EPSC Abstracts
Vol. 13, EPSC-DPS2019-1361-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Direct detections of the Yarkovsky drift with Gaia DR2

Federica Spoto (1), Paolo Tanga (1) and Benoit Carry (1,2)
(1) Université Côte d'Azur, Observatoire de la Côte d'Azur, CNRS, Laboratoire Lagrange, Nice, France
(2) IMCCE, Observatoire de Paris, Université PSL, CNRS, Sorbonne Université, Paris, France

1. Introduction

The ESA Gaia mission, currently surveying the sky from the Sun-Earth L_2 Lagrangian point down to magnitude 21 [4] has released the most detailed map of the Milky Way in April 2018. This second data release (DR2) contains 1.7 billion of stars with positions and proper motions, 1.3 billion of parallaxes, but for the first time also 22 months of epoch astrometry and photometry for more than 14 000 small bodies have been released [5], along with other new parameters [1].

The accuracy of the astrometry reported by Gaia is without precedents: it reaches the sub-mas level for the brighter objects (G $<$ 17.5) [5]. This uncommon and extreme astrometric precision opens new perspectives in the study of the small bodies population, and in particular in the detection of small non-gravitational perturbations.

The most important one is the Yarkovsky effect: it is the result of the recoil force acting on rotating bodies as a consequence of their anisotropic thermal emission [6]. It produces a semi-major axis drift, changing the orbit of small asteroids over long time span. Its direct detection is challenging, because it depends on physical properties (e.g. thermal inertia, obliquity, albedo) that are usually very difficult to measure. Other methods have been developed to directly detect the Yarkovsky effect from the astrometry [3, 2], but they need accurate observations covering tens of years.

We present our new direct detection of the Yarkovky effect obtained using a combination of the available ground-based observations and the new ultra-precise Gaia observations in DR2. From our detections, we also present new estimations of some physical parameters, like the density.

2. The sample

Gaia DR2 contains more than 14 000 asteroids. Most of them are main belt asteroids, but there are also Near-Earth asteroids and two Trans-neptunian objects. Furthermore, the majority of the asteroids are large bodies (larger than 5 km in diameter). Figure 1 shows the distribution of almost all the minor bodies in Gaia DR2 in the plane given by the orbital uncertainty (in au) and the diameter (in km). The blue points represent the near-Earth asteroids, while the light red points correspond to objects in the main belt.

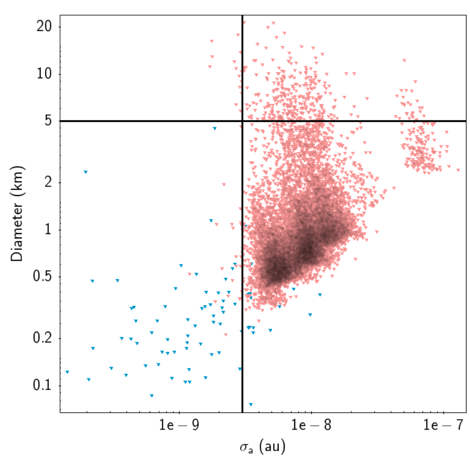

Figure 1: *Orbital uncertainty in au with respect the diameter in km for roughly the whole sample of objects in Gaia DR2. The blue points correspond to near-Earth asteroids, while the light red points represent the objects in the main belt. The two black lines mark the boundaries of the zone in which the Yarkovsky effect can be detected (quadrant on the bottom left)*

The Yarkovsky effect can be detected only on small objects (diameter less than 5 km, black horizontal line) and with very accurate orbits (we have set our threshold at $3e-9$ au, black vertical line). As a result, we have found 70 objects in Gaia DR2 meeting the requirements. It is worth noting that they are almost all near-Earth asteroids.

3. The method

Given the secular nature of the Yarkovsky effect, it cannot be detected using Gaia observations alone, which cover only 22 months. For each asteroid, we thus combine the whole set of available ground-based observations with the ones in Gaia DR2. The combination is a challenge itself, due to the enormous accuracy of Gaia observations, which are two orders of magnitude better than the ones from ground-based or other space telescopes. We have thus developed a new method to correct the already existing bias of ground-based astrometry reduced with old stellar catalogs (debiasing) and a new weighting scheme taking into account the performances of each observer for each catalog used, with respect to the year of the observation and the magnitude of the object.

4. The detections

We present our results:

- The detections of the Yarkovsky effect for a sub-sample of our initial list, which includes cases like (3200) Phaeton, which is the target of the DESTINY+ mission, and the binary asteroid (66391) $1999KW_4$, which will have a close encounter with the Earth in May 2019.
- The estimation of physical parameters for the same sub-sample of asteroids.

Acknowledgements

This work has made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

References

[1] Gaia Collaboration, Brown, A. G. A., Vallenari, A., Prusti, T. et al: Gaia Data Release 2. Summary of the contents and survey properties, Astronomy & Astrophysics, Vol. 616, 2018.

[2] Del Vigna, A., Faggioli, L., Milani, A. et al: Detecting the Yarkovsky effect among near-Earth asteroids from astrometric data, Astronomy & Astrophysics, Vol. 617, 2018.

[3] Farnocchia, D., Chesley, S. R., Vokrouhlický, D., et al: Near Earth Asteroids with measurable Yarkovsky effect, Icarus, Vol. 224, 2013.

[4] Gaia Collaboration, Prusti, T., de Bruijne, J. H. J., Brown, A. G. A. et al.: The Gaia mission, Astronomy & Astrophysics, Vol. 594, 2016.

[5] Gaia Collaboration, Spoto, F., Tanga, P., Mignard, F. et al.: Gaia Data Release 2. Observations of Solar System Objects, Astronomy & Astrophysics, Vol. 616, 2018.

[6] Vokrouhlický, D., Milani, A., Chesley, S. R.: Yarkovsky Effect on Small Near-Earth Asteroids: Mathematical Formulation and Examples, Icarus, Vol. 148, 2000.