ABOUT DISTRIBUTION AND ORIGIN OF THE PECULIAR GROUP OF SPORADIC METEORS

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ABSTRACT

A particular group of sporadic meteors are picked out from analysis of meteor catalogues derived from results of radar observations in Mogadisho and Kharkov. The semi-major axes are equal or more than 1.73 AU and inclinations of orbits are equal or more than 90° for these meteors. The distributions of radiants, velocities and elements of orbits were derived. The probable source of meteor bodies of this peculiar group is the long-period comets, in particular, the comets of the Kreutz’s group.

INTRODUCTION

The multi-mode character of the distributions of heliocentric radiants and velocities of sporadic meteoroids follows from analysis of meteor observational data (Andreev, Belkovich, 1987). This fact points to a complicated structure of the sporadic meteoroid complex. It in turn is the consequence of the plurality of parent bodies and origin mechanisms of meteoroids. The perturbing action of the planet and nongravitational forces influence on the structure of meteoroid complex. The analysis also shows presence of the meteoroids at orbits which have not analogues among another Solar system bodies.

METHOD OF REDUCTION OF OBSERVATIONAL DATA

Let us try to take into account these facts at least roughly and for large meteoroids (Andreev, 1988). In the present time comets and asteroids are considered as main sources of meteoroids. The difference in point of views on the problem consists in the estimation of the relative contribution these sources (Kresak, 1967). Jupiter is the main perturbing body in the Solar system. The circular restricted three-body problem is the simplest dynamical framework allowing to take into account the principal perturbational influence of Jupiter. In our case that is the system of three bodies: Sun, Jupiter and a particle (Kresak, 1969, 1972, 1979).

On this base we represent the whole sporadic meteoroid complex as the aggregate of several groups of meteoroids. Every group is determined by the value of Tisserand’s invariant

\[ T = a^{-1} + 2A_j^{-3/2} \sqrt{a(1-e)} \cos i, \]

and the inclination of the meteoroid orbit i to the ecliptic. In the equation \( A_j \) is the Jupiter’s semi-major axis, \( a \) and \( e \) is meteoroid semi-major axis and eccentricity respectively.
Groups of meteoroids are determined as follows:

Group I: $T < T_0$ - meteoroid orbits are similar to comet ones,

Group II: $T \geq T_0$, $i < 90^\circ$ - meteoroid orbits are similar to asteroid ones,

Group III: $T \geq T_0$, $i \geq 90^\circ$ - this type of orbit absents among the orbits of small bodies.

Where $T_0$ is equal to 0.5767.

From investigation of the comet orbit distribution on value of $T$ from Marsden’s catalogue for 1979 year it follows that almost all long-period and parabolic comets have $T < 0.36$. This value of $T$ have been taken for determination of two components of group I. Meteoroids whith $T > T_0 \geq 0.36$ are related to subgroup Ib. And meteoroids whith $T < 0.36$ are related to subgroup Ia.

Let us to carry out the analysis of the meteoroid orbits of the third group. The semi-major axes are less than 1.73 AU and inclinations are large than $90^\circ$ for meteoroid orbits from this group.

The investigation of the similar orbits had been carried out by Jones et al (1985) from television observations of meteors.

RESULTS

The reduction of 12 catalogues available on magnetic tapes of Lund Data Center shows that the number of such meteors increase then the masses of the meteoroids decrease.

Table 1. Data on catalogues and number of meteors with peculiar orbits

<table>
<thead>
<tr>
<th>Name of catalogue</th>
<th>$N_{\text{tot.}}$</th>
<th>$N_{\text{III}}$</th>
<th>$n$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HARPHOT</td>
<td>1006</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>MCRDSKY</td>
<td>1989</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>FIREBAL</td>
<td>359</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>SOVPHOT</td>
<td>551</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>TVJONES</td>
<td>434</td>
<td>53</td>
</tr>
<tr>
<td>6</td>
<td>HAR6165</td>
<td>18453</td>
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<td>7</td>
<td>HAR6869</td>
<td>19219</td>
<td>1773</td>
</tr>
<tr>
<td>8</td>
<td>OBNINSK</td>
<td>8424</td>
<td>1553</td>
</tr>
<tr>
<td>9</td>
<td>KHARKOV</td>
<td>5114</td>
<td>1622</td>
</tr>
<tr>
<td>10</td>
<td>ADE6061</td>
<td>2040</td>
<td>87</td>
</tr>
<tr>
<td>11</td>
<td>ADE6869</td>
<td>1414</td>
<td>146</td>
</tr>
<tr>
<td>12</td>
<td>MOGADIS</td>
<td>5180</td>
<td>845</td>
</tr>
</tbody>
</table>

$\Sigma = 8234$
In the table \( N_{\text{tot.}} \) is the number of sporadic meteors in the
catalogue, \( N_{\text{III}} \) is the number of meteors of the third group in the
catalogue, \( \Sigma \) is the total number of meteors of the third group in
all catalogues, \( n = \frac{N_{\text{III}}}{N_{\text{tot.}}} \) for the catalogue, per cent.

The catalogue of the sporadic meteors is a result of
extraction of meteors of six meteor showers: Lirids, \( \eta \)-Aquarids,
Perseids, Orionids, Leonids and Geminids. The value of \( D \) is equal
or less than 0.2 is the criterion of belonging to a meteor shower
(Southworth, Hawkins 1967).

Catalogues with the numbers from six to eleven will be
considered only in the analysis because of sufficient quantity of
the third group meteors.

Data on meteoroids with the smaller masses are presented in
the KHARKOV catalogue and meteoroids with the greatest masses are
in the MOGADIS catalogue. It is follows from the comparison of
the distributions of pre-atmospheric velocities, heliocentric
velocities and radiants, Tisserand’s invariants, and orbital
elements a, e, q, and i for these two catalogues that character of
semi-major axis and eccentricity distributions depends on
meteoroid masses. The dependence corresponds to the scheme of the
Pointing-Robertson effect. In this point of view one can note that
this effect does not influence on orbital inclination and the
distributions of inclination angles have practically similar shape
for the meteoroids of the third group in all catalogues.

Analyses of the observational bias due to intersection
probability of the Earth’s orbit by meteoroids with orbits
satisfied to conditions
\[
a \cdot (1 - e) \leq 1 \text{ AU} \leq a \cdot (1 + e).
\]

had been carried out.

In the present time we do not know the evolutional mechanisms
drastically changing orbital inclinations except close encounters
with the major planets. Therefore it is naturally to look for the
parent bodies for these meteoroids among small bodies already
moving on orbits with inclinations greater than 90°. These small
bodies known now are comets.

Mechanism of the origin of meteoroids is the desintegration
process of comets during their perihelion passage. According to
Whipple’s model of comet nucleus velocities of ejected meteoroids
are the large the less masses of particles. It is evidently that
the larger velocities of ejected particles the larger deviations
of meteoroid orbits from comet’s one. These deviations only can
form orbits with small semi-major axes similar to ones for
considered meteoroids.

CONCLUSION

Analyses of desintegration processes during perihelion
passage on Sekanina’s scheme (Sekanina, 1967) shows that the third
group meteoroids can be formed by desintegration of nucleus of
long-period and parabolic comets with very small perihelion distances. The Kreutz' group comets are likely the main contributor.

REFERENCES


