MINOR METEOR SHOWERS OF NOVEMBER, DECEMBER, AND JANUARY

By M. SRIRAMA RAO,* P. V. S. RAMA RAO,* and P. RAMESH†

[*Manuscript received January 7, 1969*]

Summary

Systematic visual observations of 7987 meteors were made during the months November, December, and January in 1961–7. Major shower meteors were identified and the remaining data were analysed for evidence of minor meteor shower activity. By tracing the paths of 894 meteors which appeared to make up 70 groups, common radiant points were found suggesting the existence of minor meteor showers. Two further tests of significance supported this contention. Ten out of the 70 minor meteor showers were found to occur in at least two different years on approximately the same dates and therefore are considered to be established minor meteor showers. The majority of the minor shower radiants were found to lie close to the plane of the ecliptic.

I. INTRODUCTION

Denning (1891), in England, made one of the earliest systematic visual observations of meteors and later prepared a catalogue of 4367 meteor shower radiants (Denning 1899). More recently Nilsson (1964), in Australia, identified about 60 minor shower radiants during a radio survey of meteors. Both these surveys were made from high latitude stations: the former in the northern hemisphere and the latter in the southern hemisphere. The aim of the present investigation was to identify minor meteor showers observed over a low latitude station at Waltair, India.

Systematic visual observations of meteors were made from 1961 to 1967 during the winter months November, December, and January when the sky is clearer than at other times of the year. A total of 7987 meteors were observed. Major shower meteors were eliminated from the general sporadic background and the remaining data for 3158 meteors were examined for evidence of minor meteor shower activity. Day-to-day variation in daily mean hourly rates of occurrence was studied following the method adopted by Srirama Rao and Lokanadham (1967) and Srirama Rao *et al.* (1968).

II. IDENTIFICATION OF MINOR METEOR SHOWERS

The various available meteor paths of the selected 3158 meteors were retraced on appropriate star charts from the original star maps. Those that appeared to have common radiant points were replotted on separate charts for still closer examination.

* Department of Physics, Andhra University, Waltair, India.

† Department of Physics, S.V. University, Tirupati, India.

TABLE 1

GROUPS OF METEORS WITH COMMON RADIANTS

Group No.	Dates Observed	Number in Group	Radiant Coords α	δ	Max. Hourly Rates	Hour of Max. Activity L.T.	S.T.
1	6–9 Nov. 1966	16	360°	53°	12·0	0000	2135
2	8–10 Nov. 1961	3	115	−15	6·6	0300	2443
3	8–10 Nov. 1961	5	67	0	2·2	0200	2343
4	8–15 Nov. 1961	10	350	−11	1·9	2300	2051
5	8–19 Nov. 1961	18	103	23	5·6	0200	2355
6	13 Nov. 1965	4	35	48	13·2	2030	1828
7	17 Nov. 1966	16	98	5	19·1	0400	0202
8	21–27 Nov. 1962	18	103	23	4·0	0000	2242
9	24–27 Nov. 1962	6	108	7	2·9	0000	2244
10	28 Nov. 1961 to 3 Dec. 1961	4	37	19	6·6	2200	2105
11	28 Nov. 1965	5	85	−20	6·5	2330	2228
12	28–29 Nov. 1965	7	122	2	6·4	0200	0058
13	30 Nov. 1964	5	84	37	5·6	2300	2205
14	1 Dec. 1964	16	108	5	6·0	0200	0109
15	1 Dec. 1964	10	65	60	7·3	0100	0009
16	1 Dec. 1964	13	77	−7	6·0	0000	2309
17	1–4 Dec. 1964	35	129	21	9·8	0300	0213
18	2–5 Dec. 1961	4	156	18	3·1	0200	0117
19	2–5 Dec. 1961	3	138	4	6·6	0130	0047
20	2–5 Dec. 1961	6	147	13	2·9	0100	0017
21	3–8 Dec. 1964	46	93	18	7·0	0100	0025
22	3 Dec. 1964	7	71	−32	4·8	0000	2317
23	3–6 Dec. 1962	6	172	−4	5·0	0300	0225
24	3–6 Dec. 1962	10	129	−6	13·2	0500	0425
25	3–6 Dec. 1962	17	147	11	8·3	0230	0155
26	4 Dec. 1964	8	160	−15	26·4	0400	0321
27	4–12 Dec. 1964	22	86	10	4·6	0300	0237
28	5–6 Dec. 1962	5	132	21	6·6	0300	0225
29	5–8 Dec. 1964	29	142	15	8·0	0300	0253
30	7–11 Dec. 1964	11	47	47	6·7	2300	2240
31	8 Dec. 1964	10	57	22	7·5	0100	0037
32	11–14 Dec. 1964	31	123	7	6·0	0300	0253
33	11–15 Dec. 1963	7	69	23	2·7	2200	2157
34	12–13 Dec. 1961	7	75	25	7·6	0000	2353
35	11–20 Dec. 1963	15	88	22	2·9	2300	2309
36	12–14 Dec. 1964	20	153	0	9·0	0300	0257
37	12–14 Dec. 1966	36	158	5	6·0	0300	0257
38	12–15 Dec. 1963	9	156	30	13·2	0300	0301
39	12–15 Dec. 1963	5	127	4	6·6	—	—
40	14 Dec. 1964	6	189	1	11·4	0200	0201
41	14–17 Dec. 1961	4	132	18	6·6	0000	0009
42	17–20 Dec. 1963	7	175	2	8·2	0400	0426
43	18 Dec. 1962 to 3 Jan. 1963	28	73	27	3·2	2230	2246
44	23 Dec. 1962 to 5 Jan. 1963	23	90	28	2·6	0100	0200
45	25–27 Dec. 1962	8	120	28	4·2	0300	0348

TABLE 1 (*Continued*)

Group No.	Dates Observed	Number in Group	Radiant Coords α	δ	Max. Hourly Rates	Hour of Max. Activity L.T.	S.T.
46	25–30 Dec. 1962	8	112°	6°	5·2	0100	0156
47	29–31 Dec. 1961	5	93	18	3·8	2200	2304
48	2–5 Jan. 1962	8	105	16	9·9	0300	0417
49	3–10 Jan. 1965	28	184	10	10·2	0200	0332
50	4–5 Jan. 1963	5	154	11	6·6	0500	0624
51	4–7 Jan. 1962	9	133	22	5·0	0130	0258
52	4–12 Jan. 1962	21	151	18	5·8	0100	0236
53	6–8 Jan. 1962	4	85	21	4·3	0000	0132
54	6–7 Jan. 1965	13	113	5	11·5	0000	0132
55	7–9 Jan. 1962	8	119	34	6·6	2200	2336
56	7–11 Jan. 1962	11	91	7	5·0	0000	0140
57	10–12 Jan. 1962	6	138	31	3·1	0300	0448
58	16–17 Jan. 1967	22	167	10	13·8	0300	0512
59	19 Jan. 1966	9	127	−22	16·5	0000	0220
60	19–22 Jan. 1966	8	178	−12	3·3	0300	0527
61	20 Jan. 1966	11	109	3	8·5	0200	0423
62	21–24 Jan. 1963	7	167	37	3·8	0130	0401
63	21–30 Jan. 1963	16	115	21	6·6	2330	0217
64	21–30 Jan. 1963	24	141	18	5·5	0100	0347
65	21–30 Jan. 1963	11	203	−6	2·5	0300	0547
66	21–30 Jan. 1963	13	125	18	13·2	0000	0247
67	22–27 Jan. 1966	14	202	−2	11·5	0300	0543
68	22–27 Jan. 1966	17	130	12	9·5	0300	0543
69	24–29 Jan. 1963	11	170	16	7·2	0300	0551
70	27–31 Jan. 1965	24	133	12	19·0	0000	0259

Each group of meteors showing a common radiant point was tentatively identified as a minor meteor shower. There were 70 groups in all derived from a total of 894 meteors.

To determine the radiant coordinates (α, δ), the paths of the meteors in each group were plotted on a stereographic projection of the sky and extended backward along great circle paths (Fig. 1). Theoretically the point of intersection of these extended paths gives the radiant but in practice, owing to small plotting errors, the centre of a circle enclosing the intersections is taken and the radius of this circle gives an estimate of the error involved. The present experimental error was found to vary between 0 and $\pm 10°$, the average being $\pm 6°$. The extended paths of a few meteors in each group did not intersect the error circle but, following the standard method of identification adopted by Millman's (personal communication) group of observers, a meteor is considered to be part of a minor shower if its extended path passes within $\pm 15°$ of the radiant. The period during which each group of meteors was observed is given in Table 1, along with the number of meteors in each group, its radiant coordinates, and other relevant data.

The activity of the 894 meteors suspected to be associated with minor showers was compared with the activity for the sporadic background (Fig. 2). By plotting the daily mean hourly rate of occurrence of all the 3158 meteors against the date observed (Fig. 2(*a*)) the day-to-day variation in activity is seen to be greater than is the case when suspected minor shower meteors are not considered (Fig. 2(*b*)).

The average level of meteoric activity in Figure 2 decreases from around 13·4 meteors per hour in (*a*) to 9·0 in (*b*) and the expected reduction considering the number of meteors used in the data is from 3158 to 2264, that is, by a factor of 1·4.

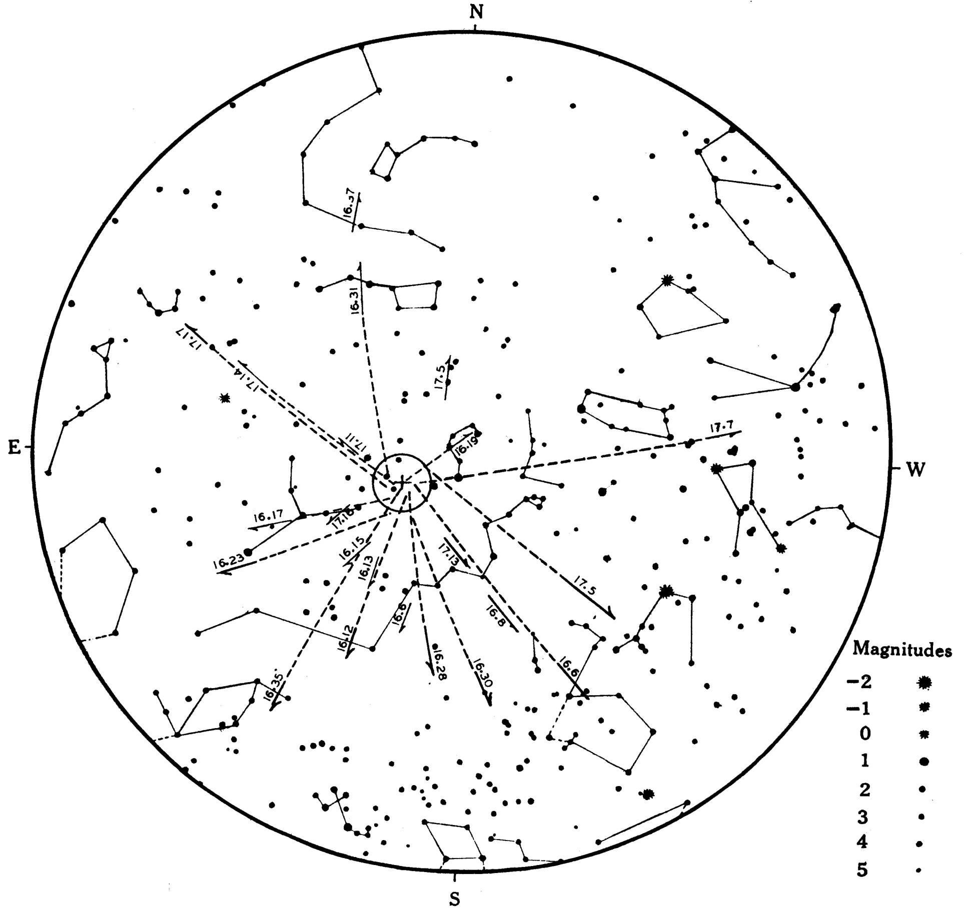

Fig. 1.—Radiant determination of the minor shower listed as group 58 in Table 1. In this case $\alpha = 167° \pm 7°$, $\delta = 10° \pm 7°$.

However, the amplitude of fluctuation of 24·0 in (*a*) has reduced to 10·5 in (*b*), that is, by a factor of 2·3, which is fairly high compared with the expected ratio of 1·4.

The substantial decrease in the amplitude of fluctuation that is found when the data for the 894 suspected minor shower meteors are ignored indicates that these meteors are concentrated mostly on certain days. This further substantiates our assumption that the groups of meteors in Table 1 are significant minor meteor showers.

Prentice (1948) pointed out that the activity outside the major shower periods is maintained by a large number of minor streams (with rates not exceeding one per hour) which agrees with our observations.

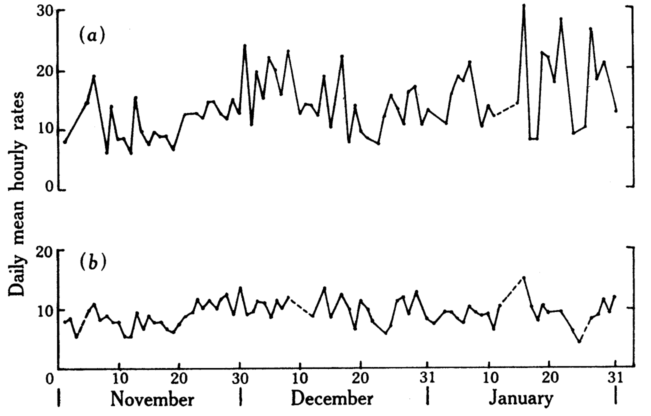

Fig. 2.—Showing (a) the combined activity of the 3158 sporadic and minor shower meteors and (b) the sporadic activity when the suspected 894 minor shower meteors are not included.

From a study of diurnal variation in the hourly rates of each of the 70 suspected minor showers the hour of maximum activity and the maximum hourly rate were obtained. These values are shown in the last three columns in Table 1. The maximum

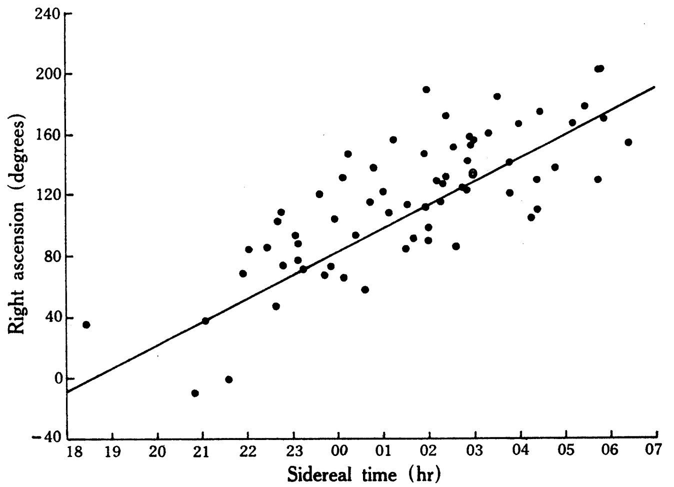

Fig. 3.—Right ascension of the suspected minor shower radiant plotted against the sidereal time at the hour of maximum activity for each group of meteors. The computed straight line shows the expected relationship.

hourly rates represent minor shower activity above that of the normal sporadic background. If a group of meteors having a common radiant really corresponds to a minor meteor shower, the maximum hourly rate should occur at a local time when the radiant is at its upper transit; i.e. when it crosses the celestial meridian. It follows from this that the relationship of the right ascension of each suspected minor shower radiant to the sidereal time at the local hour of maximum activity should be linear. Figure 3 shows such a plot for the 70 groups of meteors considered along with the straight line computed from the expected relationship.

TABLE 2

LIST OF ESTABLISHED MINOR METEOR SHOWERS

Minor Shower No.	Reference	Dates Observed	Radiant Coordinates α	δ
1	Group 5	8–19 Nov. 1961	103°	23°
	Group 8	21–27 Nov. 1962	103	23
2	Group 21	3–8 Dec. 1964	93	18
	Group 35	11–20 Dec. 1963	88	22
	Nilsson (1964)	5–10 Dec. 1961	95	15
	Nilsson	8–12 Dec. 1960	96	15
3	Group 20	2–5 Dec. 1961	147	13
	Group 25	3–6 Dec. 1962	147	11
	Group 29	5–8 Dec. 1964	142	15
4	Group 27	4–12 Dec. 1964	86	10
	Nilsson	7–12 Dec. 1960	91	9
5	Group 32	11–14 Dec. 1964	123	7
	Group 39	12–15 Dec. 1963	127	4
6	Group 33	11–15 Dec. 1963	69	23
	Group 34	12–13 Dec. 1961	75	25
7	Group 36	12–14 Dec. 1964	153	0
	Group 37	12–14 Dec. 1966	158	5
8	Group 50	4–5 Jan. 1963	154	11
	Group 52	4–12 Jan. 1962	151	18
9	Group 65	21–30 Jan. 1963	203	−6
	Group 67	22–27 Jan. 1966	202	−2
10	Group 66	21–30 Jan. 1963	125	18
	Group 68	22–27 Jan. 1966	130	12
	Group 70	27–31 Jan. 1965	133	12
	Nilsson	16–22 Jan. 1961	134	14

Some deviation exists due probably to the difficulty of accurately determining the hour of maximum activity, since a smooth curve of diurnal variation is only possible with much more data than were available here. However, the agreement is close enough to support the assumption that the selected groups of meteors represent minor meteor showers.

Again, if the minor showers are real, corresponding streams of meteoric particles should exist in space, and thus should recur on the same calendar dates in successive years. An attempt was made to establish this repeatability by selecting groups from Table 1 with similar radiant coordinates and periods of activity. The 10 resulting groups of meteors which may be considered established minor meteor showers are listed in Table 2. Each of the showers listed was found to be active in at least two different years.

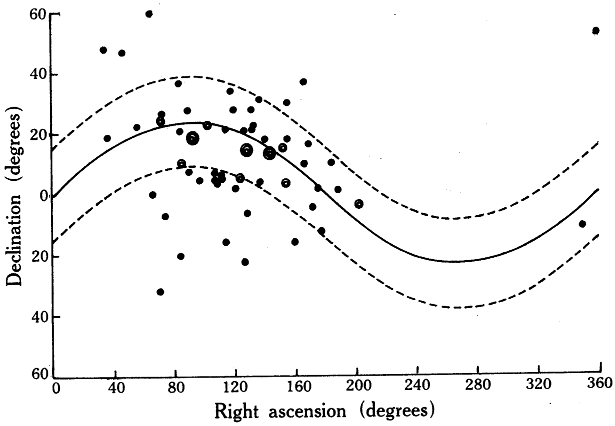

Fig. 4.—Distribution of the minor shower radiants about the plane of the ecliptic. The solid curve represents all points where the plane of the ecliptic cuts the celestial sphere. The dashed curves represent a divergence of $\pm 15°$ from the plane of the ecliptic.

The meteor group 5 in Table 1 has identical radiant coordinates to group 8. The former was active during November 8–19 and the latter during November 21–27, but, because of the identical coordinates, the different observation periods are accounted for by assuming a long duration of activity. The two groups are considered to be the same meteor shower with a period of activity November 8–27 and are listed as minor shower 1 in Table 2. Such long durations of activity are not uncommon as is evidenced by the 1 month duration of the Taurid meteor shower activity.

The details of group 21 were found to agree reasonably well with those of a minor shower identified by Nilsson (1964) in the years 1960 and 1961. The period of activity of group 35, while not coinciding with that observed for group 21 in 1964, overlaps the periods of activity of the minor shower observed by Nilsson. Since the radiant coordinates of groups 21 and 35 are also in close agreement they are listed in Table 2 as the one minor shower, No. 2, active December 3–20.

In the same way four recurring groups of meteors with overlapping observed periods and radiant coordinates in close agreement are listed as minor shower 10. active January 16–31.

III. Distribution About the Plane of the Ecliptic

It is interesting to study the distribution of the radiants of the minor showers on the celestial sphere in relation to the plane of the ecliptic. Figure 4 is a plot of the declination of the minor shower radiants versus their right ascension. The solid curve represents all points where the plane of the ecliptic cuts the celestial sphere. The dashed curves represent a divergence of $\pm 15°$ from the plane of the ecliptic. The open circles represent the established minor meteor showers listed in Table 2, all of which lie within the above divergence limits. The filled circles correspond to the rest of the minor showers listed in Table 1. Many of these radiant points also lie within the divergence limits of $\pm 15°$. This result is similar to that of Ellyett and Roth (1955) for major meteor showers. The 60 minor shower radiants identified by Nilsson were also found to lie close to the plane of the ecliptic.

IV. Acknowledgments

The authors wish to thank Miss S. Burland of the Dominion Observatory, Canada, for supplying the set of rules used by Professor Millman's group for radiant determinations of meteor showers. They are also grateful to the Council of Scientific and Industrial Research of India for financial assistance.

V. References

Denning, W. F. (1891).—*Mem. Br. astr. Ass.* **1**, 20.
Denning, W. F. (1899).—*Mem. Br. astr. Ass.* **53**, 203.
Ellyett, C. D., and Roth, K. W. (1955).—*Aust. J. Phys.* **8**, 390.
Nilsson, C. S. (1964).—*Aust. J. Phys.* **17**, 205.
Prentice, J. P. M. (1948).—*Rep. Prog. Phys.* **11**, 389.
Srirama Rao, M., and Lokanadham, B. (1967).—*Ind. J. pure appl. Phys.* **5**, 537.
Srirama Rao, M., Rama Rao, P. V. S., Venkataramayya, Y., and Rao, C. V. R. (1968).—*Ind. J. pure appl. Phys.* **6**, 377.