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Asteroid Science with the Palomar Transient Factory Survey

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Abstract

The Palomar Transient Factory (PTF) is a synoptic survey designed to explore the transient and variable sky. We use PTF observations of fields that were observed multiple times (≥ 10) per night, for several nights, to find asteroids, construct their lightcurves and measure their rotation periods. Here we briefly present our pipeline and preliminary results from a pilot program that covered an area of 21 deg^2 for three nights with ≈ 20 min cadence. Our pipeline was able to detect 558 unique asteroids, 128 of them were unknown. We present high quality rotation periods for 64 main belt asteroids. We estimate that implementing our search for all existing high cadence PTF data will be able to establish the rotation periods for ~10,000 minor planets.

1. Introduction – the PTF survey

The Palomar Transient Factory (PTF) is a fully-automated, wide-field survey aimed at a systematic exploration of the optical transient sky [1]. Operating daily, the survey uses 11 4Kx2K CCD array with 7.26 deg^2 field of view assembled on the 1.2-m Oschin Telescope at Palomar Observatory. With an exposure time of 60s the survey reaches a depth of ~21 mag. The PTF survey samples the fields of view in a variety of cadences to match the scientific goals of different programs such as the search for supernova and galactic variables.

2. Method

An automatic pipeline was written and is used on fields with >10 images per night, in order to detect known and unknown asteroids, derive their lightcurves and measure their rotation periods and shapes. The pipeline searches for moving sources in different rates. The observations are reported to the MPC and identified by its web service. For each asteroid we construct the lightcurve using relative photometry methods [2] and calibrate the magnitude against the Sloan Digital Sky Survey. The lightcurves are corrected for light-travel time and the rotation periods are found using two-harmonies Fourier series fitting.

3. Results

Our pilot run included three nights on February 2010. All together, we covered an area of 21 deg^2 on the ecliptic and detected 558 unique asteroids, 128 of them were unknown before. For example, a single field of view is presented in Fig. 1. Asteroids with diameters as small as hundreds of meters are visible (Fig. 2). All of the observed asteroids are part of the main belt of asteroids. The lightcurves of 64 objects have enough quality to measure their rotation periods. None of them have a published lightcurve. Upper/lower limits on the rotation periods derived for another 53 asteroids. Examples of six lightcurves are presented in Fig. 3.

4. Figures

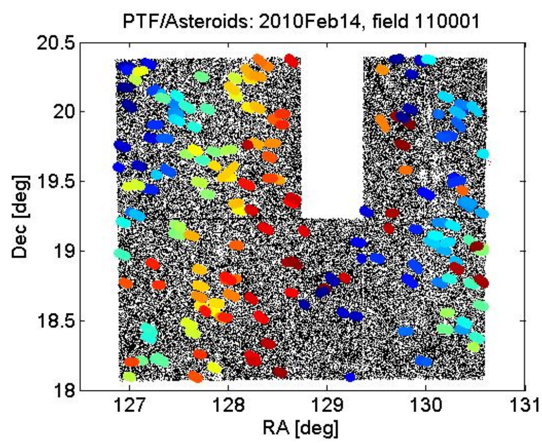

Figure 1: A single PTF field of view of 3.4x2.3 degrees. The colorful dots are asteroids detected above the fixed background sources (black dots). The missing rectangular is a malfunctioning chip.

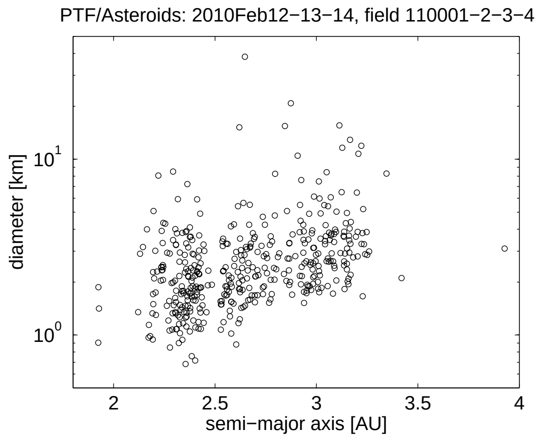

Figure 2: 430 of the detected objects have known orbits that allow us to estimate their sizes. Main belt asteroids as small as 700 m are seen in this sample.

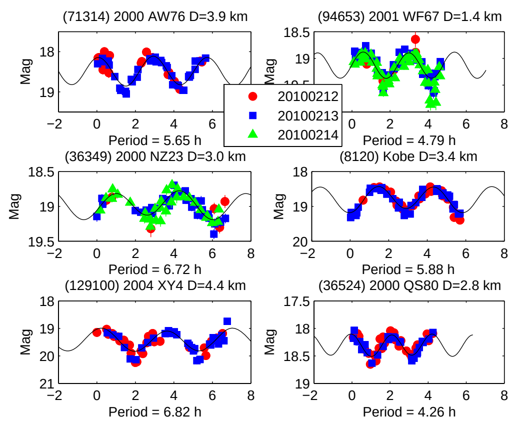

Figure 3: Example of six folded lightcurves revealing the asteroid rotation periods. Note that the diameter of these objects is smaller than 5 km.

4. Tables

Table 1: Rotation periods of 64 asteroids.

Asteroid	Rotation period	Asteroid	Rotation period
2960	5.31±0.01	*6262*	8.02±0.02
7270	7.53±0.06	*7728*	11.8±0.1
8120	5.88±0.04	*8128*	4.667±0.009
9921	8.01±0.03	*10121*	9.58±0.04
12845	3.52±0.02	*13246*	14.3±0.1
14164	11.81±0.09	*14197*	10.65±0.05
16228	7.23±0.08	*20601*	3.36±0.03
21705	3.46±0.01	*25171*	11.5±0.3
28509	5.04±0.04	*32553*	3.98±0.03
33934	5.8±0.1	*35005*	8.58±0.07
36349	6.72±0.04	*36402*	8.21±0.05
36524	4.26±0.02	*45259*	11.6±0.3
45601	3.37±0.02	*46672*	3.7±0.1
47149	9.54±0.08	*47154*	5.21±0.05
47714	10±3	*48233*	3.62±0.02
49766	6.7±0.1	*57394*	6.73±0.04
60527	6.01±0.07	*61378*	4.69±0.02
63429	9.1±0.8	*71314*	5.65±0.04
74421	3.64±0.02	*77829*	13.6±0.2
78296	5.28±0.05	*78420*	4.90±0.02
79721	10.1±0.3	*87028*	6.71±0.08
90896	7.38±0.04	*92519*	3.07±0.01
93335	6.26±0.06	*94653*	4.79±0.06
95796	7.2±0.1	*105026*	4.25±0.02
118217	5.8±0.6	*124374*	9.7±0.2
124966	5.56±0.04	*126334*	3.49±0.02
126935	6.05±0.03	*129100*	6.82±0.06
192591	4.62±0.03	*195812*	4.67±0.05
215701	6.00±0.09	*231717*	4.23±0.02
231958	4.52±0.05	*2010CV249*	5.8±0.2
2010CA149	5.04±0.01	*P0001U*	3.2±0.1
P000ZL	2.5±0.2	*P00038*	6.8±0.4

6. Summary and Conclusions

The PTF is an efficient survey to detect asteroids and to study their rotation periods. While watching the ecliptic, the PTF survey observes on average 26.5 asteroids in one square degree. Using the entire archive of the PTF we predict our automatic pipeline will find millions of asteroids in the main belt including small members of dynamical families and secondary members of rotationally-disintegrated objects. ~10,000 rotation periods will be derived, making the PTF the largest sample of asteroid rotation periods and will allow studying spin distribution of km-sized objects. The PTF data is also efficient in detecting near-Earth asteroids, trans-Neptunian objects and binary asteroids.

References

[1] Law, N.M. et al.: The Palomar Transient Factory: System Overview, Performance, and First Results, *PASP*, Vol. 121, pp. 1395-1408, 2009.

[2] Ofek, E.O. et al.: A VLA search for 5 GHz radio transients and variables at low Galactic latitudes, arXiv:1103.3010, 2011.