

Meteor stream identification: a new approach. Application to 3675 radio meteors

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Abstract. The new criterion D_N for meteoroid streams identification, based on variables directly linked to observations, was applied to a set of radio meteors observed in Adelaide. 28 streams, combining 28% of the 3675 orbits have been detected. 8 streams have a single crossing point with the Earth orbit, 20 groups were identified as twin showers.

Key words: Adelaide radio meteors – meteor streams searching

1. Introduction

An application of the new distance function D_N by Valsecchi et al. (1998) was presented recently in Jopek et al. (1998). The new metric was applied successfully to a set of 865 photographic meteor orbits and the results were compared to those obtained using the D_{SH} criterion of Southworth and Hawkins (1963). It is quite obvious that we have a strong motivation to apply the new distance function to other existing data samples; here we have chosen the radar meteors observed during the radio surveys in 1960-61 and in 1968-69 in Adelaide.

These meteors were already searched for groupings. Nilsson (1964) analyzed 2101 orbits, and Gartrell and Elford (1975) made a search using 1667 radio meteors. In the present paper we describe the results of a cluster analysis made on 3675 Adelaide radio meteors, a set obtained by combining the radio meteors used by Nilsson and Gartrell and Elford. To the best of our knowledge, searching for meteor streams in the combined sample was never done before.

2. The radio meteor data and the cluster analysis method

We obtained the Adelaide meteor data from the IAU Meteor Data Center (Lindblad, 1991) in the form of the diskette files `adelaid1.dat` and `adelaid2.dat`. We extracted from these files the apparition time, the geocentric coordinates of the radiant and the pre-atmospheric velocity, correcting for the zenith attraction, and recalculated all the orbits. We 84 rejected orbits having eccentricity $e > 1.2$, and thus obtained a subset containing 3675 orbits.

METEORIDS 1998, Astron. Inst., Slovak Acad. Sci., Bratislava, 1999, pp. 307– 310.

Table 1. Single radiant meteor streams detected in the Adelaide radio data. The second and third columns give the number of members and the shower activity dates. The next ones give the arithmetic means of the orbital elements and the radiant parameters (θ is the elongation of the anti-radiant point). The last column lists the reliability levels used to find the streams and their before-after perihelion flags. The streams names for which we did not found counterparts in Nilsson (1965) and Gartrell and Elford (1975) are marked by question marks; those marked with asterisks were never probably identified before. All angular values are given in degrees and refer B1950, q is in AU , V_G is in km/s .

Name	M	Dates	e	q	ω	Ω	i	α_R	δ_R	V_G	θ	Notes
Puppids	16	Dec 8–Dec 17	0.500.97	347	79	70		142	–54	39	117	AB99%
Carinids	6	Jan 18–Jan 23	0.540.98	4	120	75		163	–62	41	120	AB95%
*Chamaeleonids	33	Feb 11–Feb 17	0.600.94	338	145	75		207	–78	42	120	AB95%
* λ Octantids	25	Mar 12–Mar 21	0.640.95	337	177	72		327	–83	40	117	AB95%
? α Arietids	8	May 20–May 28	0.950.15	41	63	11		37	20	37	112	A 99%
? ζ Cetids	19	Jun 8–Jun 19	0.890.15	325	81	45		292	–5	37	121	B 95%
δ Aquarids	99	Jul 22–Aug 6	0.960.08	152	305	33		340	–17	40	120	B 95%
Sextantids	14	Sep 2–Sep 29	0.880.13	211	3	19		152	3	32	119	A 99%

The set of 3675 meteors was tested for stream membership by a cluster analysis program implementing a single neighbour linking technique, the algorithm applied for the very first time by Southworth and Hawkins (1963), and then extensively used by, e.g., Lindblad (1971), Gartrell and Elford (1975), Sekanina (1976) and lastly by Jopek et al. (1998). As a quantitative measure of the distance D_{kl} between two meteors (k, l) (meteor association test) we have used our new metrics D_N described in Valsecchi et al. (1998). The threshold of the association test was found by the method described in Jopek, Froeschlé (1997). We decided to accept all streams detected with the thresholds D_c for which the reliability level $W_M = 95\%$ or $W_M = 99\%$.

3. Results of the classification

At the reliability level 95% we detected 25 streams of 6 or more members, combining 35% of the 3675 meteors. In the second search at the reliability level 99%, 18 streams of 8 or more members have been detected and the stream component included 21% of the meteor sample. The cluster analysis among the 2101 radio orbits made by Nilsson resulted in the list of 61 separate radiants given by 3 or more meteors. About 25% of the meteors were associated with showers. Gartrell and Elford (1975) amongst the 1667 radio data found that 29.8% of the orbits were associated with at least two other orbits. Jointly, Gartrell and Elford listed 69 associations of 3 or more members. The percentage of stream meteors identified by our search is similar, but the number of groups is in our case much lower. In Tables 1 and 2 we list the mean parameters of the identified streams.

4. Conclusions

The results of the cluster analysis presented here are preliminary; we hereafter list some issues that we are going to verify in the next steps of our study.

- Amongst 3675 Adelaide radio meteors, 28 streams of 6 or more members were found with the D_N distance function at the reliability levels $W_M = 95\% - 99\%$, (1011 meteors, 28%).
- Only 4 streams have retrograde orbits.
- 8 streams (see Table 1) have a single crossing point with the Earth's orbit.
- The streams with radiant in the constellation of Chamaeleon and near the star λ Octantis were possibly never identified before.
- 20 groups (see Table 2) were identified as twin showers, e.g.: η Aquarids – Orionids, γ Pegasids – γ Sextantids, γ Sextantids – κ Leonis, η Ophiuchids – ϑ Cetids, ε Arietids – S.Taurids, δ Piscids – S.Arietids.
- The Geminids appear as a twin shower, with the second radiant in Aries.
- The group of 4 streams of high inclination and moderate eccentricity — Puppids, Carinids, Chamaeleonids, λ Octantids (Table 1) — looks interesting in view of the "toroidal" group of sporadic meteors mentioned by Hawkins (1962). To our knowledge, the Puppids found by Nilsson (1964) and the Carinids identified by Gartrell and Elford (1975) were the only Southern streams with orbits of the toroidal class.

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Table 2. Meteor streams with two radiant detected in the Adelaide radio data. 8 streams listed at the bottom, at the reliability level $W_M = 95\%$ coalesced into one complicated structure.

Name	M	Dates	e	q	ω	Ω	i	α_R	δ_R	V_G	θ	Notes
η Aquarids	1	Apr 13–Apr 13	0.860.41	74	22132			319	4	58 144		A 95%
Orionids	25	Oct 16–Oct 30	0.860.55	88	28158			95	13	64 155		B 95%
ω Sagittarids	5	Jun 10–Jun 17	0.950.06	158	261 40			301	−30	39 125		B 95%
? β Librids	4	Dec 14–Dec 15	0.940.09	29	261 39			230	−7	40 121		A 95%
? ψ Piscids	3	Jun 11–Jun 13	0.870.30	59	81147			16	20	58 146		A 95%
ϑ Hydrids	12	Dec 5–Dec 16	0.970.28	117	79122			128	−1	57 137		B 95%
? γ Pegasids	7	Jun 9–Jun 15	0.640.74	108	80149			360	17	62 158		A 95%
? γ Sextantids	2	Dec 14–Dec 16	0.540.68	83	82139			150	−9	59 154		B 95%
? η Ophiuchids	4	Feb 12–Feb 19	0.730.58	91	326143			258	−6	61 153		A 95%
? ϑ Cetids	2	Aug 17–Aug 20	0.750.64	82	325144			38	−3	61 153		B 95%
?Arietids	160	Jun 8–Jun 18	0.920.16	37	82 22			53	22	36 115		A 99%
Geminids	127	Dec 5–Dec 17	0.890.19	352	264 17			105	24	34 113		B 99%
Ophiuchids	25	Jun 8–Jun 19	0.780.47	100	263 4			268	−24	25 96		B 95%
Scorpid	13	Dec 5–Dec 15	0.760.47	234	69 4			248	−23	24 97		A 95%
α Aquarids	16	Mar 12–Mar 22	0.890.23	46	358 5			339	−7	32 109		A 99%
ζ, ϵ Piscids	49	Sep 22–Sep 29	0.860.29	125	2 5			17	7	30 106		B 99%
α Cancri	11	Jan 17–Jan 23	0.820.31	5	296 5			137	16	29 106		B 95%
? β Geminids	6	Jul 23–Aug 1	0.850.27	148	214 5			109	21	31 107		A 95%
ϵ Arietids	35	May 19–May 28	0.820.36	65	63 6			46	21	28 102		A 99%
S. Taurids	28	Nov 16–Nov 24	0.790.45	107	57 5			61	19	25 97		B 99%
ϑ Leonids	13	Feb 10–Feb 17	0.830.31	301	328 5			163	10	30 105		B 99%
? α Cancri	6	Aug 17–Aug 24	0.870.32	242	324 9			133	11	32 103		A 99%
? δ Piscids	12	Apr 12–Apr 30	0.820.35	63	26 9			9	11	28 103		A 99%
S. Arietids	121	Oct 16–Oct 31	0.830.34	115	28 6			40	12	28 104		B 99%
? κ Cancri	2	Jan 21–Jan 23	0.930.20	131	121 6			141	12	36 109		B 95%
? ϵ, ρ Geminids	4	Jul 24–Jul 28	0.900.24	52	122 10			107	28	33 107		A 95%
σ Sagittarids	22	Jun 7–Jun 19	0.890.24	128	261 10			283	−27	32 109		B 95%
γ Librids	7	Dec 7–Dec 15	0.880.26	49	257 9			239	−18	32 108		A 95%
? γ Sextantids	10	Feb 12–Feb 19	0.880.44	101	146 19			150	−6	30 98		B 95%
? κ Leonids	3	Aug 17–Aug 22	0.790.43	72	146 12			143	27	27 99		A 95%
α Virginids	10	Mar 14–Mar 22	0.970.14	130	178 12			199	−9	39 113		B 95%
? α Leonids	15	Sep 23–Sep 29	0.970.09	29	183 18			159	13	41 117		A 95%
ω Sagittarids	2	Feb 12–Feb 16	0.900.14	216	145 20			301	−29	34 117		A 99%
β Capricornids	3	Feb 12–Feb 19	0.930.17	43	327 13			305	−13	37 112		A 99%
β Capricornids	3	Feb 12–Feb 16	0.860.23	222	151 4			309	−21	31 110		A 99%
β Capricornids	6	Feb 12–Feb 16	0.820.34	242	144 5			314	−21	28 104		A 99%
α Aquarids	6	Aug 16–Aug 20	0.800.34	297	145 9			338	−2	27 104		B 99%
λ Aquarids	5	Aug 18–Aug 20	0.900.22	340	142 4			345	−6	33 109		B 99%
ω Piscids	9	Aug 16–Aug 24	0.940.13	323	148 27			351	7	37 116		B 99%
Aquarids-Cetids	5	Aug 18–Aug 24	0.930.13	144	327 22			357	−11	36 116		B 99%