A search for active asteroids with the Palomar Transient Factory survey

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The Palomar Transient Factory (PTF; Law et al. 2009; Rau et al. 2009, http://www.astro.caltech.edu/ptf)) is a synoptic survey designed to explore the transient and variable optical sky. PTF images are 60-second exposures of 7.26 deg^2 of sky, in either SDSS-g or Mould-R band, at 1.01 arcsec per pixel resolution, obtained with the 1.2-meter Oschin Schmidt telescope at Palomar Mountain, equipped with the refurbished CFHT12k camera (Rahmer et al. 2008). Using original software, we perform an automated, untargeted search for small solar system bodies in PTF images collected during the survey's first three years of operation (March 2009 through March 2012). We search the resulting database of small body observations for new occurrences of comet-like activity.

The currently known group of active asteroids (Jewitt 2012), including the potentially ice-bearing subset of main-belt comets (Hsieh & Jewitt 2006, Hsieh et al. 2012a), consists both of objects which were initially discovered as active and objects which were initially discovered as inert and later found to be cometary. Therefore in this study we seek to observe new objects (when the cadences are conducive to discovery) in addition to observing known asteroids. For fields observed three of more times in a night, we extract observations of all moving objects using the motion-detection pipeline described by Polishook et al. (2012), while fields observed less than three times in a night are searched for known objects using the JPL small-body database and HORIZONS ephemeris generator (Giorgini et al. 1996).

Prior to our search, all images are processed by the IPAC-PTF pipeline (Grillmair et al. 2010, Laher et al. in prep.), in which the astrometric reduction program SExtractor (Bertin & Arnouts 1996) generates a catalog of sources in each image, including their astrometry and instrumental photometry. The ratio of an object's total brightness above background to its maximum surface brightness (specifically, this ratio's deviation from a typical stellar value), is used to search for resolved activity. This zero-dimensional parameter plays a similar role in activity detection to the full-width at half maximum (FWHM) and has been shown to be at least as robust, and has already lead to the discovery of cometary activity in at least one previously asteroidally-designated object (Waszczak et al. 2011).

We supplement the mostly highly-accurate, SDSS-calibrated (York et al. 2000) PTF apparent magnitudes (Ofek et al. 2012) with less-precise, less accurate but longer-term external survey data retrieved from the Minor Planet Center (http://www.minorplanetcenter.net) in an attempt to identify statistically significant secular or periodic brightening. The use of an external survey's data is only merited if that survey's long-term variability of several-kilometer in diameter outer main-belt objects (e.g. due to temporal calibration variation or shape rotation and aspect angle changes) are first well-characterized. Hence, a careful assessment of such variability in MPC data was first conducted as a part of this study.

Active observations of the two most recently discovered active asteroids, P/2010 R2 La Sagra (Hsieh et al. 2012a) and P/2006 VW139 (Hsieh et al. 2012b) occur in our existing dataset, along with hundreds of Oort-cloud and Jupiter-family comets. These serve to train our detection algorithm. To date we have obtained over two million observations of known small bodies, and are in the process of extracting moving objects with the pipeline of Polishook et al. (2012).

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