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# The ever changing population of large NEAs: a global view

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## Abstract

The progress in NEA discoveries has led to a situation such that the population of NEAs with $H < 16$ can be assumed to be complete, or almost complete [3]. This sample of large NEAs is unbiased, and is sufficiently large to allow a meaningful statistical analysis. We compare its statistical features with those of the NEA population model of [1], finding nontrivial differences. In addition, we analyze the evolution of the sample under the action of secular perturbations.

## 1. Introduction

The tabulations available at the NEODyS website indicate that we know, as of January 2011, 193 NEAs with $H < 16$, and that their orbital elements are very well determined (uncertainty in orbital semimajor axis smaller than $10^{-5}$ AU), with the exception of two cases, 1984 $QY_1$ and 2007 $VA_{85}$, with uncertainties in the semimajor axis of 0.19 AU and $9 \cdot 10^{-4}$ AU, respectively. These two cases are excluded from our sample.

This NEA sample is sufficiently large to consider its orbital distribution as statistically meaningful, and to regard it as a proxy for the real orbital distribution of NEAs with $H < 18$, which was one of the main goals of [1].

To complete our sample, we have identified, among multi-opposition and numbered asteroids with $H < 16$, those that can become Amors, or even Apollos, as a consequence of secular perturbations. The degree of completeness of this latter population of "potential NEAs" is presumably lower than that of NEAs.

We study the evolution of the orbits of our combined sample of bright NEAs and potential NEAs due to secular perturbations, taking snapshots of the osculating elements at fixed epochs, and compare the orbital distribution of these snapshots with the orbital distribution of NEAs of [1].

## 2. The population of large NEAs

The proportion of different orbital classes within our sample of large NEAs differs significantly from the model [1], as shown in Table 1.

Table 1: Orbital classes among NEAs.

| | Bottke et al. (2002) | Large NEAs |
|---|---|---|
| Amors | $32\% \pm 1\%$ | $50\%$ |
| Apollos | $62\% \pm 1\%$ | $47\%$ |
| Atens | $6\% \pm 1\%$ | $3\%$ |
| IEOs | $2\% \pm 0\%$ | $0\%$ |
| PHAs | $21\%$ | $14\%$ |

In addition, there are significant differences between the two populations in the orbital distributions of Amors and Apollos, as shown in Tables 2 and 3.

Table 2: Orbital distribution among Amors.

| | Bottke et al. (2002) | Large NEAs |
|---|---|---|
| $a < 2$ AU | $27\% \pm 3\%$ | $25\%$ |
| $e < 0.4$ | $25\% \pm 3\%$ | $23\%$ |
| $e < 0.6$ | $87\% \pm 4\%$ | $91\%$ |
| $i < 10°$ | $41\% \pm 2\%$ | $27\%$ |
| $i < 20°$ | $74\% \pm 1\%$ | $51\%$ |
| $i < 30°$ | $87\% \pm 1\%$ | $74\%$ |

Table 3: Orbital distribution among Apollos.

| | Bottke et al. (2002) | Large NEAs |
|---|---|---|
| $a < 2$ AU | $55\% \pm 4\%$ | $49\%$ |
| $e < 0.4$ | $9\% \pm 1\%$ | $9\%$ |
| $e < 0.6$ | $34\% \pm 2\%$ | $37\%$ |
| $i < 10°$ | $20\% \pm 1\%$ | $16\%$ |
| $i < 20°$ | $48\% \pm 2\%$ | $37\%$ |
| $i < 30°$ | $67\% \pm 1\%$ | $58\%$ |

Thus, compared to the model [1], the current population of large NEAs has:

- a significantly larger proportion of Amors;
- significantly smaller proportions of Apollos, Atens, IEOs and PHAs;
- a larger proportion of high-inclination Amors;
- a larger proportion of high-inclination Apollos.

## 3. Secular evolution

NEAs typically move in chaotic orbits, that allow them to encounter one or more planets. However, this only happens for small values of the MOID computed with respect to a given planet. Unless encounters with Jupiter are possible, encounters with the terrestrial planets which are able to significantly alter the orbit are sufficiently infrequent, so that in the time interval between such encounters the osculating orbital elements can undergo significant variations due to secular perturbations.

Therefore, it is statistically meaningful to examine the evolution of a NEA sample subject only to secular perturbations. NEAs with $a > 1.3$ AU may secularly evolve to orbits with $q > 1.3$ AU, outside the NEA region, while some non-NEA asteroids may secularly evolve to orbits with $q < 1.3$ AU, thus becoming NEAs.

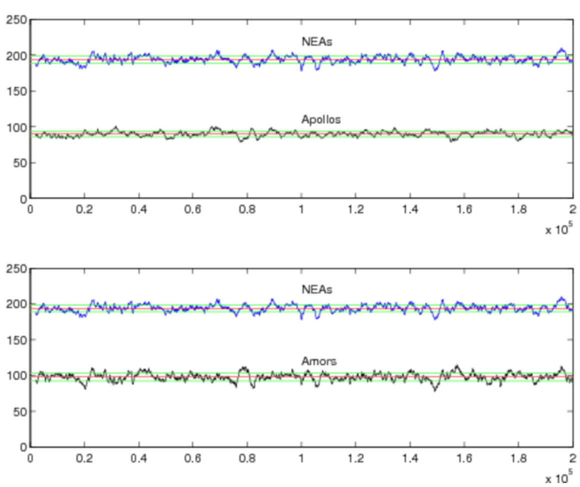


Figure 1: Time evolution of the number of NEAs and Apollos in the sample (top); time evolution of the number of NEAs and Amors in the sample (bottom). Red lines: averages, green lines: $1\sigma$ variations.

We have augmented our sample of large NEAs by including all the numbered and multi-opposition asteroids with $H < 16$ that can, due to secular perturbations, become NEAs. This combined sample, composed of large NEAs and Potential NEAs (PNEAs), amounts to 273 objects. Its secular evolution has then been computed over a time span of 200,000 yr, starting from the present epoch, using the secular perturbation theory of [2]. Figures 1 and 2 present some relevant results; note how stable are the proportions of Apollos, Amors and PHAs over time.

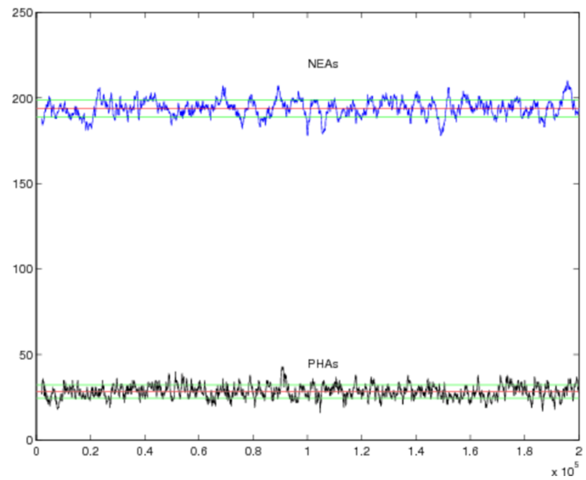


Figure 2: Time evolution of the number of NEAs and PHAs in the sample. Red lines: averages, green lines: $1\sigma$ variations.

## 4. Conclusions

A first look at the orbital distribution of the sample of large ($H < 16$) NEAs and potential NEAs shows significant differences with respect to that of [1]; we are investigating the possible sources of the discrepancies.

## References


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