EPSC Abstracts
Vol. 13, EPSC-DPS2019-512-1, 2019
EPSC-DPS Joint Meeting 2019

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

Solar System Science with ESA Euclid

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Abstract

The ESA Euclid mission has been designed to map the geometry of the dark Universe. Scheduled for launch in 2022, it will conduct a visible and near-infrared imaging survey over 15,000 deg^2 down to $V_{AB} \sim 24.5$. Although the survey will avoid ecliptic latitudes below 15°, the survey pattern in repeated sequences of four broad-band filters seems well-adapted to Solar System objects (SSOs) detection and characterization. I will present the expected the impact of Euclid on planetary sciences and the current status of the Solar System Science Working Group (SSO SWG) of the Euclid consortium.

1 Introduction

The ESA Euclid mission has been designed to map the geometry of the dark Universe. Scheduled for launch in 2022, it will conduct a six-years visible and near-infrared imaging and spectroscopic survey over 15,000 deg^2 down to $V_{AB} \sim 24.5$ (Laureijs et al., 2011). The 1.2 m telescope is equipped with two instruments: VIS, a visible camera and NISP, a near-infrared imager and spectrometer. The telescope has a large field of view of 0.57 deg^2, and a pixel scale of 0.1″ for VIS and 0.3″ for NISP.

Although the survey will avoid ecliptic latitudes below 15°, the survey pattern in repeated sequences of four broad-band filters seems well-adapted to Solar System objects (SSOs) detection (Lieu et al., 2019) and characterization (Carry, 2018).

2 Impact on Solar System Science

I will present how Euclid will constrain the orbits of SSOs, their morphology (activity and multiplicity), physical properties (rotation period, spin orientation, and 3-D shape), and surface composition (taxonomy and classification).

One of the key points of Euclid observations will be the extension of the spectral coverage provided by Gaia and the LSST to 2 microns (Fig. 1). This extended wavelength range is crucial to disentangle several compositionnal classes (DeMeo et al., 2009), and will allow to refine the spectral classification of SSOs down to kilometer-sized main-belt asteroids.

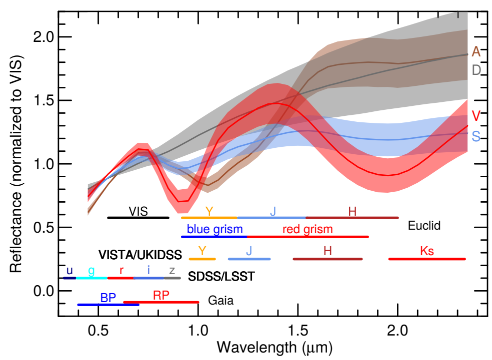

Figure 1: Examples of asteroid classes (A, D, S, and V) that are degenerate over the visible wavelength range. For reference, the wavelength coverage of each photometric filter and grism on board Euclid is shown, together with the filter sets of SDSS and LSST (u, g, r, i, z), VISTA and UKIDSS (Y, J, H, Ks), and the Gaia blue and red photometers (BP, RP).

The consecutive repeated observations of the same field by Euclid will provide 70 min-long lightcurves. Combined with sparse photometry such as measured by Gaia and the LSST, this time-resolved photometry will contribute to the determination of SSO rotation period, spin orientation, and 3-D shape model.

The point-spread function of Euclid will be at the diffraction limit of a 1.2 m telescope in space. This sharp angular resolution will allow to resolve binary systems in the Kuiper Belt and detect activity around Centaurs.

3 Expected number of objects

Using current census of SSOs to extrapolate the total amount of SSOs detectable by Euclid, Carry (2018) predicted that about 150,000 SSOs should be observed over the course of the survey (Fig. 2). These objects will be found in each population of SSO, from neighboring near-Earth asteroids (NEAs) to distant Kuiper-belt objects (KBOs) and including comets. These objects will however all have high inclination, which contrasts with many SSO surveys focusing on the ecliptic plane (Mahlke et al., 2018).

There is a potential for discovery of several 10^4 SSOs by Euclid, in particular distant KBOs at high positive declination, which will not be covered by LSST. The follow-up of these discoveries to secure orbits may however be challenging.

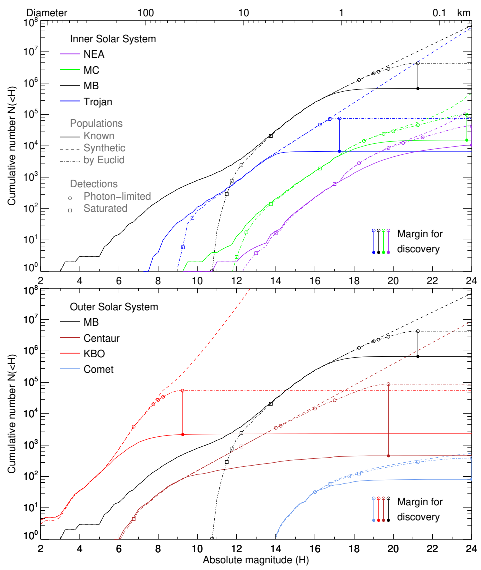

Figure 2: Cumulative size distribution of each SSO population, for current census (solid lines) and synthetic populations (dashed lines). The number of known objects, observable at Euclid limiting apparent magnitude over the entire celestial sphere, are represented by the dot-dashed lines. The total number of objects expected on the sky are marked by the filled circles. The difference between these filled circles and the current census represents the margin for discovery.

4. Summary

In summary, the depth of Euclid survey (V_{AB} ∼24.5), its spectral coverage (0.5 to 2.0 micron), and observation cadence has great potential for Solar System research. A dedicated processing for SSOs has been set in place within Euclid consortium to produce catalogs of astrometry, multi-color and time-resolved photometry, and spectral classification of some 10^5 SSOs, delivered as Legacy Science.

This group has so far prepared tools to simulate observations of SSOs by Euclid, and test detection algorithms. I will present the expected impact of Euclid and the preliminary results from the simulations.

Acknowledgements

BC is supported by CNES.

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