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Selection effects in the discovery of NEAs

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To highlight discovery selection effects, we consider four NEA subpopulations:
(a) "Taurid asteroids", the Apollos with orbits similar to those of 2P/Encke and of the Taurid meteoroid complex;
(b) Atens, to which we add the Inner Earth Objects;
(c) non-Taurid Apollos;
(d) Amors.
The "Taurid asteroids" are identified by Asher *et al.* (1993) with a reduced version of the D-criterion (Southworth and Hawkins 1963), involving only a, e and i:

$$D = \sqrt{\left(\frac{a-2.1}{3}\right)^2 + (e-0.82)^2 + \left(2\sin\frac{i-4^\circ}{2}\right)^2} \leqslant 0.25.$$

It turns out that the distribution of the longitudes of perihelion ϖ of NEAs with $D < 0.25$ is significantly non-random, due to the existence of two groups whose apse lines are approximately aligned with those of 2P/Encke and of (2212) Hephaistos.

Asher *et al.* (1993) suggested that this finding supports a scenario in which a giant Jupiter family comet could have ended in an Encke-like orbit and suffered a hierarchical fragmentation in the last 20 000 yr, the ϖ concentrations being the signature of this process. Valsecchi *et al.* (1995) investigated the dynamics of 2P/Encke and of Taurid asteroids. If the hierarchical fragmentation of a single cometary progenitor had really taken place, traces of it should be recognizable in past orbital separations; this, however, turned out not to be the case.

Given that the dynamics in the Taurids region does not support the scenario of a common progenitor for the NEAs residing there, we are left with the problem of explaining the ϖ concentrations. Could they be due to observational selection effects?

To investigate this possibility, we reconstructed the geometry at the discovery of each NEA with Orbfit (http://adams.dm.unipi.it/ orbmaint/orbfit/), using the observations available at NEODyS (http://newton.dm.unipi.it/neodys2/) and the discovery dates of NEAs available at the Minor Planet Center (http://www.minorplanetcenter.net/iau/mpc.html).

Due to the small sizes of Near Earth Asteroids (NEAs), most of them are discovered when moving near the Earth. Two correlations can be established:
• between the discovery date and the longitude of node of the NEA's orbit;
• between the discovery date and a range of possible longitudes of perihelion of the NEA's orbit, depending on the semimajor axis and the eccentricity of the latter.
These correlations would have no effect on the distributions of the longitudes of nodes and perihelia on known NEAs if the rate of NEA discovery over the year were constant. However, as pointed out by Kresák and Klačka (1989), this is not the case: there are significant seasonal variations of observing conditions that result in a variable rate of asteroid discoveries over the year. As a consequence:

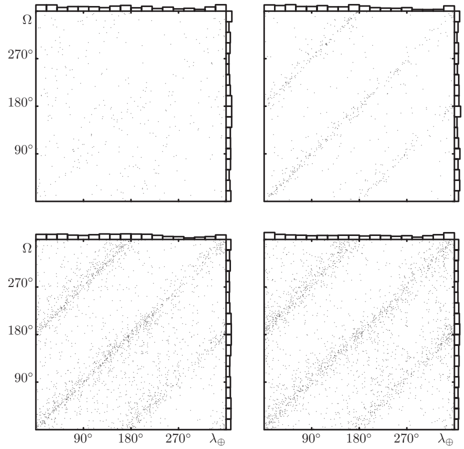

Figure 1. Plot of the longitude of node Ω vs longitude of Earth at discovery $\lambda_\oplus$ for (clockwise from top left): Taurid asteroids, Atens, Amors and non-Taurid Apollos.

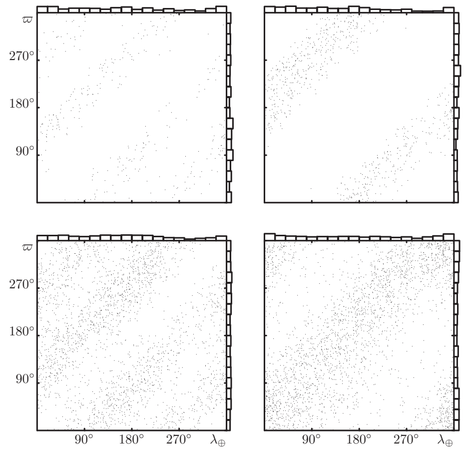

Figure 2. Same as Fig. 1 for the longitude of perihelion ϖ.

• small asteroids in inclined orbits tend to have the longitude of node close to Earth longitude at discovery;

• Amors tend to have the perihelion longitude close to Earth longitude at discovery;

• Atens tend to have the aphelion longitude close to Earth longitude at discovery;

• Taurids, due to their orbital size and shape, tend to be discovered when the Earth longitude is about 100° to 120° ahead of or behind their perihelion;

• non-Taurid Apollos show a similar selection effect, although to a much lesser degree.

These selection effects must be taken into account when evaluating the completeness of a survey.

References

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