019) and Kramer (06.104.048). The relation of Comet Halley to the Orionids and η Aquarids has been discussed by Hajduk (03.014.005). Comet-stream associations have been discussed by Lindblad (op. cit.). The relation between the Scorpionid stream and Comet 1770 I has been discussed by Bakharev (03.104.049). Several other authors have reported meteor streams that may be associated with Comet Lexell 1770 I. Some inherent difficulties of the suggested associations with this comet have been pointed out by Cook *et al.* (1973). Associations between comet orbits and radar meteor streams have been studied by Sekanina (op. cit.) and Gartrell (op. cit.). The Poynting-Robertson effect and its influence on particles ejected from Comet 1866 I is discussed by Sherbaum and Shaido (06.104.028).

The mass-distribution index in meteor streams has been investigated by Dohnanyi (03.104.039) and Hughes (06.104.045). The distribution of meteor masses in the Geminid stream has been discussed by Fialko *et al.* (06.104.034). Cook (02.104.034) has classified a number of streams in terms of thediscrete beginning-height criteria of Ceplecha.

Variations in the impact counts on dust detectors onboard the lunar orbiter Explorer 35 have been correlated with the appearance of the major meteor showers by Alexander *et al.* (06.094.191; 1972). Increases in the count rate are ascribed to lunar ejecta from stream meteoroids impacting on the lunar surface. Correlations between increases in the twilight sky brightness and the appearance of certain meteor streams have been reported by Link and Weill (02.082.074), Link and Robley (06.082.045), Fehrenbach *et al.* (1972), and by Andrianov *et al.* (1971).

Visual observations

Visual observations of meteors have been reported by the American Meteor Society (AMS), the British Astronomical Association (BAA) meteor section, Nippon Meteor Society (NMS), and by observers in India. The AMS reports 150000 meteors observed in the period 1969–71. An extensive catalog of radiants based on visual observations in 1950–69 has been prepared by Yabu (manuscript, NMS). Visual observations of individual meteor showers are detailed below.

Quadrantids. Members of the BAA recorded strong displays of the Quandrantids in 1970 and 1971 (02.104.019, 20; 06.104.080, 81). The visual meteor data permit a determination of the period of maximum activity and thus a new determination of the regression of the node. Furthermore, it is shown that the time of maximum is noticeably dependent on the brightness of the meteors under observation. Comparisons of visual, telescopic, and radar results suggest that brighter Quadrantids peak at a later time. The maximum is retarded by about one hour for each one-magnitude decrease. This important work shows that amateur groups can still contribute significantly to meteor research.

Perseids. Continued radar-visual studies of Perseid meteors have been carried out by groups in Czechoslovakia and Sweden. Czechoslovakian observations have been reported (03.104.003). They include in their studies telescopic observations using binoculars and a 29-km baseline. Perseid observations during the favorable return in 1969 have been reported by Hindley (02.104.018).

Draconids. The strong display of Draconid meteors anticipated for October 1972 did not materialize.

Geminids and Southern Geminids. Observations of Geminid meteors in 1969 were made by Hindley (02.104.018). A telescopic meteor shower reported by Hindley and Houlden (03.104.012) as the 11 Canis Minorids is most likely identical with the photographic Southern Geminids listed by Lindblad. The southern branch of the Geminids is prominent in the Harvard Radio Meteor data.

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