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Serendipitous asteroid observations by OSIRIS/Rosetta

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Abstract

In recent years, many efforts have been undertaken to extract the astrometry, photometry, and colors of Solar System Small Bodies from large surveys and wide-field camera, such as the SDSS Moving Object Catalog [2] or EuroNear [3]. Since 2006, the IMCCE provides a service, called `SkyBoT` [1], that list all the Solar System Objects in a given field of view for a given epoch. Such a tool is of high interest for any data mining purpose of large archives.

We will present an extension of `SkyBoT` from ground-based to space-based geometries. As a demonstration, we will present our search for serendipitously observed asteroids in the data archive of the OSIRIS instrument on-board the ESA Rosetta mission.

1. Introduction

With the advent of all-sky surveys with dedicated resources to detect and identify Solar System Objects (SSOs) like, for instance, the Catalina Sky Survey or PanSTARRS, the number of astrometric measurements of SSOs has literally sky-rocketed, leading to an increase of the numbered asteroids from a few thousands in the early 1990s to above 350 000 currently. This has allowed major advances in the study of the dynamics of these bodies, with, e.g., the identification of families and even pairs of asteroids [4]. The availability of a large number of photometric measurements also began a new era in the study of the geometric properties of asteroids, with the development of algorithms that allow to determine the spin and 3-D shape of these bodies [5]. Along with on-going surveys, a wealth of measurements, in both astrometry and photometry, are still to be unveiled in data archives. One of the main interests of these archives is the possible longer baseline in time that they may provide, allowing significant refinement of the uncertainty of orbital parameters.

2. Serendipitous observations

We call a serendipitous observation any observation of an asteroid that was **not** targeted. Contrary to objects with fixed coordinates such as stars or galaxies, it is not easy to identify a set of frames in an archive where a given SSO is present. The `SkyBoT` service [1] has been developed for that purpose. For any given geometry of observation (epoch and field of view), `SkyBoT` in a few seconds finds all the SSOs that are present in the field of view. Several projects and archives routinely use `SkyBoT` to identify SSOs, like the project EuroNear [3] or the W. M. Keck.

3. Development of SkyBoT

Because it was intended to provide timely answers to users through Internet requests, `SkyBoT` was designed for speed. Among the shortcuts used to optimize the algorithm, the geometry was limited to ground-based observations. However, there was a strong motivation to develop a version of `SkyBoT` for space-based observations. Indeed, asteroids are among the brightest sources of the sky in the mid-infrared (5–20 μm), and the flux, thermally emitted, at these wavelengths is one of the most critical observable to estimate their diameter and surface properties (albedo, thermal inertia).

4. OSIRIS on-board ESA Rosetta

We used the archive of the OSIRIS instrument on-board the ESA Rosetta space mission as a test bed. We chose OSIRIS because its two cameras have large fields of view (NAC: 2.2×2.2^{o} and WAC: 12×12^{o}), and its distance from the Earth, above the ecliptic plane, provides geometries of observations unreachable from Earth. These measurements are expected to provide strong constraints on the orbit of SSOs (see the interest of such observations in [6]). We are currently analyzing the whole NAC and WAC archives. For that, we:

1. list all the SSOs present in each field of view, using `SkyBoT` (see Fig. 1). We found more than 2 million of SSO observations in both NAC and WAC pointings.

2. discard SSO observations with an apparent magnitude fainter than the predicted limiting magnitude of the image (computed from the exposure time and the filter). This reduces the amount of SSOs to about 10^4 (estimates still in progress).

3. digest the images into an automatic pipeline to measure the astrometry and photometry of the sources, provided by `SkyBoT` (on-going analysis).

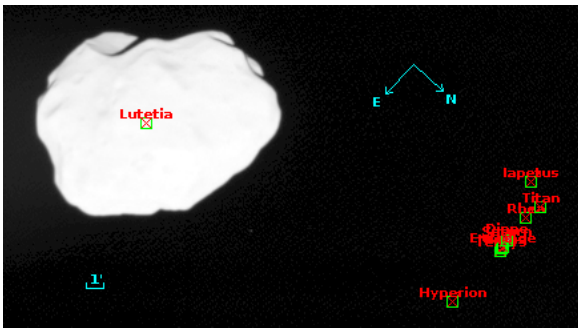

Figure 1: Screenshot of Aladin, showing an example of SSO identification in OSIRIS image. `SkyBoT` compellingly lists all the SSOs present in the field of view (Lutetia and Saturn), and even those fainter than the limiting magnitude (Saturn's satellites in this case).

5. Summary and Conclusions

Based on the motivation of accumulating astrometric and photometric measurement of Solar System Objects (SSOs) to refine their orbits and study their geometric properties, we updated the `SkyBoT` tool to allow the identification of SSOs in space-based observations. We are currently searching the archive of the OSIRIS instrument on-board ESA Rosetta for any non-targeted, serendipitous, observation of asteroids.

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