Planetary Society STEP Grant 2021

Demystifying Near-Earth Asteroids

D-NEAs

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What is the D-NEAs project?

- Asteroid thermal properties, such as thermal inertia, are available for only a few hundred objects.
- This is mainly because the methods rely on observations which are possible only for a limited number of objects.
- The D-NEAs project aims to develop a novel method enabling the characterization of near-Earth asteroids, that relies on relatively easily collected ground-based observations.

What is the main idea?

- We explore the fact that the Yarkovsky effect depends on an asteroid’s physical properties, but manifests in the object’s orbital motion.
- The new method compares the theoretical and measured values of the Yarkovsky effect (Fenucci et al., A&A, 2021).

$$\left(\frac{da}{dt}\right)(a, D, \rho, K, C, \gamma, P) = \left(\frac{da}{dt}\right)_m$$

- The most critical parameter to constrain is thermal conductivity (Delbo et al. 2015)
- A Monte Carlo model provides a probability distribution of thermal conductivity (inertia).

Examples of input parameters modelling

- NEO orbit distribution model by Granvik et al. (2018) ==> Source region(s)
- NEO albedo distribution model by Morbidelli et al. (2022) ==> Albedo probability for a given source region
- Albedo distribution combined with an absolute magnitude provide object's size probability distribution
- NEO obliquity distribution by Tardioli et al. (2017) ==> Obliquity probability distribution
- However, if albedo or obliquity of a given object are measured, their probability distributions are simply asssumed to be Gaussian

The basic model and ongoing improvements

Basic model

- Analytic circular Yarkovsky model
- Constant density model
- Constant thermal inertia model

Improvements

- Semi-analytic Yarkovsky eccentric model
- Semi-analytic Yarkovsky model + thermal inertia variation
- Layered density model

Semi-analytical Yarko model and thermal inertia variation

Semi-analytical Yarkovsky model

The instantaneous drift (Vokrouhlicky et al. 2017) is:

$$\frac{\mathrm{d}a}{\mathrm{d}t} = \frac{2}{n^2 a}\mathbf{f}_Y \cdot \mathbf{v}$$

Total drift

$$\left(\frac{\mathrm{d}a}{\mathrm{d}t}\right)_{\mathrm{tot}} = \int_0^T \frac{\mathrm{d}a}{\mathrm{d}t}\,\mathrm{d}t$$

TI variation (Rozitis et al 2018)

$$\Gamma = \Gamma_0 r^{-\alpha}$$

where Γ_0 is the **TI at 1 au**

Assuming constant ρ and *C*, *K* varies as

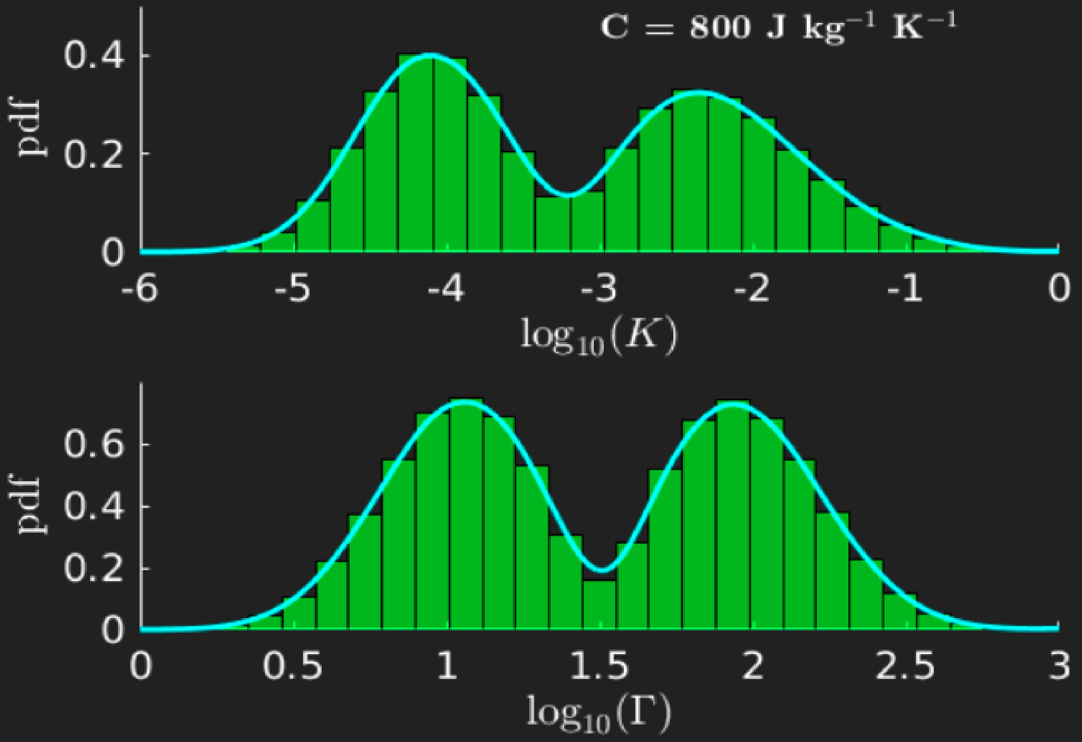
$$K = K_0 r^{-2\alpha}$$

where K_0 is the **conductivity at 1 au**

Some results: the case of 2011PT

2011PT: H ~ 24.1, e ~ 0.215, P ~ 11 min, da/dt ~ −0.00884 ± 0.00146 au/My

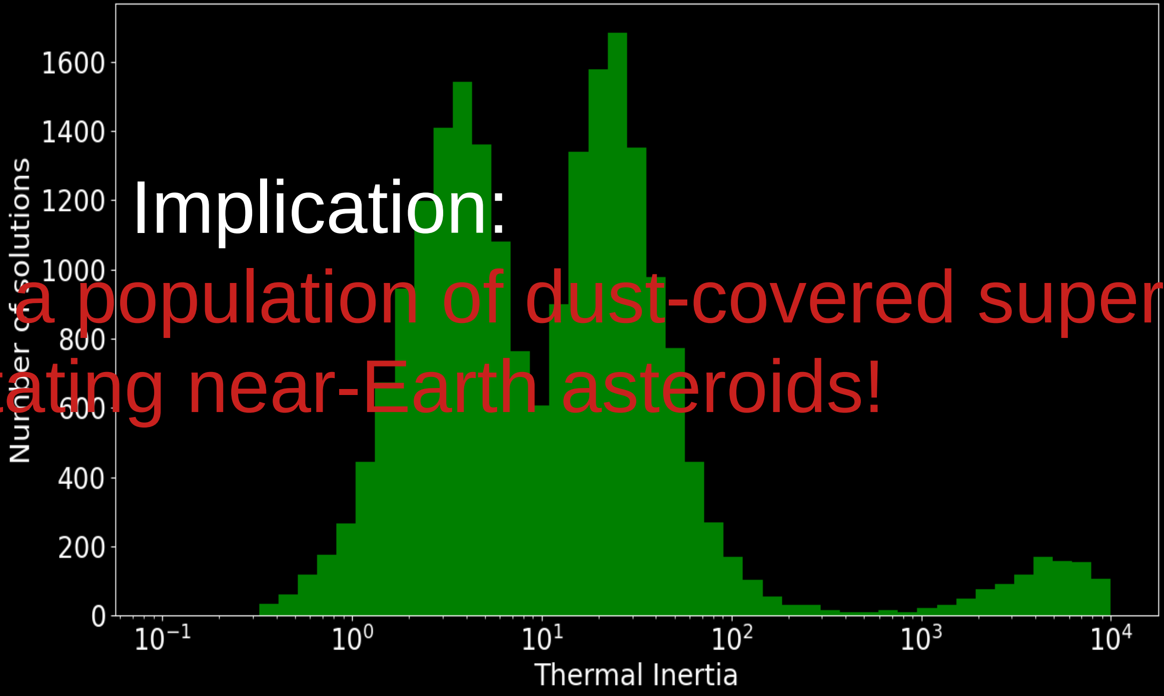
Result: very low TI



Some results: the case of 2016GE1

2016 GE1: H ~ 26.7, e ~ 0.52, P ~ 33 s, da/dt ~ -0.0583 ± 0.0187 au/My

Result: very low TI



Implication:

There could be a population of dust-covered super fast rotating near-Earth asteroids!

Thank you for your attention!

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