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NEOSSat's new NEO orbital model

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Abstract

NEOSSat (Near-Earth Object Surveillance Satellite), scheduled to launch in early 2012, will be Canada's next space telescope. Its scientific objective is to search for and track Near Earth Objects (NEOs) to determine their orbital parameters, in particular targeting NEOs with semi-major axes smaller than Earth's. In order to optimize NEOSSat's ability to carry out this goal, a new NEO orbital distribution model was calculated using over 300 core-years of computation. This model greatly improves the resolution and statistics of the previous orbital model from a decade ago (Bottke et al. 2002, [1]). The inclusion of Mercury and the use of a smaller time-step result in improved accuracy for orbits in NEOSSat's main search region (i.e. semi-major axes less than 1 AU) as well as an improved asteroid impact-speed distribution for terrestrial planets, especially Mercury. In addition, two new near-Earth asteroid (NEA) populations appearing in our model are (1) NEAs that orbit completely interior to Venus and (2) NEAs in retrograde orbits.

1. Introduction

Near-Earth Objects (NEOs) are comets and asteroids (NEAs) whose orbits come within 1.3 AU of the Sun. There are an estimated 1000 asteroids with diameters over 1 km on near-Earth orbits [1]. These objects are scientifically interesting as they have existed since the formation of the Solar System. Their orbits bring them close to Earth, which makes them potential targets for future manned and unmanned space probe missions (for example, see [2]). Also, understanding the distribution of NEA orbits leads to better studies of impact chronology on terrestrial planets and their moons.

NEOSSat is a Canadian space telescope designed to observe NEOs [3]. An NEO orbital model is necessary in order to determine the optimal pointing strategy for NEOSSat to achieve its observational goals. Thus, with the launch of NEOSSat scheduled for early 2012, a new NEO orbital model was developed. This work presents the new model, which is an update of a previous model [1] with improvements enabled by advances in computing power over the past decade.

2. NEOSSat

NEOSSat is a microsatellite built by the Canadian Space Agency and Defense Research and Development Canada. Its scientific mission (50% of operational time) is to discover NEOs and determine their orbital parameters. With its sun-blocking baffle, NEOSSat can observe objects with solar elongations down to 45°. NEOSSat will be in a Sun-synchronous orbit at an altitude of approximately 650 km with a period of ∼100 minutes (∼14 orbits per day). Simulations of NEOSSat's pointing strategy show that 7 NEOs (3 known, 4 unknown) are expected to be found per 14 day operational period (∼1 month real time), along with many larger asteroids from the main belt.

3. NEO Orbital Models

Although the development of the NEO orbital model was motivated by a need to determine discovery rates and a pointing strategy for NEOSSat, this model is completely independent of any instruments. The orbital model is the steady-state NEO orbital distribution from a SWIFT-RMVS4 numerical integration using the Sun, the first six planets, and massless test particles initially in one of five NEO sources: the ν_6 secular resonance, the 3:1 mean motion resonance, the outer main belt population, the intermediate Mars-crossing population, and the Jupiter-family comets.

The major changes of this model compared to Bottke et al. (2002) [1] are the inclusion of Mercury in the integration (and consequently, a smaller timestep) and an increase in statistics from using ∼6.5 times as many particles as before. The new model is, in general, similar to the old model, but the accuracy for orbits with $a < 1$ AU is greatly improved, which is NEOSSat's primary search region. In addition, due to the increased number of particles, the new model show an improved resolution in phase space.

Two NEA populations appear in this new model but not in any previous model. They are NEAs that orbit completely interior to Venus ("Vatiras") and NEAs in retrograde orbits. Table 1 shows the relative proportions of NEAs, by class, in the old and new models. The Vatira population (i.e. NEAs with aphelion $Q < 0.72$ AU, see Figure 1) may be missing in the old model due to the exclusion of Mercury. Analysis of the NEAs in the Vatira class found that most high inclination Vatiras are exhibiting Kozai oscillations.

Table 1: Percentage of NEAs by class

Class	Ref.[1]	This work
Amor	$31 \pm 1\%$	$30.1 \pm 1.5\%$
Apollo	$61 \pm 1\%$	$63.3 \pm 0.9\%$
Aten	$6 \pm 1\%$	$5.0 \pm 0.5\%$
Atira ($Q < 1.0$ AU)	$2 \pm 0\%$	$1.4 \pm 0.1\%$
Vatira ($Q < 0.72$ AU)	$0 \pm 0\%$	$0.25 \pm 0.07\%$

The new model also indicate that 0.10% of the NEA population should be in retrograde orbits (see Greenstreet et al. presentation, this meeting). Currently, there are two non-comet Minor Planet Centre objects with retrograde orbits (2009 HC82 and 2007 VA85). Analysis of the history for these objects show that the 3:1 mean motion resonance is the dominant mechanism for producing retrograde inclinations.

The NEO orbital model can also be used to calculate asteroid impact speed distributions for terrestrial planets. With better statistics in the new model, impact speed distribution calculations are more robust. For example, Mercury impactor speed distribution calculated with the old model [4] clearly have artifacts due to small number statistics, which are not present in the new model. Thus, future impact chronology work should use this new model to compute cratering rates.

4 Summary and Conclusions

A new NEO orbital model has been developed, with improved resolution and statistics over the Bottke et al. (2002) model, showing two populations of NEAs not present in previous models: NEAs in orbits completely interior to Venus (Vatiras) and NEAs in retrograde orbits. In addition, improved statistics in the new model can eliminate artifacts in impact speed distributions calculated with the old model.

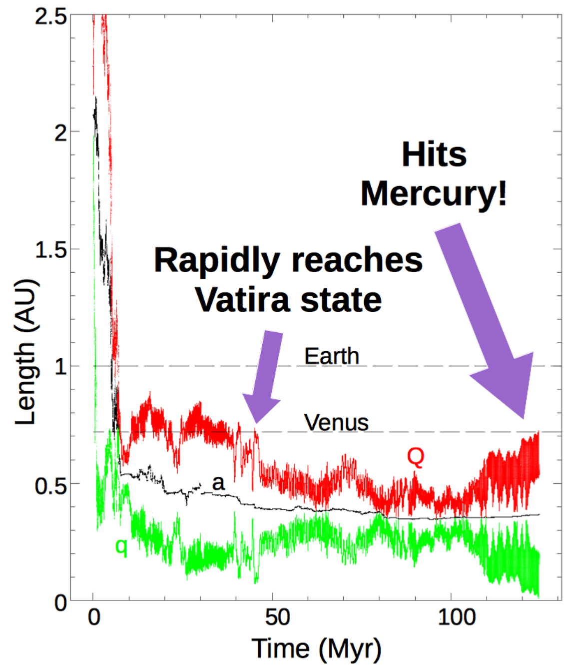

Figure 1: The orbital history of a NEA showing aphelion Q, semi-major axis a, and perihelion q over time. The NEA reaches the Vatira state when its Q drops below the semi-major axis of Venus (0.72 AU).

Acknowledgements

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References

[1] Bottke, W. et al.: Debiased orbital and absolute magnitude distribution of the near-Earth objects, *Icarus*, Vol. 156, pp. 399–433, 2002.

[2] Abell, P. et al.: Scientific exploration of near-Earth objects via the Orion Crew Exploration Vehicle, *Meteoritics & Planetary Science*, Vol. 44, pp. 1825–1836, 2009.

[3] Hildebrand, A. et al.: Advantages of searching for asteroids from Low Earth Orbit: The NEOSSat mission, *Earth, Moon and Planets*, Vol. 95, pp. 33–40, 2004.

[4] Marchi, S. et al.: A new chronology for the Moon and Mercury, *The Astronomical Journal*, Vol. 137, pp. 4936–4948, 2009.