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.

METEOROIDS 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	0.50	0.97	347	79	70	142	−54	39	117	AB99%
Carinids	6	Jan 18–Jan 23	0.54	0.98	4	120	75	163	−62	41	120	AB95%
*Chamaeleonids	33	Feb 11–Feb 17	0.60	0.94	338	145	75	207	−78	42	120	AB95%
*λ Octantids	25	Mar 12–Mar 21	0.64	0.95	337	177	72	327	−83	40	117	AB95%
?α Arietids	8	May 20–May 28	0.95	0.15	41	63	11	37	20	37	112	A 99%
?ζ Cetids	19	Jun 8–Jun 19	0.89	0.15	325	81	45	292	−5	37	121	B 95%
δ Aquarids	99	Jul 22–Aug 6	0.96	0.08	152	305	33	340	−17	40	120	B 95%
Sextantids	14	Sep 2–Sep 29	0.88	0.13	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 radiants 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.

References

Gartrell, G., Elford, W.G.: 1975, Aust. Journ. Phys., **28**, 591.
Hawkins, G.S.:1962, Astron. J., **67**, 241.
Jopek, T.J., Froeschlé, Cl.: 1997, Astron. Astrophys.**320**, 631.
Jopek T.J., Valsecchi G.B., Froeschlé Cl.: 1998, submitted to MNRAS.
Lindblad, B.A., 1971, Smith.Cont.Aph., **12**, 1.
Lindblad, B.A.: 1991, In Origin and Evolution of Interplanetary Dust, Kluwer Acad. Publishers, Levasseur-Regourd A.C. and Hasegawa H. (eds), 311.
Nilsson, C.S.:1964, Aust. Journ. Phys., **17**, 205.
Sekanina, Z.: 1976, Icarus **27**, 265.
Southworth, R.B., Hawkins, G.S.: 1963, Smith.Cont.Aph. **7**, 261.
Valsecchi G.B., Jopek T.J., Froeschlé Cl.: 1998, submitted to MNRAS.

Table 2. Meteor streams with two radiants 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 58144	A95%
Orionids	25	Oct 16–Oct 30	0.860.55 88 28158	95 13 64155	B95%
ω Sagittarids	5	Jun 10–Jun 17	0.950.06 158 261 40	301 −30 39125	B95%
?β Librids	4	Dec 14–Dec 15	0.940.09 29 261 39	230 −7 40121	A95%
?ψ Piscids	3	Jun 11–Jun 13	0.870.30 59 81147	16 20 58146	A95%
ϑ Hydrids	12	Dec 5–Dec 16	0.970.28 117 79122	128 −1 57137	B95%
?γ Pegasids	7	Jun 9–Jun 15	0.640.74 108 80149	360 17 62158	A95%
?γ Sextantids	2	Dec 14–Dec 16	0.540.68 83 82139	150 −9 59154	B95%
?η Ophiuchids	4	Feb 12–Feb 19	0.730.58 91 326143	258 −6 61153	A95%
?ϑ Cetids	2	Aug17–Aug20	0.750.64 82 325144	38 −3 61153	B95%
?Arietids	160	Jun 8–Jun 18	0.920.16 37 82 22	53 22 36115	A99%
Geminids	127	Dec 5–Dec 17	0.890.19 352 264 17	105 24 34113	B99%
Ophiuchids	25	Jun 8–Jun 19	0.780.47 100 263 4	268 −24 25 96	B95%
Scorpids	13	Dec 5–Dec 15	0.760.47 234 69 4	248 −23 24 97	A95%
α Aquarids	16	Mar12–Mar22	0.890.23 46 358 5	339 −7 32109	A99%
ζ,ε Piscids	49	Sep 22–Sep 29	0.860.29 125 2 5	17 7 30106	B99%
α Cancrids	11	Jan 17–Jan 23	0.820.31 5 296 5	137 16 29106	B95%
?β Geminids	6	Jul 23–Aug 1	0.850.27 148 214 5	109 21 31107	A95%
ε Arietids	35	May19–May28	0.820.36 65 63 6	46 21 28102	A99%
S. Taurids	28	Nov16–Nov 24	0.790.45 107 57 5	61 19 25 97	B99%
ϑ Leonids	13	Feb 10–Feb 17	0.830.31 301 328 5	163 10 30105	B99%
?α Cancrids	6	Aug17–Aug24	0.870.32 242 324 9	133 11 32103	A99%
?δ Piscids	12	Apr 12–Apr 30	0.820.35 63 26 9	9 11 28103	A99%
S. Arietids	121	Oct 16–Oct 31	0.830.34 115 28 6	40 12 28104	B99%
?κ Cancrids	2	Jan 21–Jan 23	0.930.20 131 121 6	141 12 36109	B95%
?ε,ρ Geminids	4	Jul 24–Jul 28	0.900.24 52 122 10	107 28 33107	A95%
σ Sagittarids	22	Jun 7–Jun 19	0.890.24 128 261 10	283 −27 32109	B95%
γ Librids	7	Dec 7–Dec 15	0.880.26 49 257 9	239 −18 32108	A95%
?γ Sextantids	10	Feb 12–Feb 19	0.880.44 101 146 19	150 −6 30 98	B95%
?κ Leonids	3	Aug17–Aug22	0.790.43 72 146 12	143 27 27 99	A95%
α Virginids	10	Mar14–Mar22	0.970.14 130 178 12	199 −9 39113	B95%
?α Leonids	15	Sep 23–Sep 29	0.970.09 29 183 18	159 13 41117	A95%
ω Sagittarids	2	Feb 12–Feb 16	0.900.14 216 145 20	301 −29 34117	A99%
β Capricornids	3	Feb 12–Feb 19	0.930.17 43 327 13	305 −13 37112	A99%
β Capricornids	3	Feb 12–Feb 16	0.860.23 222 151 4	309 −21 31110	A99%
β Capricornids	6	Feb 12–Feb 16	0.820.34 242 144 5	314 −21 28104	A99%
α Aquarids	6	Aug16–Aug20	0.800.34 297 145 9	338 −2 27104	B99%
λ Aquarids	5	Aug18–Aug20	0.900.22 340 142 4	345 −6 33109	B99%
ω Piscids	9	Aug16–Aug24	0.940.13 323 148 27	351 7 37116	B99%
Aquarids-Cetids	5	Aug18–Aug24	0.930.13 144 327 22	357 −11 36116	B99%