IDENTIFICATION OF ASTEROIDS USING THE VIRTUAL OBSERVATORY: THE WFCAM TRANSIT SURVEY

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Abstract

We describe here two complementary methodologies to identify and discover asteroids serendipitously observed in large-area astronomical surveys using Virtual Observatory tools such as SkyBoT, TOPCAT, and STILTS. The application of these methods on the WFCAM Transit Survey is demonstrated.

We provide more than 15,600 accurate positions (mean RMS 0.15 arcsec) and J-band magnitudes (typical accuracy of 0.11 mag) for over 1800 asteroids. From the repeated observations we build light curves and use them to provide shape models.

1. Introduction

Most of the ~750,000 solar system small bodies known today are asteroids. Their study is motivated by their intrinsic importance as remnants of the early stages of the solar system formation and by practical reasons concerning space exploration and their frequent impacts with the Earth.

Wide imaging surveys offer the opportunity to discover and characterize asteroids serendipitously observed (e.g. [1]). Among them, exoplanets surveys are excellent resources to get dense lightcurves of asteroids as both types of targets share similar observing requirements: large field of views (FOV), long sequences, and short cadence. Lightcurves can be then used to determine fundamental physical parameters of asteroids such as the asteroid's shape, rotational period or the scattering properties of the surface .

In this study we have made use of the WFCAM Transit Survey (WTS), with 200 nights over five years at the 3.8-m United Kingdom Infrared Telescope (UKIRT). The purpose of WTS was to perform the first ever systematic near-infrared search for transiting exo-planets around cool dwarfs. It ran as a backup programme when observing conditions were not good enough. As a consequence, the observations were not uniformly distributed over time.

WTS targeted four fields, each 1.6 square degrees in size, in J-band and observed them once in the ZY HK s filters. The four detectors of WFCAM cover 13.65 arcmin × 13.65 arcmin each and have a plate scale of 0.4 arcsec.

2. Methodologies

Two different and complementary methods were used to identify the asteroids in the WTS images. This allowed us to compare and validate the results obtained in both methods.

2.1 Sighted method

This method searched for detections of already known asteroids in the WST J-band images based on the prior information obtained from the Virtual Observatory (VO) compliant service SkyBoT (Sky Body Tracker, [2]).

2.2 Blind method

We applied the ssos pipeline to the WTS images [3], defined as a versatile tool to detect and identify Solar System objects in astronomical images that does not require prior knowledge, e.g. form SkyBoT queries, and therefore allows for the detection of both known and unknown asteroids.

3. Results

The Sighted method recovered 14532 positions of 1615 distinct asteroids. The Blind approach detected 1165 asteroids at 9897 positions.

Of the 9243 known asteroids recovered by the Blind method, 8768 (95%) were also recovered by the Sighted method. In addition, the Blind method detected 654 detections belonging to 182 unkown asteroids.

We ended up with 15661 detections corresponding to 1821 different asteroids. The number of asteroids as a function of the latitude in Fig. 1, which also represents each dynamical class with a different symbol. The completion limit of our survey is 18.9mag in the J band.

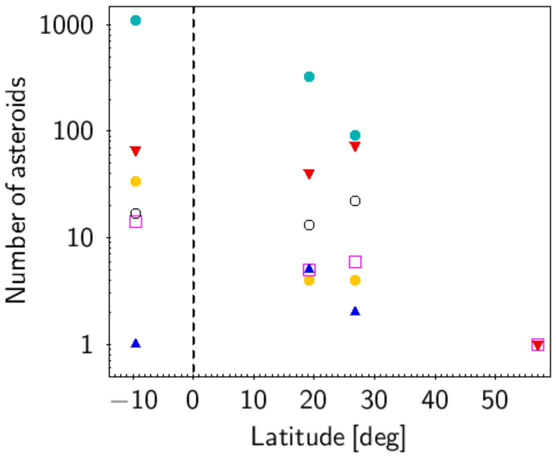

Figure 1. *Number of asteroids of each dynamical class as a function of the ecliptic latitude. Green filled circles stand for Main Belt asteroids, black oper circles for Hungaria objects, yellow filled circles for Jupiter's trojans, magenta open squares fors Mars-Crossers, blue filled up triangles for NEAs and red filled down triangles for new discovered asteroids. The black dashed line represents the ecliptic.*

We measured proper motions for 1794 asteroids, spanning from 0.5"/h to 124"/h.

We obtain an unique spin/shape solution by combining our data with photometry from the Lowell Observatory photometry database ([4], [5]). Five shape-spin models are presented, with periods ranging from 5.5 to 16.0h (see an example in Fig. 2).

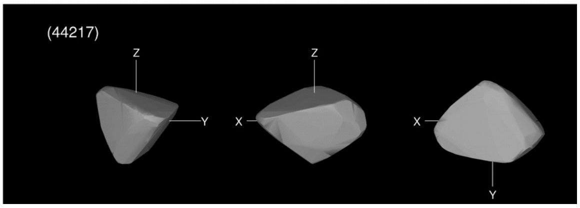

Figure 2. *Convex shape model of the asteroid ID 44217 corresponding to the first pole solution. Z is the rotation axis.*

4. Conclusions

In this work we present to different and complementary methods to search for asteroids serendipitously observed in archive images. Both methods were validated in the set of J band images of the WTFCAM Transit Survey collected in the framework of the RoPACS project. The two methods present more than 90% of common detections for known asteroids and one of them is able to identify 182 potential new discoveries.

Joining together the results of both methods we built a catalogue which is publicly available at the Spanish Virtual Observatory portal[1]. The catalogue contains 15661 detections of 1821 asteroids. This information was submitted to the Minor Planet Center to improve the orbital parameters of known asteroids and report the new ones.

We obtain spin/shape models for five asteroids from combined photometry with the Lowell Observatory photometry database.

The effectiveness of the two methodologies has been proved. They can, in fact, be applied to similar searches in other large-area astronomical surveys.

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