Constructing new population models for near-Earth asteroids

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meteoroid had no thermal inertia, then the temdistribution would be symmetrical about the subnt and the meteoroid would experience a net force utward from the Sun. The only consequence of this ald be to weaken the Sun's grip on the meteoroid. al bodies have ghermal inertia, which causes a that the hottest part of the meteoroid is its aftererather than the subsolar point. This is similar to where the afternoon is typically the warmest time is a result, the Org on the meteoroid has not only ent that is radially outward from the Sun, but also ong-treek component.

lor g-teck component causes a secular increase in Object najor wis (and to a lesser degree, eccentricity) for ade sense of rotation shown in the figure, so that the tiny Yarkovsky force can profoundly change The sign of the diurnal Yarkovsky effect depends nse of rotation Olf the meteoroid shown in Fig. 1a the retrograde sense, the orbit would shrink in-

1.5

0

tors means that there is an optimal size for maximizing th diurnal Yarkovsky effect for a given rotation speed and then mal structure. A very large object would have a poor area-to mass ratio (e.g., the effect is negligible on a large body lik the Earth). On the other hand, the smaller the body, th better the area-to-mass ratio, but at some point the radiu becomes so small that the thermal wave penetrates all th way across the body, lessening the temperature difference between the night and day sides and weakening the effect (e.g., a slowly rotating dust particle). For fortation period believed to be typical in the solar system $[P \sim 5] h \times (D)$ 1 km), where is the diameter of the body], optimal size for the Yarkovsky effect range from centimeters to meters Objects having zero or infinitely fast rotation rates experi ence no diurnal Yarkovsky force.

З

2.5

Semimajor axis [AU]

3.5

Yarkovsky & YORP thermal forces



NEO population model

An observational-bias-free and self-consistent model of NEOs including

- I. their orbital distribution, and
- 2. their size-frequency distribution.

Bias (or efficiency) equation

n(a,e,i,H) = B(a,e,i,H)N(a,e,i,H)

observed population bias

true population (this is what we want to know!)

Bias



Jedicke et al. 2002

A simple solution

$N(a,e,i,H) = \frac{n(a,e,i,H)}{B(a,e,i,H)}$

Limited to 4xID distributions because $N_{bin} >> N_{object}$

We need to find physically meaningful constraints for the system...

... and they do exist in the form of statistically distinct orbital histories for NEOs originating in different parts of the main asteroid belt!

A more robust approach taking into account varying orbital dynamics corresponding to N_{s} different source regions

$$n(a, e, i, H) = B(a, e, i, H)N(H)\sum_{i=1}^{N_s} f_i N_i(a, e, i)$$

M

$$\sum_{i=1}^{N_S} f_i = 1$$

First developed by Bottke et al. (2000, 2002).

NEOs and their source regions



Bottke et al. 2002



Bottke et al. 2002

Known shortcomings of the Bottke model

- much more Amors known than predicted (+5 σ)
- inability to explain high-i orbits
- inclination distribution for Earth-like NEO orbits
- Yarkovsky effect not modeled
- single slope for the SFD
- only valid for 13<H<22
- resolution sub-optimal (cf. minimoons)
- no observational constraints on asteroids with Q<IAU

Understanding the distribution of small NEOs

co-authors alphabetically: Beshore, Bottke, Jedicke, Michel, Morbidelli, Nesvorny, Tsiganis, Vokrouhlicky Modification of the Bottke model (SFD is source dependent):

$n(a, e, i, H) = B(a, e, i, H) \sum_{i=1}^{N_{3}} f_{i}N_{i}(a, e, i, H)$

 $\sum_{i=1}^{NB} f_i = 1$

The goal and the means to reach it

- extend and improve the Bottke model
- at least 30x more observational data
- Yarkovsky modeling when populating escape hatches in the MB
- Include new NEO source regions
- different SFDs for different source regions
- better resolution

NEO detections by CSS's Mt. Lemmon station 2006-2011



Example orbital evolution



Yarkovsky in the MB



Escape hatches in the MB



Relative importance of various escape hatches as a function of asteroid diameter



Asteroids with a < I AU

co-authors alphabetically (the NEOSSat Science Team): Brown, Cardinal, Chodas, Gladman, Greenstreet, Gural, Hildebrand (NESS PI), Larson, Tedesco, Wiegert, Worden, ...

The goal and the means to reach it

- improve our understanding of asteroids with a<IAU
- ~10 Atiras (objects with Q<q_{Earth}) known => need to detect more to improve understanding on their population characteristics => ground-based search is tedious at solar elongations <60deg => use a space-based platform
- NEOSSat is a suitcase-sized follow-up to MOST
- launch to a polar orbit in late 2012
- expect to detect | Atira-class asteroid (Q<IAU) every month, nominal mission will last 2 years
- good handle on detection biases

NEOSSat-I.0 NEA model





Greenstreet et al. 2012

NEOSSat-1.0 NEA model





Testing the resulting models with peculiar objects

NEAs on retrograde orbits



Greenstreet et al. 2012

NEOs temporarily captured by the Earth-Moon system



turday, May 26, 2012

Granvik et al. 2012