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Earth's missing co-orbitals

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Abstract

Some, but not all, of the planets in our solar system are accompanied by Trojan asteroids, objects confined by solar and planetary gravity to orbit the Sun 60° ahead or behind the planet [1]. They most likely represent material from the formation and early evolution of the planets, put in "safe storage" well away from planetary gravitational wells.

Numerous objects are known to exist in a temporary 1:1 orbital resonance with the Earth[1], yet no *stable* Trojan companions have so far been found; observational searches from the ground [3, 4] and, more recently, *in situ* by the OSIRIS-REx spacecraft [5] have so far not born fruit. For the ground-based searches, this is because detection of objects in Earth-like orbits is hampered by the low solar elongation [6]. Indeed, the temporary Earth Trojan, 2010 TK_7, found by the WISE satellite [7] has a significant orbital eccentricity, rendering it easier to detect. Therefore, the existence of permanent Trojan companions to our planet remains an open question.

Searches to-date for objects permanently locked to the Earth may, however, have been too limited in scope. Because of the low Earth-Sun mass ratio and the particular dynamics of asteroids in Earth's orbital vicinity, not only Trojan but also "horseshoe" orbits - where the asteroid is not restricted to move near L4 and L5 but only to avoid the location of the planet itself - are theoretically stable for at least a Gyr [8, 9]. Interestingly, the current observational census of near-Earth asteroids shows a relative deficit of objects at a=1 au (Fig. 1). The dip in the plotted distribution corresponds to 70-80 "missing" asteroids and is significant at the 6-σ level. This feature is reproduced by population completeness models [10] and is due to the very long Earth re-approach times (100s of yr) for the asteroids vs the relatively short (10s of yr) timespan of NEA surveying to-date. Most of these objects will have a semimajor axis within one Earth Hill sphere radius (∼0.01 au) of 1 au so they are likely to be trapped in different modes of the 1:1 resonance. Regardless of their dynamical status, they are self-evidently unobservable with current instrumentation. In this presentation, I will discuss what these missing coorbitals might be and how best to find them.

[1]The so-called "coorbital" asteroids [2]

1. Figures

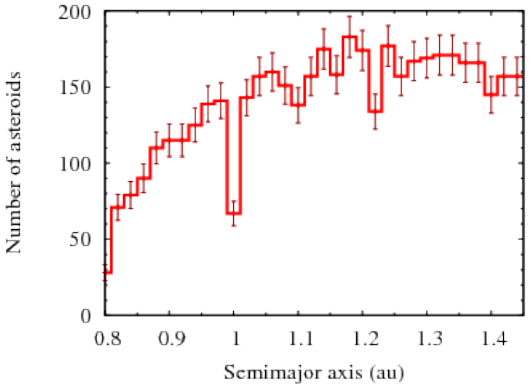

Figure 1: Number of NEAs as a function of semimajor axis plotted with a bin size of 0.02 au. Data was downloaded from the *NEODyS-2* online service (https://newton.dm.unipi.it/neodys/) on 21st November 2017. The error bars represent 1-σ Poisson statistics. Note the dip at a=1 au representing a ∼50% deficit of discovered objects relative to asteroids in neighbouring orbits.

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