Orionid meteor stream

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Abstract. Based on data available at the IAU Meteor Data Center in Lund 60 precisely reduced photographic Orionid orbits and 17 video observed orbits are analysed. Mean photographic and video orbits are compared with the orbit of comet Halley. The Orionid meteoroid stream structure and radiant motion is studied, and compared with previous visual and photographic studies of the stream. Reports based on visual observations of a very complicated radiant structure of the Orionid stream are not substantiated.

Key words: meteoroid streams – Orionids – orbits

1. Introduction

The Orionid meteor stream is active in the period October 2 - November 7 (Cook 1973). It normally reaches a broad maximum on October 20-22 with a peak visual hourly rate of 15-30 meteors per hour. An interesting feature of the Orionid stream is its suggested association (together with the Eta Aquarid stream) with comet Halley (McIntosh and Hajduk 1983 and others).

2. History

In the catalogue of principle apparitions of meteors Quetelet (1839) listed several historical accounts of increased meteor activity in mid-October. Independently Herrick (1839, 1840) reported an increased level of meteor activity in mid-October. It is, however, not clear if these reports actually refer to the present day Oriond meteor stream. The first precise radiant determination of the Orionids was made by A. Herschel in 1864 and 1865 (Denning 1899). The derived radiant position was $\alpha = 90°$, $\delta = 15.5°$. Numerous radiant studies were made during the following decades. Denning (1876) lists an Orionid radiant observed October 18-19, 1874 with a radiant position $\alpha = 88°$, $\delta = 11°$. Denning (1918) strongly emphasized that the Orionid radiant was stationary - i.e. the radiant appeared to be stationary in (α, δ) during the entire period of shower activity. A lively debate followed in the literature (Olivier 1923, Denning 1923, Dole 1929, McIntosh 1929, Prentice 1933, 1936, 1941). The observations by Olivier, Dole, McIntosh and Prentice showed quite conclusively that a radiant motion in right ascension occurs. For details of this debate see Olivier (1925), Lovell (1954) and Kronk (1988). A list of authors dealing with the Orionid shower and its activity from 1900 to 1968 was summarized by Hajduk (1970).

An interesting feature of the Orionid shower as reported by many visual observers is the apparent complexity of the radiant. In particular van Rootsman (1930) and Prentice (1933, 1936 and 1939) have postulated a multiple radiant structure. Prentice lists three separate Orionid radiants each having its own radiant motion. He also lists different times of maximum activity for these radiants. On the other hand, Hoffmeister (1948) in his extensive studies of the major visual meteor showers finds a well defined Orionid radiant area centered at $\alpha = 93.5°$, $\delta = 15.9°$ (equinox 1925.0). In Hoffmeister's study (pp. 61, 114-115 and 274) there is only a very slight indication of a secondary radiant. A very precise set of Orionid radiants was obtained in 1911-20 by Pokrovsky (1928). Again there is no indication of a multiple radiant structure. Note that most of the above radiant positions are quoted for equinox 1925 or 1950. Hence for a direct comparison of these radiants with radiants referred to equinox 2000 add 1.05° or 0.70°, respectively, to the quoted right ascension values of the radiant.

3. Modern visual, telescopic and video observations

Observations of the Orionid meteor shower carried out by a team of visual observers at the Skalnate Pleso Observatory in 1945-50 have been analysed by Štohl and Porubčan (1981) and Porubčan and Zvolánková (1984). The observations indicate a shower maximum in the solar longitude interval $207.0° - 207.8°$ (1950.0). During the International Halley Watch (IHW) visual recordings of the Orionid shower were carried out by a world-wide network of amateur observers (Edberg et al. 1988, Porubčan et al. 1991). The IHW visual data turned out to be a very heterogeneous data sample, and numerous difficulties were encountered in the data analysis (Porubčan et al. 1991).

The return of comet Halley in 1986 caused a renewed interest in the Orionid (and Eta Aquarid) meteor streams, and a number of theoretical studies on the evolution of these streams have appeared in the literature (Babadzhanov and Obrubov 1979, Hughes 1987, McIntosh and Jones 1988) and others. These theoretical studies were based on very few photographic Orionid and Eta Aquarid meteoroid orbits.

Telescopic observations of the Orionid meteor radiant have been analysed by Znojil (1968) and Porubčan (1973). In Porubčan's study a total of 60 Orionid telescopic meteors were analysed and individual telescopic radiants were computed. A mean radiant $\alpha = 94.8°$, $\delta = 16.0°$ at solar longitude 208° (equinox 1950) was determined. There is an indication of a splitting of the telescopic radiant into two subradiants during in the initial phase of Orionid activity. The study showed that radiants of faint meteors are more dispersed than those obtained from photographic observations.

Two-station video observations of the Orionids have been reported by Hawkes, Jones and Ceplecha (1984) and de Lignie and Jobse (1995). In all 19 precisely reduced Orionid orbits have been published to date. A discussion of the video observations is given in section 9.

4. Photographic observations

The first photographic observations of the Orionid meteor shower were made at the Harvard Observatory, where three Orionids were recorded on October 20, 1922 (King 1923). A radiant position at $\alpha = 94.6°$, $\delta = 15.7°$ (equinox 1922) was determined in good agreement with A. Herschel's observations in 1864-1865. Comparatively few double station Orionid orbits were obtained during the Harvard small camera photographic meteor program in Massachusetts and during the first few years of the Super Schmidt program. In Kresák and Porubčan (1970) the Orionids were studied based on only 30 photographic orbits. With this in mind we decided to make a new study of the Orionid radiant and orbit based on all precisely reduced photographic Orionid orbits available at the IAU Meteor Data Center in Lund (Lindblad 1991, 1995, Lindblad and Steel 1994). The purpose of the study was: (1) to analyse the Orionid radiant structure and motion, (2) to study the activity profile of the stream and (3) to determine a precise mean Orionid orbit.

5. Photographic data sample and search method

The photographic orbital data available at the IAU Meteor Data Center (IAU MDC) were analysed using a computerised stream search technique based on the D-criterion of Southworth and Hawkins (1963). Southworth's stream search program performs a cluster analysis in five - dimensional q, e, i, ω, Ω space. The stream search input file PRCORB96.TMP consisted of 4456 precisely reduced orbits observed in the period 1936 to 1993. The data were searched for streams at the D-criterion rejection level $D_s = 0.09$. The correct D_s value to be used in a sample of N meteor orbits is approximately given by the formula $D_s = 0.80\, N^{-1/4}$ (Lindblad 1971). A total of 66 Orionid orbits were identified by the computer search. All Orionids appeared in the period October 2-29, with 63 appearing in the interval October 16-29. A preliminary mean orbit for the Orionids was derived by the computer program. Individual Orionid orbits were next checked to see if they deviated from the mean orbit by more than 3σ in any of the orbital elements. The four deviating cases were meteors 11042 (229P), 22931 (104C), 027 (019O) and 113 (057N) which subsequently were rejected. In addition, we rejected two MORP orbits 035I and 113I. These orbits were included in the 1990 version of the IAU MDC MORP file, but were not included in the final MORP publication by Halliday, Griffin and Blackwell (1996). The final set of 60 photographic Orionid orbits is listed in chronological order in Table 1. A mean Orionid orbit derived from this set is shown in Table 3.

Table 1. Orbital elements and encounter data for photographic Orionids (1950.0). Vg and Vh in km s^{-1}, q in AU and 1/a in AU^{-1}.

No	Y	M	Day	α (°)	δ (°)	Vg	Vh	q	1/a	e	i (°)	ω (°)	Ω (°)	Publ no.
22851	59	10	7.01	84.6	14.3	67.19	40.86	.715	.1163	.917	162.4	66.1	12.9	103C
12116	58	10	10.40	86.1	14.7	67.41	41.63	.668	.0474	.968	162.6	70.9	16.5	308P
12149	58	10	16.41	89.7	15.2	67.35	42.24	.610	-.0071	1.004	163.0	77.0	22.4	313P
372	64	10	17.06	92.3	16.0	67.20	41.50	.634	.0704	.955	164.9	75.2	23.5	088O
93010	93	10	18.08	91.4	15.4	67.53	42.31	.613	-.0103	1.006	163.5	76.5	24.1	351B
93011	93	10	18.13	91.6	14.9	66.68	41.52	.604	.0646	.961	162.3	78.7	24.1	352B
89	58	10	18.92	93.4	16.5	67.70	42.00	.635	.0215	.986	166.0	74.4	24.9	076O
93012	93	10	18.96	92.1	15.3	66.20	41.15	.584	.0993	.942	162.9	81.5	25.0	353B
93013	93	10	19.06	92.4	15.0	67.31	42.17	.609	.0036	.998	162.6	77.1	25.1	354B
93014	93	10	19.07	92.6	15.3	66.72	41.50	.602	.0663	.960	163.2	78.9	25.1	355B
2664	50	10	19.37	93.1	15.8	66.77	41.44	.607	.0701	.957	164.3	78.4	25.4	162W
9097	53	10	19.42	93.3	15.8	64.24	39.09	.553	.2836	.843	163.6	88.4	25.6	270H
2633	50	10	19.50	92.6	15.7	66.34	41.27	.585	.0861	.950	163.8	81.2	25.5	160W
12229	58	10	20.47	94.4	16.1	67.06	41.67	.610	.0493	.970	164.9	77.6	26.4	323P
257	79	10	20.75	91.7	14.2	67.40	43.00	.575	-.0801	1.046	160.6	80.0	26.3	122N
110	77	10	20.77	94.9	15.3	64.50	38.90	.574	.3012	.827	162.7	86.4	26.9	054N
84005	84	10	20.96	93.5	15.4	66.61	41.81	.569	.0384	.978	163.1	82.3	27.3	032B
85028	85	10	21.13	94.2	15.4	67.72	42.61	.606	-.0370	1.022	163.6	76.9	27.2	060B
14911	66	10	21.32	93.5	15.4	67.08	42.23	.582	-.0038	1.002	163.1	80.2	27.2	208S
12255	58	10	21.34	95.7	15.8	66.81	41.30	.616	.0839	.948	164.5	77.5	27.3	325P
5006	52	10	21.35	96.0	16.0	66.98	41.49	.614	.0667	.959	164.8	77.4	27.8	344J
12358	58	10	21.37	95.3	15.8	64.31	39.08	.557	.2855	.841	163.7	87.9	27.3	333P
5015	52	10	21.38	95.2	16.2	66.66	41.44	.589	.0719	.958	165.1	80.5	27.8	277H
5039	52	10	21.44	95.5	15.7	66.73	41.47	.599	.0690	.959	164.0	79.3	27.8	278H
21001	92	10	21.69	94.7	15.6	66.77	41.75	.583	.0449	.974	163.7	80.8	27.9	046T
111	77	10	21.70	95.2	15.2	67.20	41.60	.611	.0540	.967	163.2	77.6	27.8	055N
89	76	10	21.71	95.4	14.6	64.70	39.40	.566	.2564	.855	161.4	86.3	28.1	037N
112	77	10	21.73	94.7	15.2	66.50	41.30	.588	.0902	.947	162.9	80.9	27.8	056N
22053	62	10	21.80	94.3	15.5	66.30	41.40	.571	.0820	.953	163.2	82.8	28.1	058D
21415	82	10	21.90	93.9	15.3	65.10	40.40	.541	.1695	.908	162.4	87.5	27.7	112D
342	62	10	21.92	92.6	16.0	69.20	44.60	.588	-.1792	1.110	164.4	77.2	27.9	064O
361	63	10	22.05	95.8	15.5	63.60	38.30	.546	.3559	.806	163.1	90.7	27.7	077O

Table 1. -continued

No	Y	M	Day	α (°)	δ (°)	Vg	Vh	q	1/a	e	i (°)	ω (°)	Ω (°)	Publ no.
90013	90	10	22.10	94.6	16.1	66.40	41.40	.571	.0777	.956	164.5	82.7	27.9	169B
5079	52	10	22.32	96.3	15.8	66.60	41.37	.592	.0789	.953	164.3	80.2	28.8	350J
5083	52	10	22.34	94.0	16.0	66.07	41.65	.533	.0528	.972	163.8	86.7	28.8	351J
5101	52	10	22.38	95.8	15.7	66.26	41.25	.574	.0895	.949	163.8	82.5	28.9	352J
5102	52	10	22.40	95.1	16.2	66.72	41.86	.567	.0330	.981	164.8	82.5	28.8	281H
5112	52	10	22.43	94.5	16.6	66.50	41.85	.546	.0340	.981	165.5	84.9	28.9	353J
466	87	10	22.77	94.5	16.8	65.80	41.00	.546	.1153	.937	165.9	86.2	28.3	212N
16991	58	10	23.08	94.9	15.7	68.18	43.47	.583	.0010	1.000	164.0	78.5	29.0	076C
7	58	10	23.09	94.7	17.3	69.40	44.50	.590	.0010	1.000	167.4	76.0	29.0	007E
21	68	10	23.09	94.3	17.6	66.26	41.79	.521	.0417	.978	167.3	87.9	29.5	021E
1382	46	10	23.29	95.4	15.5	65.18	40.50	.537	.1582	.915	162.9	87.8	29.3	124W
5145	52	10	23.33	96.7	16.4	66.84	41.73	.580	.0451	.974	165.4	81.0	29.7	283H
5163	52	10	23.38	95.2	16.3	68.31	43.66	.574	-.1406	1.081	165.2	79.3	29.8	284H
5165	52	10	23.38	96.8	17.1	66.91	41.75	.578	.0439	.975	166.9	81.2	29.8	285H
5183	52	10	23.45	96.7	15.6	67.32	42.31	.590	-.0091	1.005	164.0	79.2	29.8	286H
5185	52	10	23.46	94.8	16.9	65.55	41.17	.511	.0983	.950	165.7	89.9	29.8	287H
5208	52	10	23.49	96.1	15.7	66.32	41.58	.557	.0594	.967	163.7	83.9	30.0	290H
5210	52	10	23.50	97.0	15.8	67.44	42.30	.596	-.0089	1.005	164.5	78.4	30.0	291H
32943	63	10	23.94	96.3	15.5	66.90	41.90	.583	.0357	.979	163.6	80.7	29.6	059D
344	62	10	23.96	93.0	16.3	68.20	43.70	.532	-.1401	1.070	164.3	84.1	30.0	066O
889	39	10	24.40	96.3	15.6	65.82	41.12	.548	.1016	.944	163.4	85.7	30.2	125W
5268	52	10	24.42	95.4	16.9	65.88	41.63	.508	.0551	.972	165.7	89.5	30.8	295H
7613	76	10	25.32	99.2	16.1	65.10	39.90	.558	.2174	.879	164.8	86.4	31.7	013G
11123	57	10	25.34	97.9	15.3	64.07	39.41	.518	.2590	.866	162.4	91.9	31.5	243P
11127	57	10	25.38	97.3	15.5	66.89	42.27	.558	-.0045	1.002	163.4	82.9	31.6	244P
105	79	10	26.05	97.1	15.5	64.90	40.50	.520	.1667	.910	162.9	90.0	31.6	105E
107	79	10	28.15	97.3	16.0	65.60	41.80	.490	.0010	1.000	163.6	92.0	33.7	107E
28	57	10	29.10	100.1	16.2	66.20	41.90	.518	.0394	.980	164.8	88.1	35.3	020O

Alphabetical code for investigator or network:
B - Betlem (DMS), C - Ceplecha, D - Dushanbe, E - European fireball network,
F - Prairie Network, G - Gale Harvey, New Mexico Univ., H - Hawkins and Southworth,
I - MORP Network, J - Jacchia, K - Kiew, N - Nippon Meteor Society, O - Odessa,
P - Posen and McCrosky, S - Shao and McCrosky, T - Tokyo Network, W - Whipple.

6. Orionid activity profile

In general the activity curve of bright photographic meteors will delineate the activity profile of a meteor stream with high accuracy. In Fig. 1 the number of photographed Orionid meteors is plotted versus solar longitude. A step length of 1.0° in solar longitude (equinox 1950) is used. The histogram is based on a total of 60 bright Orionids photographed in the period 1946 to 1987 from in all 10 different meteor networks. It follows from the world-wide coverage and long-term nature of this photographic collection that the derived activity curve of the shower is independent of local weather and lunation effects.

The magnitude interval of the photographed Orionids (40 Orionids with listed magnitudes) is -8.3 to +1.6, with a mean magnitude of -2.0. The median values of magnitudes from the ascending, maximum and descending period of activity (here defined as ascending node intervals of approximatelly equal number of Orionids, corresponding to $\Omega \doteq$ 12-27, 27-29 and 29-34) are -3.0, -1.2 and -1.9, respectively.

¿From Fig. 1 we note that the activity profile of bright Orionids is slightly asymmetric with highest rates occurring in the solar longitude interval $208° - 210°$ (equinox 1950). There is also a central dip at shower maximum. Similar results have been reported by McIntosh and Hajduk (1983). The central dip at the maximum of the stream (in case of the Eta Aquarids) was firstly recognized by Hajduk (1980). A weighted mean of the three highest rate values in Fig.1 indicates a shower maximum at solar longitude 208.9° (equinox 1950).

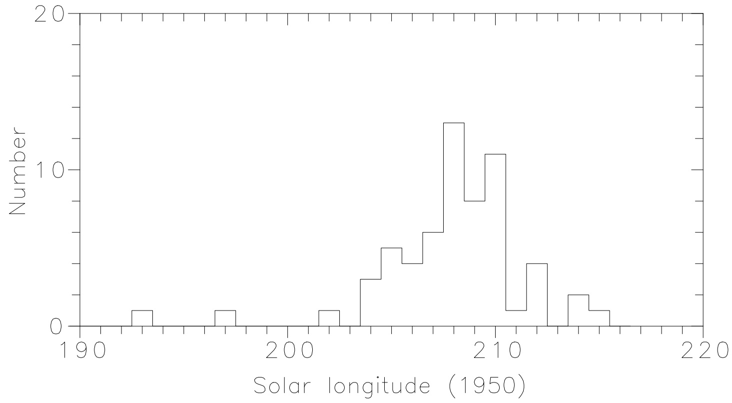

Figure 1. Number of photographic Orionids versus solar longitude (1950.0)

7. Radiant motion and structure

The distribution of 60 photographic Orionid radiant points is plotted in the scatter diagram in Fig. 2 (designated by asterics). Radiant activity is first detected on October 7 at approximately $\alpha = 84.5°$, $\delta = 14.5°$ and ends on October 29 at $\alpha = 100.0°$, $\delta = 16.0°$. The derived radiant motion found by a least square fit is

$$\alpha = 94.64^o + 0.694^o\ (\odot - 208.0^o) \qquad (1)$$

$$\delta = 15.79^o + 0.093^o\ (\odot - 208.0^o) \qquad (2)$$

where $\odot$ is the date measured in degrees of solar longitude at the time of observation and referred to the equinox of 1950.0. In order to investigate the radiant area of the Orionid shower the positions of individual radiants in Fig. 2 must be corrected for radiant motion, i.e. reduced to a common solar longitude corresponding to shower maximum. The result using eqs. (1) and (2) is shown in Fig. 3. The size of the radiant area is estimated to be about 5° x 4°.

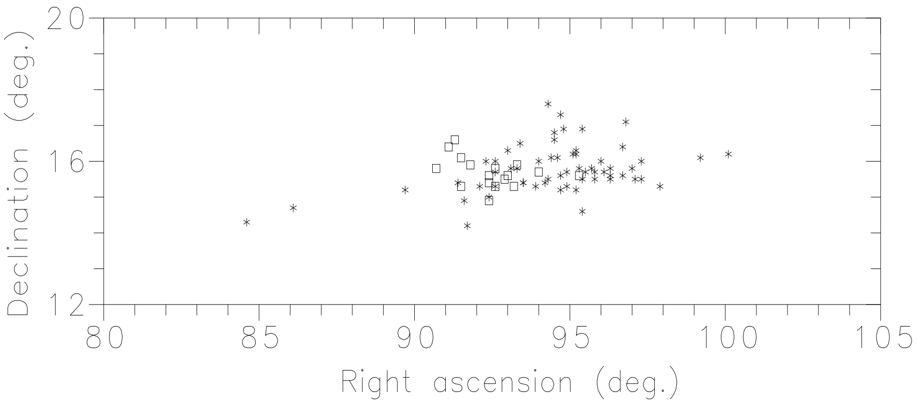

Figure 2. Distribution of Orionid radiant points (1950.0)

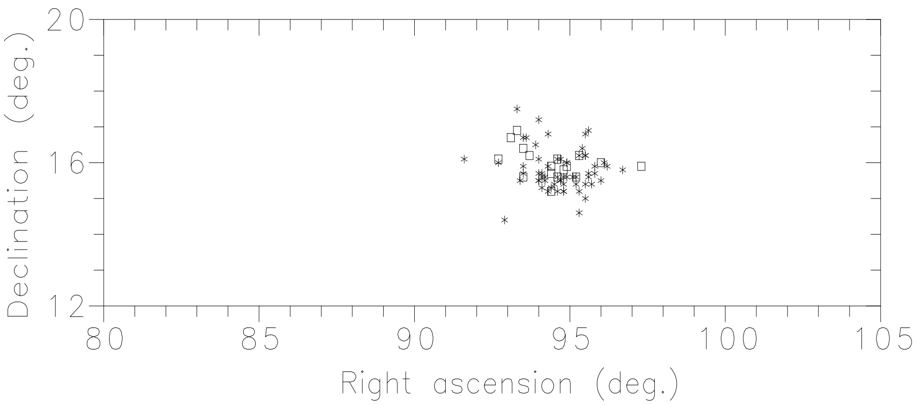

Figure 3. Radiant positions reduced to solar longitude at maximum

In Fig. 2, we have included 17 video Orionid radiants (designated by open squares). The video Orionid radiants represent faint meteors and they are recorded during one single night (October 19). Inspection of Fig. 3, where all photographic and video Orionid radiant positions are reduced to a common solar longitude of 208°, using eqs. (1) and (2), shows that the video radiants are very well consistent with the radiants of bright photographic meteors.

In his study of the Orionid radiant Prentice (1936) lists three separate subradiants, each of which he claims to show an individual radiant motion. We have not been able to find any support for these claims in the photographic data sample. In particular Prentice's first radiant is completely absent in our data.

8. Orbit from photographic observations

The distribution in reciprocal semi-major axis of the 60 photographic and 17 video Orionids is shown in Fig. 4. We note that there are in all 12 meteors with negative values of $1/a$. We consider these negative $1/a$ values to represent the error tail of a Gaussian distribution. To what extent these errors are of an observational nature or are of a "cosmic" nature (i.e. represent very perturbed Orionid orbits) we do not know. The mean stream orbit derived from the 60 photographic Orionids is listed in Table 3 together with the orbit of Comet Halley and mean orbit of the Eta Aquarids derived by Lindblad et al. (1994). It is obvious that the current orbit of the Orionid meteor stream differs somewhat from the comet's orbit. In particular there is a displacement of the longitude of perihelion π by about 60°. This discrepancy has been noted by numerous researchers (Porter 1952, McIntosh and Hajduk 1983 and others). Porter considered this discrepancy so large that he doubted that there was a generic relation between the orbit of Halley's comet and the orbit of the Orionid stream. However, the agreement in several of the orbital elements (in particular the eccentricity and inclination) is very good and does support the believe that comet Halley is indeed the progenitor of the Orionid stream.

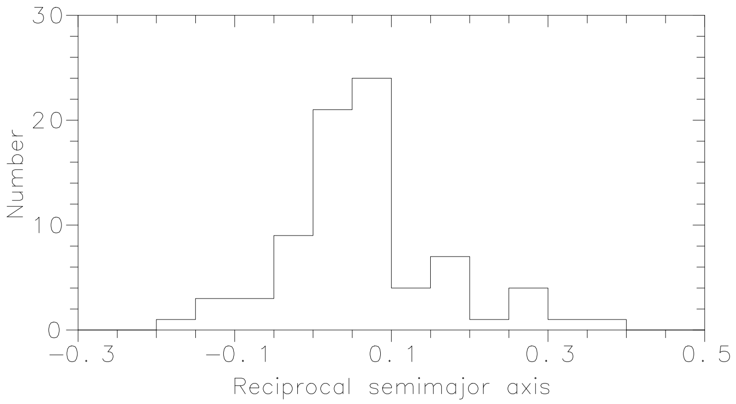

Figure 4. Distribution of reciprocal semi-major axis (AU^{-1}) for 60 photographic and 17 video Orionids

9. Orbit from video observations

The advent of comparatively inexpensive low-light level TV-systems has made it possible for both professional and amateur groups to make precise video observations of meteors. At present there exists at the IAU MDC a file of 1425

Table 2. Orbital elements and encounter data for video Orionids (1950.0). Vg and Vh in km s^{-1}, q in AU and 1/a in AU^{-1}.

No	Y	M	Day	α (°)	δ (°)	Vg	Vh	q	1/a	e	i (°)	ω (°)	Ω (°)	Publ no.
93219	93	10	19.04	93.9	15.3	66.7	41.3	0.616	0.0836	0.949	163.4	77.6	25.8	076Y
93220	93	10	19.05	96.0	15.6	67.9	41.7	0.677	0.0441	0.970	164.6	69.5	25.8	077Y
93227	93	10	19.07	93.1	15.6	66.3	41.2	0.589	0.0987	0.942	163.7	80.9	25.8	081Y
93232	93	10	19.07	93.3	15.3	68.2	42.9	0.626	-0.0696	1.044	163.5	74.2	25.8	085Y
93235	93	10	19.07	91.4	15.8	65.0	40.5	0.526	0.1626	0.914	163.3	89.3	25.8	087Y
93236	93	10	19.08	92.2	15.3	67.8	42.9	0.596	-0.0674	1.040	163.1	77.7	25.8	088Y
93237	93	10	19.08	94.7	15.7	67.5	41.8	0.643	0.0407	0.974	164.5	73.7	25.8	089Y
93239	93	10	19.08	93.1	15.4	65.2	40.1	0.567	0.1916	0.891	162.9	85.0	25.8	090Y
93244	93	10	19.08	91.8	16.4	66.0	41.2	0.552	0.0926	0.949	164.8	85.1	25.8	093Y
93250	93	10	19.10	92.0	16.6	66.9	42.0	0.570	0.0183	0.990	165.6	81.9	25.8	097Y
93254	93	10	19.10	93.3	15.8	68.0	42.6	0.620	-0.0420	1.026	164.5	75.2	25.8	101Y
93256	93	10	19.10	92.2	16.1	66.3	41.4	0.567	0.0758	0.957	164.4	83.2	25.8	102Y
93259	93	10	19.11	94.0	15.9	65.6	40.1	0.591	0.1934	0.886	164.2	82.3	25.8	104Y
93267	93	10	19.13	93.1	14.9	68.4	43.3	0.627	-0.1012	1.064	162.8	73.6	25.8	108Y
93279	93	10	19.14	93.6	15.5	67.5	42.2	0.619	0.0031	0.998	163.9	76.0	25.9	116Y
93285	93	10	19.18	93.7	15.6	67.1	41.8	0.613	0.0407	0.975	163.8	77.3	25.9	120Y
93286	93	10	19.18	92.5	15.9	65.7	40.8	0.559	0.1350	0.925	163.9	85.0	25.9	121Y

Alphabetical code for investigator or network:
Y - Dutch Meteor Society (de Lignie and Jobse, 1995)

meteoroid orbits determined by video techniques (Lindblad 1999). A computer search in this file produced 19 orbits which were classified as Orionid meteors. Two of these orbits (observed on October 29) deviated from the mean by 3σ in the inclination and were subsequently rejected. Table 2 lists the 17 accepted Orionid orbits. In order to compare the video and photographic data the individual video orbits in Table 2 were reduced to the 1950 equinox.

The mean video orbit derived from Table 2 is compared in Table 3 with the photographic orbit. There is good agreement in most of the orbital elements. However, the mean video orbit is of slightly longer period than the photographic orbit. If this difference is due to smallness of sample or if the correction to pre-atmospheric velocity v_{inf} used for the reduction of the video meteors is inaccurate, is difficult to say. One should note that a very small inaccuracy in the assumed correction for atmospheric deceleration of a high velocity meteor is sufficient to transform the orbit from a long period orbit into a hyperbolic orbit.

10. Radar studies

Although not germaine to the main objective of the present paper a few words may be said about radar studies of the Orionid meteor stream. Gartrell and

Elford (1975) detected the Orionid stream in their observations during October 1969. Their mean orbit is listed in Table 3. We note that the agreement with the photographic orbit is very good. However, Gartrell and Elford also list a hyperbolic "branch" of the Orionids. The separate listing of hyperbolic Orionids is most likely an artifact of the computer stream search program. Sekanina (1976) has published a mean Orionid orbit based on radar data obtained during the Harvard radio meteor program 1961-65 (Table 3).

Table 3. Mean Orionid orbits (1950.0)

Name	α	δ	Vg	Vh	q	$1/a$	e	i	ω	Ω	N
Orionids (photogr.)	94.5	15.8	66.52	41.53	.576	.0689	.961	164.0	81.9	27.7	60
Stand. dev.	2.6	.7	1.16	1.20	.039	.1014	.057	1.3	5.2	3.4	
Orionids (video)	92.5	15.7	66.83	41.64	.598	.0529	.970	163.9	79.3	25.1	17
Stand. dev.	1.1	.4	1.08	.96	.038	.0899	.052	.7	5.3	.0	
Orionids (radar) (Gartrell and Elford 1975)	95	14	67*	-	0.65	0.14	0.85	161.8	76	24	6
Orionids (radar) (Sekanina 1976)	94.6	16.1	64.6	39.3	.562	.2597	.854	164.4	87.0	27.1	17
Eta Aquarids (Lindblad et al. 1994)	336.4	-1.8	65.4	40.8	.568	.1082	.940	164.0	95.6	43.9	17
1P/Halley (1986 III)	337.6	-.5	65.90		.582	.0550	.967	162.2	111.8	58.1	

* - listed velocity is V_{inf} N - number of orbits

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