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The comet disintegration and meteor streams

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The possibilities for disintegration of a nucleus of comets by collision with some meteoroid streams, predicted by one of authors (Guliyev, 2010) are considered in three zones of the Solar System. A list of disintegrating comets consisting of 118 cases has been made by the authors. The list contains data about observed cases of comet splitting, comet twins, and data about disappeared comets. Testing the comet parameters by applying the methods of mathematical statistics confirms the hypothesis underlying this article. The frequency of passing through the three zones where there might be a collapse of a proto-comet is rather high for the proto-comets of the Sun-graser group. The results of the statistical analysis of comet outbursts yields additional arguments in favor of our hypothesis.

1 Introduction

The splitting of a comet nucleus is a common phenomenon in the Solar System. There are several hypotheses in the astronomical literature explaining this phenomenon. However, there is no generally accepted theory regarding to the disintegration of a comet nucleus. It is very probable that there are a lot of mechanisms that cause a comet nucleus to split, and, perhaps, they are not related to each other. Below, the results are described of our analyses of the hypothesis about comet splitting suggested recently by one of the present authors (Guliyev, 2010). According to this hypothesis, the splitting of some comets can occur because of their collision with meteoroid streams. For the justification of this hypothesis, data about 35 disintegrating comets have been used by Guliyev (2010).

2 Problem statement

According to the hypothesis of the first author (Guliyev, 2010), the huge nucleus of a proto-comet appearing in the inner part of the solar system may encounter some meteoroid stream. The nucleus of such a proto-comet has many cracks. Under the influence of collisions with a meteoroid stream and the tidal forces of the Sun, these cracks will increase and cause the splitting of the proto-comet nuclei into smaller fragments. Fragments will encounter the same meteoroid stream at their next return to perihelion, and they will suffer many impacts from the meteoroid stream resulting in secondary splittings. This process can repeat at each subsequent return of the fragments to their perihelion. We suppose that the Kreutz comet family is formed in this way. The hypothetical meteoroid stream for this comet family should exist in the zone

$$\Omega_p = 267\overset{\circ}{.}15;\ I_p = 76\overset{\circ}{.}34;\ 1.5\ \text{AU} \le r \le 2.5\text{AU}, \quad (1)$$

according to a working hypothesis about perihelion location along the big circle of celestial sphere with parameters Ω_p (ascending node) and I_p (inclination), as explained by Guliyev (2010). There, similar conjectures have been made relative to the Meyer and Krach comet groups, who may be formed by collisions of a proto-comet nucleus with a meteoroid stream in the zones

$$\Omega_p = 106\overset{\circ}{.}03;\ I_p = 84\overset{\circ}{.}68;\ 1.5\ \text{AU} \le r \le 2.5\text{AU} \quad (2)$$

and

$$\Omega_p = 54\overset{\circ}{.}26;\ I_p = 14\overset{\circ}{.}93;\ 0.4\ \text{AU} \le r \le 0.6\text{AU}, \quad (3)$$

respectively.

It is the main aim of our investigations to find out if there is any concentration in planes and intervals of nearer and distant nodes for other disintegrated comets, corresponding to zones (1–3). A positive answer would confirm our hypothesis (Guliyev, 2010) and encourage similar investigations for other meteoroid streams.

3 Data of comets and TNOs used in this study

Data of 118 comets discovered up to 2012 have been used in our work. These data have been taken from following sources:

- catalogue of Vsekhsvyatsky and its supplements (Vsekhsvyatsky, 1958);
- doctoral dissertation of Ibadinov (1998);
- data collected by Guliyev and Nabiyev (2006);
- data collected by Boehnhardt (2005);
- data of disappeared periodic comets (Marsden and Williams, 2008); and
- data of comet twins, observed after 2006 (Marsden and Williams, 2008).

4 Analyses of comet orbit nodes relative to the selected planes

4.1 Method

We have calculated the numbers of distant nodes for all 118 comets relative to the selected planes (1–3) with the parameters (Ω, I) and we found the number of nodes (N) corresponding to the interval (r_1, r_2) from (1–3). We have used the test method of Guliyev and Dadashov (2009). In particular, for a fixed interval (r_1, r_2), we varied the parameters $\Omega = 0°, 30°, 60°, \ldots, 330°$ and $I = 0°, 9°, 49\overset{\circ}{.}19, 47\overset{\circ}{.}30, 41\overset{\circ}{.}81, 56\overset{\circ}{.}44$ and $90°$ in such a way that the poles of the corresponding 67 planes were at equal distances from each other. In the next step of the calculations, the number of comet nodes within the fixed intervals was obtained for each of the planes under consideration. Besides this number N, we also computed the following parameters:

- the mid-range value n of these numbers over the 67 planes;
- the standard deviation σ;
- the normalized differences $t = (N - n)/\sigma$; and
- the confidence probability α of t, which is found by the one-sided Student statistical criterion.

Subsequently, we made a statistical comparison.

4.2 Results

Computing and analyzing nodes relative to the plane (1) yielded the following numerical results:

$$N = 20;\ n = 14.4478;\ \sigma = 3.87;\ t = 1.43;\ \alpha = 0.85,$$

for the distant nodes, and

$$N = 29;\ n = 22.63;\ \sigma = 3.54;\ t = 2.36;\ \alpha = 0.99,$$

for the nearer nodes.

It is important to note that these results have been obtained for the intervals $r = 1.65$–2.72 AU and $r = 1.55$–2.22 AU, respectively accordingly. These intervals differ slightly from the interval in (1), but the difference is acceptable for our purpose. The values obtained for t indicate that there is an excess of comet orbit nodes in zone (1). This excess also indicates that the hypothetic meteoroid stream in zone (1) may be a cause for the disintegration of the 118 comets.

Similar results have been obtained in the case of zone (2). Calculations and analyzes for the distant nodes gave us the following numerical results:

$$N = 15;\ n = 11.36;\ \sigma = 3.02;\ t = 1.21;\ \alpha = 0.75,$$

for the distant nodes, and

$$N = 40;\ n = 34.72;\ \sigma = 2.71;\ t = 1.95;\ \alpha = 0.97,$$

for the nearer nodes.

The basic intervals in both cases are $r = 1.50$–2.40 AU and $r = 1.40$–2.50 AU, respectively. Displacements of these intervals relative to (2) are insignificant. Hence, the results confirm the theory for this zone, too.

Finally we mention the results for the calculations relative to zone (3), corresponding to the disintegration of proto-comets for the Krach comet family:

$$N = 3;\ n = 0.49;\ \sigma = 0.75;\ t = 3.36;\ \alpha = 0.99,$$

for the distant nodes in the interval $r = 0.51$–0.66 AU, and

$$N = 9;\ n = 5.64;\ \sigma = 1.49;\ t = 2.24;\ \alpha = 0.99,$$

for the nearer nodes in the interval $r = 0.51$–0.66 AU.

Thus, in all three cases, we obtained confirmation of an excess of comet nodes in the zones (1–3), or in the vicinity of these three zones. One possible consequence of the considered mechanism is be the following: in zones (1–3), the number of comet outbursts have to be larger than in other zones. To check this possible consequence, we compared the distribution of q (the perihelion distances) and r (the solar distances where comet outbursts have been observed).

Based on this analysis, the following preliminary conclusions can be drawn. If outbursts happen only due to the influence of solar radiation (and, therefore, in the perihelion zones), both distributions have to be very similar. If other reasons, not connected to the Sun, are involved, they must be different. To check this, we drafted a list of comet outbursts, containing 131 events. Most of them were taken from the work of Andrienko and Vashenko (1980). We also found additional outbursts by plotting the light curves of 40 comets discovered after 1990. The numbers of outbursting comets in function of their solar distance at the time of the outburst is shown in Figure 1. The maxima in this distribution occur around $r = 0.6$ AU and $r = 2.0$ AU, in quite good agreement with our mechanism. The other maximum at $r = 1.1$ AU (i.e., near the Earth) might be an artefact due to visibility conditions. Figure 2 displays the distribution of the perihelion distances of 1050 long-period comets discovered up to 2012. Comparing both figures confirms the real nature of the maxima in the distribution of comet outbursts.

5 Conclusions

An indirect result of our work is that we obtained an almost complete list of disintegrating comets. Based on this list, our calculations show an excessive number of comet nodes in the zones we considered. (In some cases, the distant nodes are considered, and, in other, cases the nearer nodes.) This means that the hypothetical meteoroid stream may cause the breaking up of the comets considered. Further analyses of cometary outbursts confirm this suggestion. It is also necessary to examine known meteoroid streams with regard to the considered concentration of cometary nodes.

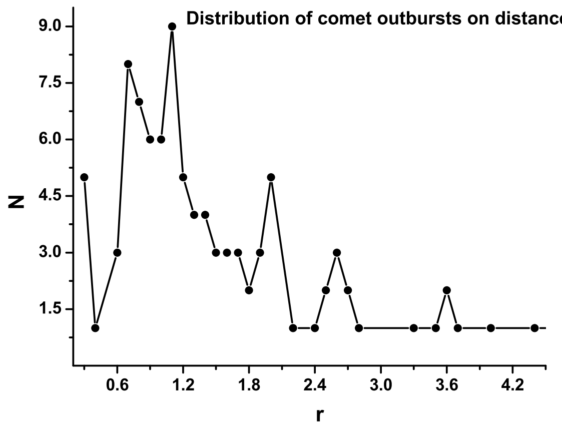

Figure 1 – Distribution of comet outbursts as a function of their distance (r) from the Sun.

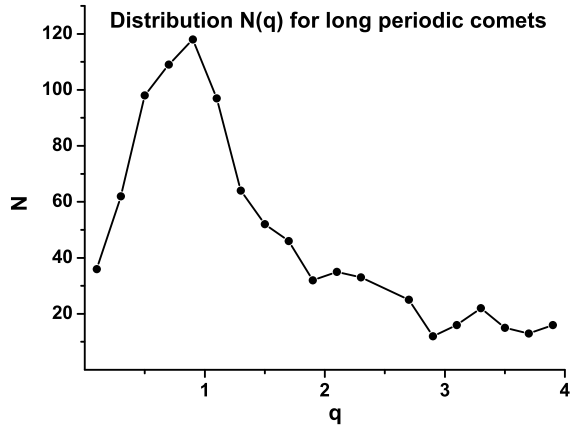

Figure 2 – Distribution of perihelion distances (q) for long-periodic comets.

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