The low thermal conductivity of the super-fast rotator (499998) 2011 PT

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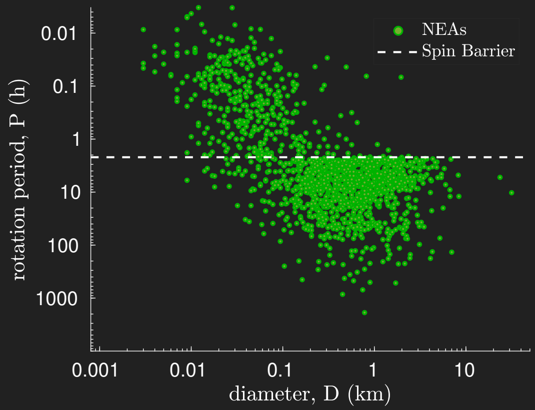
Motivation

It is supposed that:

- Small and fast rotators are **monolithic objects**
- Rocky monoliths have **high thermal inertia**
- High thermal inertia makes the Yarkovsky effect **less** effective

However:

- **Del Vigna et al. 2018** and **Greenberg et al. 2020** found small objects with fast Yarkovsky drift



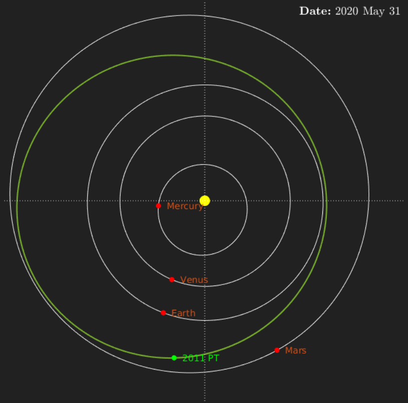
Case study: (499998) 2011 PT

Characteristics:

- $H \sim 24$ mag $\Rightarrow$ **D $\sim$ 35 m**
- $P \sim 11$ min
- **Yarkovsky effect** detected by
  - Del Vigna et al. 2018
  - Greenberg et al. 2020
  - JPL SBDB

Goal:

- Constrain the **thermal conductivity** (**thermal inertia**)



Methods: model vs. observed Yarkovsky drift

$$\left(\frac{\mathbf{da}}{\mathbf{dt}}\right)(\mathbf{a}, \mathbf{D}, \rho, \mathbf{K}, \mathbf{C}, \gamma, \mathbf{P}, \alpha, \varepsilon) = \left(\frac{\mathbf{da}}{\mathbf{dt}}\right)_{\mathbf{m}}$$

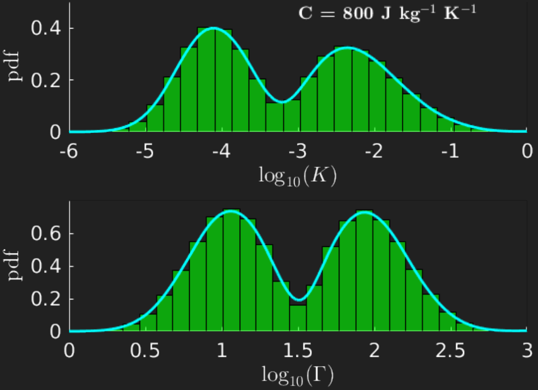
Parameters:

a	semimajor axis
D	diameter
ρ	density
K	thermal conductivity
C	heat capacity
γ	obliquity
P	rotation period

Method:

- Assume distributions for all the parameters but K
- Solve for K the model vs. observed equation
- Use a Monte Carlo method for statistical analysis

Results of the Monte Carlo simulations



- The distributions are always **bimodal**
- **First peak** in K at around

$$\sim \mathbf{7 \cdot 10^{-5}} \text{ W m}^{-1} \text{ K}^{-1}$$

- **Second peak** in K at around

$$\sim \mathbf{5 \cdot 10^{-3}} \text{ W m}^{-1} \text{ K}^{-1}$$

- $P(K < 0.1 \text{ W m}^{-1} \text{ K}^{-1}) > 0.95$

Comparison with other asteroids

The estimated thermal inertia for 2011 PT is

$$11^{+7}_{-5} \text{ and } 88^{+90}_{-45}$$

Low thermal inertia is usually associated to **regolith**

Asteroid	***D*** **(km)**	Γ **(J m^{-2} K^{-1} s$^{-1/2}$)**
Ceres	923	10 ± 10
Pallas	544	10 ± 10
Vesta	525	20 ± 15
Eros	17	150 ± 50
1950 DA	1.3	24 ± 20
Ryugu	0.87	225 ± 45
Bennu	0.49	310 ± 70
Itokawa	0.32	700 ± 200

Conclusions

- First evidence supporting the hypothesis that regolith can be retained on small and super-fast rotators (**Sanchez & Scheeres 2019**, *Icarus*)
- Large rocky boulders with low thermal inertia were found on **Bennu** and **Ryugu**. However, 2011 PT is an **E-type** asteroid.
- 2011 PT might be a rubble-pile, but it is highly unexpected

Future works and opened questions

- More studies and characterization of asteroids with $D < 100$ m are needed for the planning of *deflection* or *Asteroid Redirect* missions
- What are the processes and timescales of regolith formation on fast rotators?
- Is 2011 PT a good representative of the population of asteroids with $D < 100$ m?