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The Possible Interrelation of TNO and Long-Period Comets by MOID Distribution

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The study objects of our work were 91 TNO with diameters greater than 200 km. On the other hand, the paper used the data for 1048 and comets with aphelion and perihelion distances $Q > 30$ AU and $q > 0.1$AU, respectively, were observed until 2012. Short-perihelion comets (sporadic and concentrated in separate groups) were excluded from the analysis. If some comet split into several parties, we have taken data for only one fragment, which is marked with the letter A. Data for comets are taken from the catalog [4] and the individual Circulars International Astronomical Union, issued in period after 2008. The data for TNO, mostly borrowed from the website [5], as well as the issues of the same circulars.

Research methodology is the same as in [1]. By number of comet passes from traffic zone selected TNO is compared to the modeled 67 zones. That differs from it only on the parameters Ω (longitude of the ascending node) and I (inclination). The Ω ranges from 0^0 to 330^0 in increments of 30^0 and I - from 0^0 to 90^0 with such steps to pole the planes were equidistant from each other ([2] and[3]). Ultimately, defines the following values: N - number of comet passes in traffic zone selected TNO; n, σ, t and α - average comet passes for 67 zones, normalized difference ($t = (N - n)/\sigma$), the variance a confidence interval of t, respectively. As a validation of the values t and α appropriate use the one-sample t-test, which leads to values of 1.67 and 0.95, respectively.

To calculate the value of r (i.e. MOID) used the following formula:

$$r^2 = \left(R^2(dn) + \left[\frac{q(1+e)}{1 + e\cos\nu} \right]^2 - \frac{2R(dn)(q(1+e))}{1+e\cos\nu} \sqrt{1 - \sin^2 i \times \sin^2(\omega - \nu)} \right)$$

Here $R(dn)$ is the distance TNO in a direction of the ascending nodecomet's orbit, q and e-non-variant elements comet's orbits, i and ω angular elements of the comets orbitsrelatively to moving plane of selected TNO, ν- true anomaly of the comet.

Naturally, the formula contains some inaccuracies, because the distance of the planet towards remote host comets orbits might differ slightly from the true direction, where the distance between TNO and comet is minimal. However, for this issue, and its ultimate objective, such inaccuracy does not play a significant role. Anyway, it is extremely improbable, that redundancy of comet passes to zones of interesting us can be results of such discrepancy, most likely to the contrary, the result could be more significant when taking into account the exact distance of the planet.

Thus, at the first stage of our calculations for 91 TNO and 1048 comets are calculated values r (only 95368 values). It is difficult to assess what law should obey their distribution, but it whenever a selected should cover the intervals from TNO 0 to Q (aphelion distance of a planetary body). In a preliminary study of the set of values of r especially noteworthy existence of a large number of small values. It is possible that a more rigorous calculations, and in the case if comets and planetary data contained greater accuracy, the result would be more impressive.

Anyhow, for definition of a degree of redundancy of comets intersections in zones of movement TNO we use the above described way of comparison. Data analysis for the case $r < 1$ AU shows that 13 values of t are likely significant, greater than 0.95. Also pays attention to fact that there is a significant gap between positive and negative t values. Their ratio is 56:36, which is not by accident. In the case of $r < 0.5$ AU almost the same patter is observed (ratio 54:38), and the number of reliable t is 9. And in the case $r < 0.1$ AU large variations of t in particular, the ratio of 67:25 is likely a reflection of their uncertainty. Apparently this case will be of interest only when the number of planets and comets, as well as their accuracy, will be much more than present.

During the further analysis the correlation has been found between values t and I trans-Neptune bodies in case of $r < 1$ AU, and in case of $r < 0.5$ AU. In either case, the correlation coefficient is less than - 0.4, and its significance is greater than 0.95. Perhaps these relationship indicate that a selected planetary bodies or some of them "in contact" with the comet near the ecliptic than at lager ecliptic latitudes. Moreover, for case of $r < 1$ AU in considering the various options for comparing the values of t and H, we found that there is definite relationship only for $H < 3^m.7$.

RESULTS

1. There is significant number of comets having distant nodes of orbits in zones of orbital moving TNO;
2. In 12 cases correspondence of distant nodes in zones of orbital moving TNO does not randomness according of methods of mathematical statistics.
3. 13 from 91 values of t in the case MOID $<$ 1AU have statistical reliability more than 0.95.
4. 10 from 91 values of t in the case MOID $<$ 0.5AU have statistical reliability more than 0.95.
5. In collection of t obtained by calculations on MOID positive values dominate over negative ones obviously;
6. There is significant correlation dependence t and I;
7. There is significant correlation dependence t and H from some number bright TNO.

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