STATISTICAL CHARACTERISTICS OF HYPERBOLIC ORBITS METEORS

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ABSTRACT. We present statistical data on the distribution of orbital elements and parameters of interstellar sporadic hyperbolic meteors. We show that for some of them there is a proximity of their orbits with the Earth's orbit that can be interpreted as evidence of an existence of their interstellar origin.

Key words: meteor, orbit, hyperbolic, distribution.

In the Catalogues of Meteor Orbits (Dutch Meteor Society, photographic- and video- database from 1982 up to 2000 (Betlem, *photo@dms.web.org*; Lignie, *video@dmsweb.org*)) and MSSWG (the Meteor Science Seminar Working Group) Meteoroids Orbits (multi-station) from Yoshihiko Shigeno (photographic and TV-observations from 1953 up to 2003 (Shigeno, *cyg@nikogw.nikon.co.jp*), there are nearly 3% and 2% hyperbolic orbits of sporadic meteors respectively.

In order to reveal the peculiar characteristics of the interstellar meteors, their orbital elements and parameters of their interstellar motion have been studied by us.

Heliocentric velocity of these meteor particles slightly exceeds a parabolic limit. For 80% of meteors the excess of heliocentric velocity $dV_{\rm h} = V_{\rm obs} - V_{\rm par}$ is less than 2 km s^{-1}. Here $V_{\rm obs}$ and $V_{\rm par}$ are the observed and parabolic velocities of a meteoric particle at a distance r from the Sun ($r \sim 1$ a.u.). For a number of meteor orbits a maximum of observed distribution of their eccentricities falls within interval $e = 1.00 - 1.06$ (68%) It is demonstrated in Fig. 1. Distribution of a perihelion distance q, has a distinct maximum for $q = 0.9 - 1.0$ a.u. that is consistent with a probability maximum for meteor detecting. The second less expressed maximum is seen at $q = 0.3 - 0.4$ a.u. (about 10%, see Fig. 2).

The orbital inclination i, heliocentric interstellar velocity of a meteoric particle $V_{\rm o}$, heliocentric ecliptic coordinates of interstellar radiants λ_r, β_r and distance D of a hyperbolic orbit asymptote from the reference point are parameters of interstellar motion of a meteoric particle.

The inclination i varies from 120° to 160° for nearly 60% of hyperbolic meteors (Fig. 3). In this way their

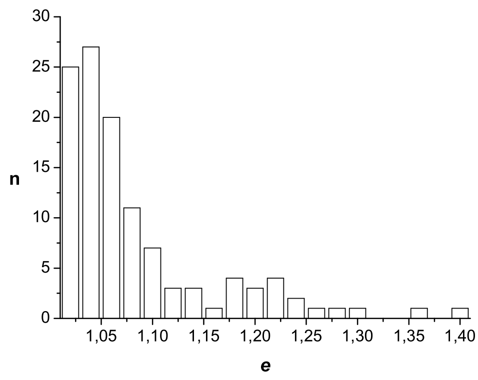

Figure 1: Distribution of the hyperbolic meteors eccentricities e.

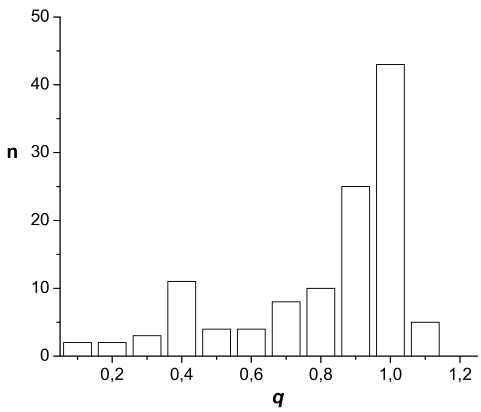

Figure 2: Distribution of the hyperbolic meteors perihelion distances q, a.u.

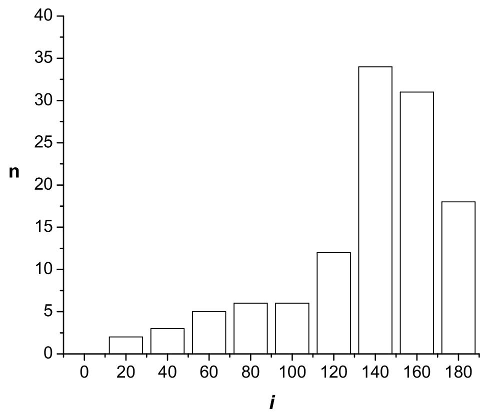

Figure 3: Distribution of the hyperbolic meteors inclinations of their interstellar trajectory i, deg.

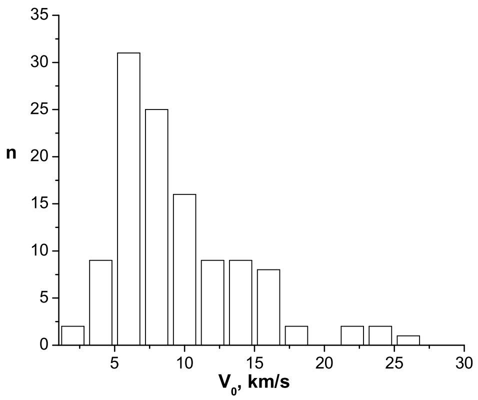

Figure 4: Distribution of hyperbolic meteors interstellar velocity $V_{\rm o}$.

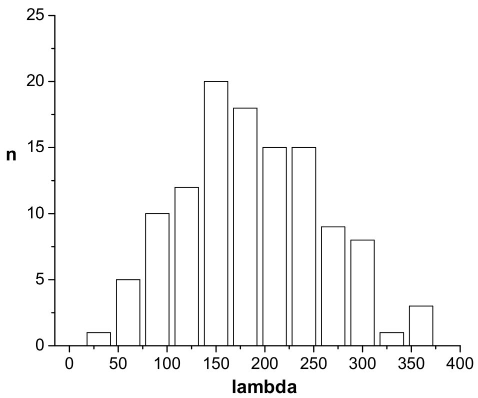

Figure 5: Distribution of ecliptic longitude λ, deg of interstellar radiants of hyperbolic meteors.

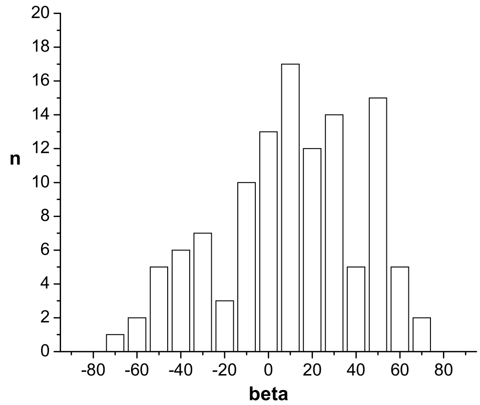

Figure 6: The same as Fig. 5 but for latitude β, deg

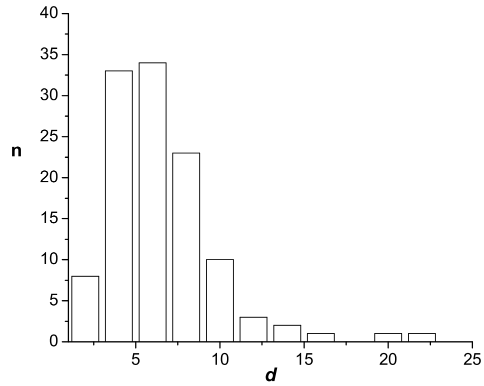

Figure 7: Distribution of hyperbolic meteors distance of asymptote from the Sun d, a.u.

orbits differ from elliptical orbits of sporadic meteors. About a half of meteor particles move at velocity $V_{\rm o}$ ranging from 4 to 8 km s^{-1} (Fig. 4). An increased concentration of interstellar radiants is observed within the region between longitudes λ_r from 90° to 240° (75%) and between latitudes β_r from $-10°$ to 50° (65%) (Figs. 5–6) that agrees with similar distributions for typical hyperbolic orbit meteors ($dV_{\rm h} > 5$ km s^{-1}) (Kramer et al., 1998). Distribution of d value has a clear maximum between 2 and 8 a.u. (80%) (Fig. 7).

Note: r_2 (+) – the approach of meteoric particle orbit with the Earth's orbit occurred in the descending node. dr(-) – an encounter of a meteor particle with the Earth took place before its passing through the perihelion.

We also determined the necessary conditions for hyperbolic orbits of sporadic meteors to approach the Earth's orbit. Approximately 25% of the meteor orbits do not cross the ecliptic plane. For 65% of meteor par-

Table 1: Observations

Date	e	q, a.u.	i	$dV_{\rm h}$, , km s^{-1}	$V_{\propto}$, km s^{-1}	λ_r	β_r	$d, a.u.$	r_2	dr
1994.03.06	1.217	0.292	44	7.2	25.6	136.2	25.9	0.9	+	–
1994.03.06	1.054	0.040	23	12.4	34.7	155.7	4.2	0.2	+	–
1996.04.22	1.008	0.497	152	0.2	3.7	294.2	27.2	7.9	+	–
1996.04.22	1.010	0.490	125	0.3	5.0	281.1	53.5	5.9	+	–

ticle orbits such an approach occurs in the descending node, and in most cases (70%) just before the meteor particle passes through the perihelion. This appears to be in a good agreement with the conclusions made in work (Kramer & Smirnov, 1999) for hyperbolic meteors with $dV_{\rm h} > 5$ km s^{-1}, and with the similar results obtained by us for hyperbolic meteor particles $dV_{\rm h} > 5$ km s^{-1} using the catalogue of transplanetary radiants (Kramer et al., 1986) based on

1) *photographic method*. 73% of meteor particles encounter with the Earth in the descending node, while for 80% of meteor paricles such encounter takes place just before perihelion;

2) *radio observations*. 67% of meteor paricles encounter with the Earth in descending node, while for 70% of meteor paricles this happens before perihelion.

According to the work (Kazantsev, 1998), some interesting hyperbolic orbits of sporadic meteor particles are given in Table 1.

As is seen from the Table 1, particles 3 and 4 have their e and q similar to those of interstellar meteors. They have been observed in the direction of the solar apex ($\lambda = 270°$, $\beta = 53°$). Thus, the given statistical characteristics of hyperbolic orbits of sporadic meteors, the heliocentric velocity of which only slightly exceeds the parabolic limit, clearly testifies their interstellar origin.

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