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Minor Meteor Showers of October Observed over Waltair during 1962–71

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Abstract

Systematic visual observations of meteors have been made over Waltair (lat. 17·5° N.) in the month of October during 1962–71. From the data for 1835 meteors collected, after identification of 436 Orionid and 153 Taurid major shower meteors, 56 groups covering 439 meteors in the remainder have been observed to display common radiant points on the daily plotted meteor maps. These 56 groups are tentatively classed as minor meteor showers, after applying some tests of significance. The list is reduced to 20 groups by identifying common radiant coordinates within a divergence of $\pm 10°$. Of these 20 groups, 10 occur in at least two different years and on nearby dates and therefore are considered to be well-established minor meteor showers. It is found that a majority of the minor shower radiants lie close to the ecliptic.

Introduction

Previous work by Denning (1891, 1899) in England and Nilsson (1964) in Australia on systematic visual and radio observations of meteors has established the existence of 4367 and 60 minor shower radiants respectively. These surveys were made from high latitude stations covering both the northern and southern hemispheres. From the data for visual meteors collected systematically at Waltair, India (a low latitude station), during the months of November, December and January 1961–67, Srirama Rao *et al.* (1969) reported the existence of 70 minor meteor showers, of which 10 were considered to be established. S. Raja Ratnam (personal communication) has similarly identified 42 minor meteor showers during February 1962–72, of which 17 are considered to be definite. The aim of the present investigation is to identify minor meteor showers from the data for meteors systematically collected during October 1962–71, over the same low latitude station, Waltair. Of the total of 1835 meteors observed during this period, 436 and 153 have been found to correspond to the Orionid and Taurid major meteor showers respectively. The remaining data for the 1246 meteors are analysed here to see if any minor shower activity can be delineated from the sporadic background.

Identification of Possible Minor Meteor Showers

Careful examination of the original paths of the 1246 visual meteors revealed that 56 groups consisting of 439 meteors apparently had common radiant points, and these groups were replotted on separate star maps for still closer study. Each of the 56 meteor groups was subjected to the analysis outlined by Srirama Rao *et al.* (1969) for the determination of the radiant coordinates. Fig. 1 illustrates the meteor

paths and radiant coordinates of a typical minor shower which occurred on the night of 29 October 1970. In general, the accuracy involved in determining the radiant point is about $\pm 7°$, the diameter of the error circle drawn around the radiant point in Fig. 1.

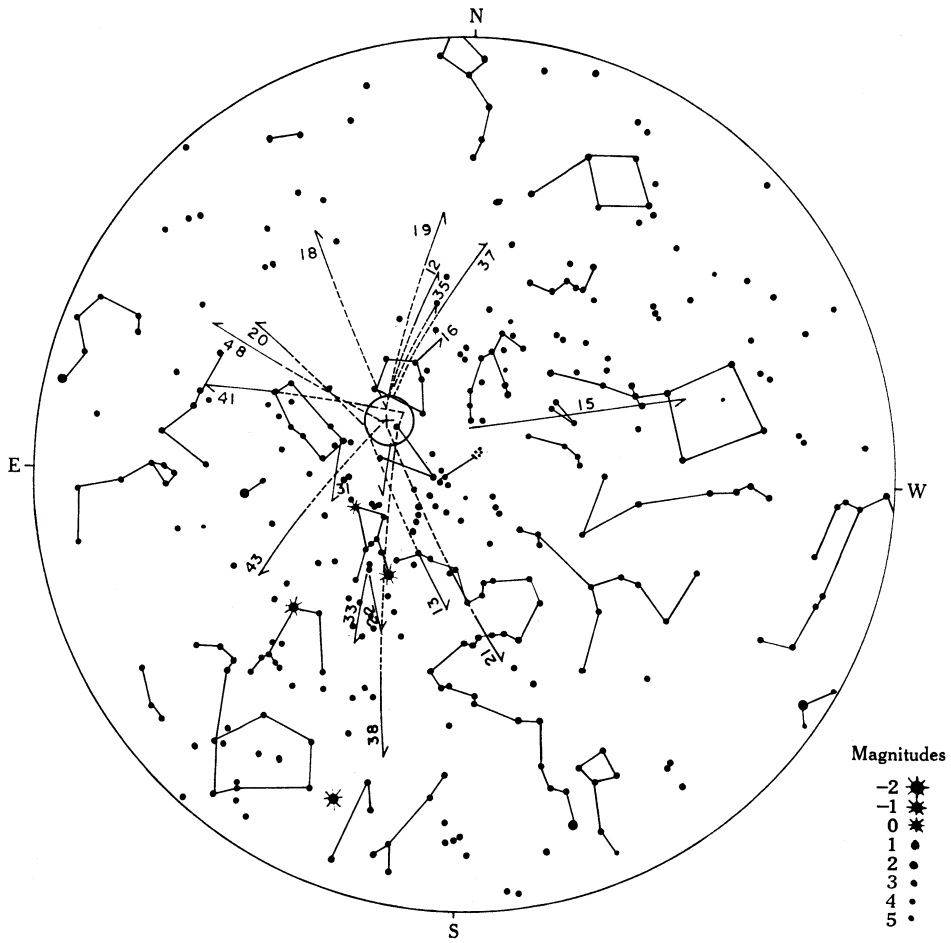

Fig. 1. Radiant determination of the minor shower observed on 29 October 1970, which is listed as group 36 of MS8 in Table 1. In this case $\alpha = 85°$ and $\delta = 30°$.

The experimental error in the present analysis is found to be of the order of $\pm 10°$. The 56 groups of meteors having common radiants correspond to 35 different dates. Table 1 presents a list of the radiant coordinates α and δ of these 56 groups, along with the number of meteors in each. Since minor showers are known to be continuously active for a number of days, the groups of meteors in this list which appear on different days and whose radiants agree within $\pm 10°$ have been further grouped together. Thus, 20 major groups suspected of being minor meteor showers are identified in Table 1. Tests of significance will now be applied to confirm these tentative identifications.

Table 1. Suspected minor meteor showers of October 1962–71

Values included in square brackets for comparison are dates of observation and radiant coordinates of minor showers listed by Nilsson (1964)

Minor shower No.	Group serial No.	Date of observation	Radiant α_t °	Radiant δ_t °	Number of meteors	Mean[A] $\bar{\alpha}$ °	Mean[A] $\bar{\delta}$ °	Duration (days)	Hour of max. activity LT	Hour of max. activity ST
MS1	1	1. x.62	48	35	4	52	33	5	0100	2027
	2	5. x.62	56	31	3					
	3	5. x.67	62	32	5					
	4	(18. x.63)	43	41	4					
MS2	5	2. x.65	118	22	4	108	11	4	0400	2318
	6	3. x.62	98	06	10					
	7	5. x.67	100	05	3					
	8	(28. x.65)	113	10	4					
MS3	9	1. x.67	80	20	9	76	14	10	0300	2255
	10	2. x.65	68	02	5					
	11	2. x.65	82	22	8					
	12	2. x.70	71	17	6					
	13	3. x.62	68	08	6					
	14	10. x.71	87	15	3					
	15	(26. x.70)	76	02	6					
MS4	16	3. x.62	344	18	15	347	19	12	2200	1752
	17	11. x.63	342	17	24					
	18	12. x.63	347	20	11					
	19	13. x.63	348	29	3					
	20	14. x.63	356	12	10					
MS5	21	4. x.68	17	14	11	18	09	14	2300	1856
		[22–29.ix.61]	[18	05]						
	22	9. x.63	21	05	7					
		[23–29.ix.61]	[19	15]						
	23	16. x.63	22	06	19					
		[24–29.ix.61]	[19	02]						
	24	17. x.63	13	12	11					
	25	(27. x.70)	17	12	3					
MS6	26	6. x.68	01	21	11	07	13	10	0000	1956
	27	13. x.63	10	15	9					
		[25–29.ix.61]	[11	04]						
	28	15. x.63	10	10	4					
	29	15. x.63	07	06	6					
MS7	30	7. x.67	35	13	4	33	21	20	2300	1916
	31	14. x.71	31	29	17					
	32	18. x.63	30	23	13					
	33	26. x.65	36	20	4					
MS8	34	(12. x.63)	91	28	10	90	32	3	0300	2356
	35	27. x.65	93	34	4					
	36[B]	29. x.70	85	30	18					

[A] Not arithmetic means but mean radiant coordinates as determined after replotting meteors of all groups corresponding to the same minor shower number.

[B] The meteor paths of group 36 of MS8 are plotted in Fig. 1.

Table 1 (*Continued*)

Minor shower No.	Group serial No.	Date of observation	Radiant α_t °	Radiant δ_t °	Number of meteors	Mean $\bar{\alpha}$ °	Mean $\bar{\delta}$ °	Duration (days)	Hour of max. activity LT	Hour of max. activity ST
MS9	37	12. x.63	22	45	8					
	38	13. x.63	24	35	18					
	39	19. x.63	25	44	10	21	43	14	0000	2020
	40	25. x.70	13	48	11					
MS10	41	31. x.64	37	04	12					
		[23–30. x.61]	[39	00]						
	42	31. x.65	33	02	5	35	06	1	0000	2111
		[20–31. x.61][c]	[45	12][c]						
		[22–27.ix.61]	[31	10]						
MS11	43	(12. x.63)	02	34	9	04	32	?	2200	1828
	44	(28. x.64)	05	30	3					
MS12	45	11. x.63	32	−12	7	29	−12	4	2200	1800
	46	14. x.63	25	−12	4					
MS13	47	11. x.63	335	51	8					
	48	17. x.63	328	49	4	328	55	8	2100	1708
	49	18. x.63	320	65	7					
MS14	50	11. x.63	335	−18	6	335	−18		2100	1652
MS15	51	15. x.63	326	06	4	326	06		0000	2008
MS16	52	19. x.69	132	67	4	132	67		0500	0121
MS17	53	24. x.65	71	37	7	71	37		0200	2240
MS18	54	24. x.70	100	45	6	100	45		0200	2240
MS19	55	29. x.70	136	01	6	136	01		0400	0100
MS20	56	29. x.70	177	45	6	177	45		0400	0100

[c] Southern Arietids.

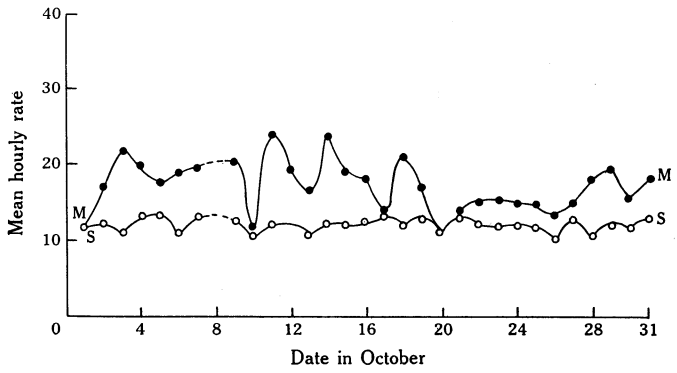

Fig. 2. Plots of meteor activity (six-observer rates) versus date in October 1962–71 for:

MM, all meteors excluding Orionids and Taurids;

SS, suspected sporadic meteors.

Tests of Significance

Test 1. If all of the 439 meteors considered in Table 1 correspond to minor showers, the remaining data for the 807 suspected sporadic meteors should show a fairly constant daily mean hourly rate throughout the month of October. The mean rates of occurrence for all the 1246 visual meteors, as determined by the method outlined by Lokanadham and Srirama Rao (1967) and Srirama Rao *et al.* (1968), are plotted for each day as curve MM in Fig. 2, while the corresponding results for the 807 suspected sporadic meteors are plotted as curve SS. The average level of meteor activity for curve MM is around 18 h^{-1} for Millman's (1961) standard group of six observers and that for curve SS is 12·5 h^{-1}. Thus the reduction in the average hourly rate by a factor of 1·4 is in agreement with the expected factor of 1·5, considering the reduction in the total number of meteors from 1246 to 807. Also, the amplitude of fluctuation has substantially decreased from about 12 for curve MM to about 2·5 for curve SS (i.e. a factor of 4·8), indicating that the minor shower meteors are concentrated mostly on certain days. This justifies our contention that the groups of meteors in Table 1 could be minor showers.

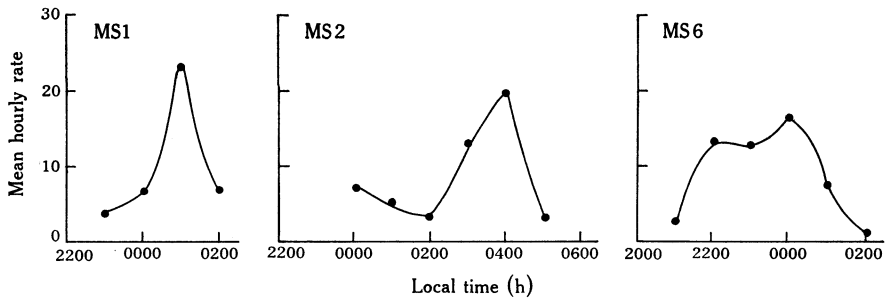

Fig. 3. Typical diurnal variations in the activities of three of the minor showers listed in Table 1.

Test 2. If the groupings in Table 1 are reliable, the time of upper transit of each of the radiant points should coincide with that of the diurnal peak in the activity of the meteors in any particular shower. In such a case, the right ascension (α) values of the suspected minor meteor showers should bear a linear relation to the sidereal times (ST) of their maximum activity. With this in mind, the diurnal variations in the hourly rates of activity for each of the 20 suspected minor showers have been studied, and the corresponding hours of maximum activity are included in Table 1. Typical diurnal variation curves for the minor showers MS 1, 2 and 6 listed in Table 1 are presented in Fig. 3. A plot of right ascension versus sidereal time at maximum activity for all of the 20 suspected minor showers is given in Fig. 4, together with the computed linear relationship expected. The rather small number of meteors in each minor shower listed in Table 1 makes it difficult to obtain an accurate determination of the sidereal time of maximum activity. For the same reason, the determination of the right ascension of the radiant of the minor shower also tends to be inaccurate. However, a linear trend of variation is evident in the points plotted in Fig. 4, and the agreement between this trend and the theoretically computed line may be said to be fairly good, considering the inaccuracies involved in the α and ST determinations for each minor shower. Close inspection of Fig. 4 shows that the points corresponding

to minor showers containing larger numbers of meteors are closer to the computed line than the others. Hence, the suspicion that the groups of meteors listed in Table 1 are minor showers is tentatively confirmed.

Established Minor Meteor Showers

If the minor meteor showers considered above are indeed real, the corresponding streams of meteoric particles should exist in space and hence the showers should recur on the same calendar dates in successive years. Also, owing to the finite width of the streams, the minor shower activity should repeat on successive dates during the same year. Thus, of the 20 suspected minor showers listed in Table 1, the first 11 are considered to be tentatively established since their activity occurred in at

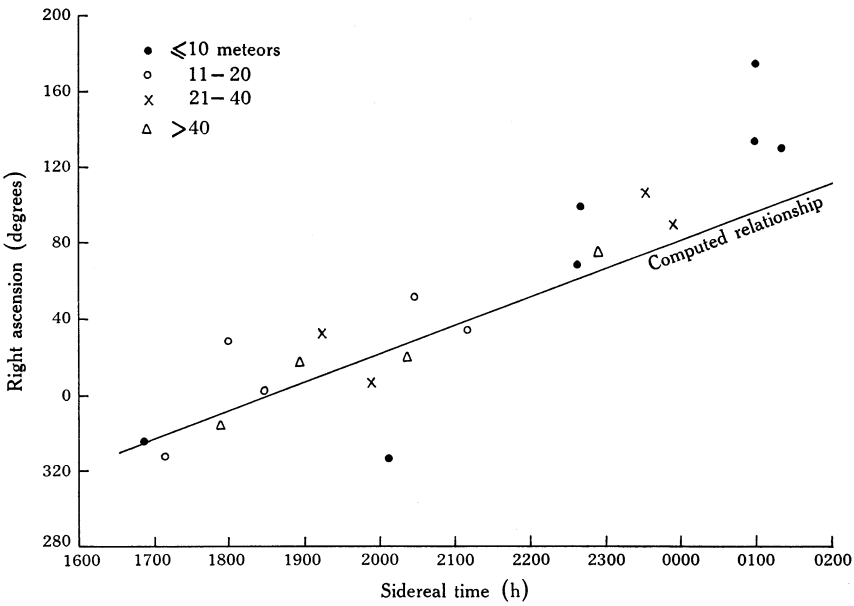

Fig. 4. Plot of right ascension versus sidereal time at upper transit for the 20 minor showers.

least two different years. To this list we might add MS12 and MS13 which show activity on more than one day, although there is no confirmation from different years. For these 13 established minor showers, most are active for durations of 12 to 27 days. However, when a date of activity recorded against any of them differs by 10 days or more from the general trend, it has been included in parentheses in Table 1 and considered as probably unreliable. Eliminating such dates, the durations of activity of the 13 established minor showers are found to vary from 1 to 20 days. The duration of MS11 is considered doubtful owing to the large gap in the two days of activity, namely 12 and 28 October, although the shower is found to occur in two different years.

Thus, the first 10 of the minor showers listed in Table 1 have been found to occur in at least two different years and also on nearby dates and therefore are considered to be well-established minor meteor showers. The long durations of shower activity observed in the present work are not uncommon, since the Taurid shower activity

extends over 6–8 weeks. The minor showers MS 14–20 cannot be confirmed owing to lack of sufficient data.

Three of the minor showers, MS 5, 6 and 10, have their radiant points close to some of those observed by Nilsson (1964) during a radio survey in the southern hemisphere. His listed dates of observation and radiant coordinates in these cases have been included (in square brackets) in Table 1 for comparison.

Distribution of Minor Shower Radiants

It is interesting to study the distribution of the minor showers on the celestial sphere. Fig. 5 presents a plot of declination versus right ascension for the 20 minor shower radiants given in Table 1. The solid curve represents all points where the

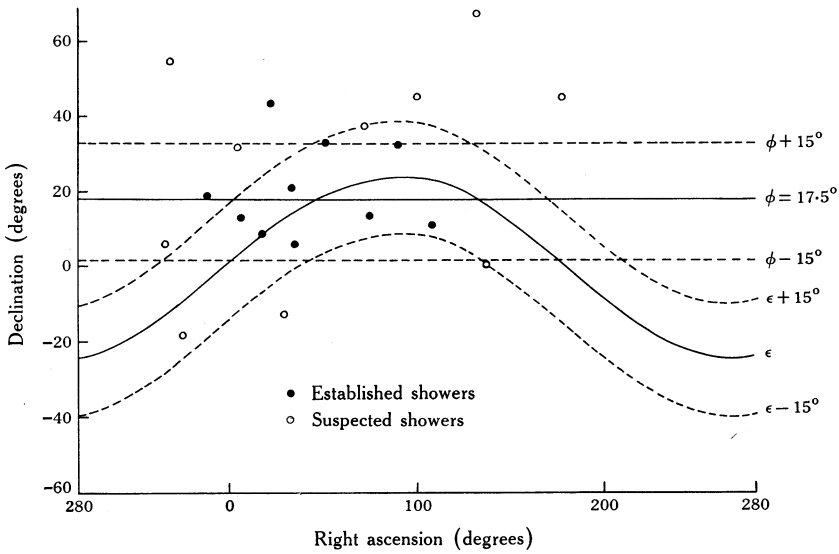

Fig. 5. Plot of declination versus right ascension for the 20 minor showers.

plane of the ecliptic (ε) cuts the celestial sphere while the dashed curves show divergences of $\pm 15°$ from the plane of the ecliptic. Of the 20 radiants, 11 (i.e. 55%) lie within $\pm 15°$ of the ecliptic. Such large deviations of radiant points from the ecliptic have been reported earlier by Hawkins (1961).

It is expected that the maximum activity of any meteor shower will be observed over places lying close to the latitude equal to the declination of the shower radiant, because at these places the upper transit of the radiant will coincide with the zenith. In this investigation, the δ values of the minor shower radiants detected lie between $+67°$ and $-18°$. That is, they may be considered to be in the range $17{\cdot}5° \pm 50°$, the absence of radiants nearer the southern extremity being due to lack of sufficient data (observations could not be made in the southern direction because of the presence of a search light from a light house). The range cannot be extended to $17{\cdot}5° \pm 90°$ since observations were usually restricted to an area much above the horizon to avoid scattered light from the ground. Of the detected radiants, 50% have their δ values in the range $17{\cdot}5° \pm 15°$, and this verifies the expectation that most of the

minor showers will have radiants lying close to the declination value equal to the latitude of observation.

It is similarly expected that at any time of observation the minor shower radiants will lie within the range $\alpha_z \pm 50°$, where α_z is the right ascension of the zenith at that time. On a typical night of 15 October at 0100 h LT, α_z has a value of 40°, and the present observations show that 50% of the detected minor shower radiants have their α values lying in the range $40° \pm 50°$. However, on the same night α_z varies between $-5°$ at 2200 h and 85° at 0400 h LT, the period during which most of the observations were made, and, considering this variation for the whole month, the detected minor shower radiants should have their α values between $-55°$ and 135°. The actual observed values of α lie in the range $-34°$ to 177°; 18 of the 20 minor shower radiants have α values satisfying the above condition, the remaining 2 lying beyond the range on the eastern side. The α values on the western side are limited to $-34°$ because the observations on that side were restricted, owing to the presence of city lights.

The main conclusion to be drawn from this investigation is that most of the orbits of the minor meteor streams lie close to the plane of the ecliptic.

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