ASTROMETRIC AND PHOTOMETRIC FOLLOW-UP OF POTENTIALLY HAZARDOUS ASTEROIDS USING JOAN ORÓ ROBOTIC TELESCOPE AT MONTSEC ASTRONOMICAL OBSERVATORY.

M. Moreno-Ibáñez[1], J. M. Trigo-Rodríguez[1], D. Rodríguez[2], and A. Sánchez[3]. [1]Institute of Space Sciences (CSIC-IEEC), Campus UAB, Facultat de Ciències, Torre C5-2ª planta. 08193 Bellaterra, Spain (trigo@ice.csic.es); [2]Guadarrama Observatory, Villalba, Madrid, Spain; [3] Gualba Observatory (MPC 442), Gualba, Barcelona, Spain.

Introduction: An important fraction of the Near Earth Object (NEO) population is formed by dark bodies that are suspicious of being dormant comets. It is roughly estimated that about a 10% of the NEOs are Jupiter-family comets (JFCs), but most come from the Main asteroid Belt (MB) [1]. These transition objects that represent the last stages of cometary evolution are among the most fascinating objects that we can find in the Earth's vicinity, and are important contributors to present impact hazard [2]. In fact, they are particularly dangerous projectiles because they have extremely low albedos with surface reflectivity typically below 0.04. Our research group is not only studying plausible meteorite analogs for these bodies [3], but also monitoring some of these NEOs with the Joan Oró robotic telescope (Fig. 1) at *Observatori Astronòmic del Montsec* (OAdM: www.oadm.cat) and other medium-sized telescopes. Our main goals are contributing to improve their orbits by performing accurate astrometric measurements, obtaining broadband photometry, rotational periods, and identifying cometary-like activity [4,5].

Methods: Accurate astrometric measurements of 30s or 60s guided exposures are reduced and submitted to the Minor Planet Center. Our program also includes ground-based photometry using standard Johnson-Cousin filters, mostly in V, R, and I filters in order to get color indexes. Guided exposures are often stacked to achieve good signal/noise ratios in order to determine the presence or absence of cometary activity from the FWHM statistics and photometric growth curves.

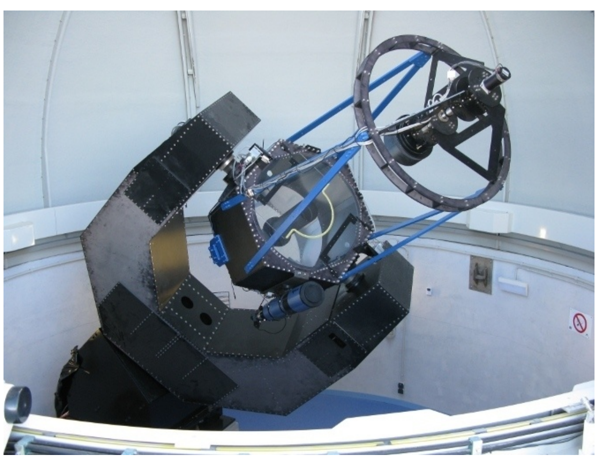

Figure 1. Joan Oró Telescope (TJO) at OAdM.

Results: Our monitoring effort involves several observatories listed in Table 1. Our photometric coverage for simplicity has been focused in standard measurements in V, R and I filters. Photometry is standardized to an aperture of 10 arcsec and photometric growth curves are studied using increasing photometric apertures, as the growth curve of an extended object soon departs from that of a point like source. Using that approach we cover the photometric and full width at half maximum evolution of each NEO to be able to detect possible traces of cometary activity.

Observatory (MPC code)	Instrument
Gualba, Barcelona (442)	SC 36.0 f/7
Guadarrama, Madrid (458)	SC 25 f/10
Montsec, TJO, OAdM	RCT 80.0 f/9.6

Table 1. Observatories involved in the present studies.

The NEOs and Main Belt (MB) asteroids monitored during 2014 appear listed in Table 2.

Target	Classification
1862 Apollo (1932 HA)	Apollo (PHA)
3200 Phaeton (1983 TB)	Apollo (PHA)
85713 (1998 SS49)	Apollo (PHA)
97249 (1999 XT106)	MB asteroid
138852 (2000 WN10)	Apollo
204131 (2003 YL)	Apollo
214088 (2004 JN13)	Apollo
294739 (2008 CM)	Apollo (PHA)
345705 (2006 VB14)	Aten
412976 (1987 WC)	Amor
2014 MQ67	Amor

Table 2. Main asteroidal targets followed during 2014.

Due to their faintness, most of the targets listed in Table 2 were only observed under Earth approaches. Most NEOs are selected to exhibit solar elongation larger than 90º and a V magnitude in the +14 and +19 range. In that way, we optimize the S/N ratio and the quality of broadband photometry. It is interesting to remark that a significant number of NEOs have significant astrometric and photometric differences in reference with the ephemerids. A photometric example is 2008 CM that was almost a magnitude brighter (V +17.0) than expected in MPC ephemerides (see Fig. 2).

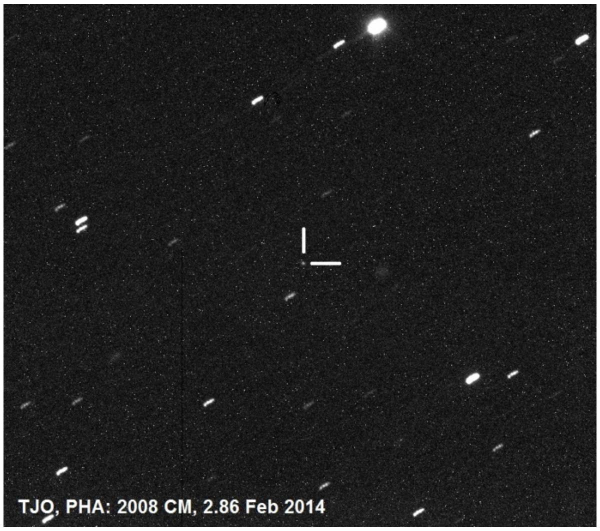

Figure 2. PHA 2008 CM observed on 2.86 Feb. 2014 at TJO (OAdM).

Some selected targets have been extensively monitored during constrained periods from our observatories in order to get accurate rotational periods. Despite of this, many NEOs are fast rotators, and irregular shapes that give as a result quite chaotic light curves like this exemplified in Fig. 3 for Aten 2006 VB14.

Conclusions: We have exemplified the NEO monitoring task that is being currently made from OAdM. Given the medium size of the TJO, its main scientific niche is the time-domain astronomy, where continuous observations are a key requisite. NEO observations are, obviously, inside this niche but still require a higher cadence that is currently provided by some amateur observatories. The main advantage of our telescopic follow-up is a flexible and robotic operation mode allowing for the monitoring of sources during extended time periods and under a rapid reaction time. It has been previously demonstrated the importance of such continuous photometric monitoring programs in MB asteroids [5,6], or in comets, e.g. [7].

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References: [1] Bottke, W.F. et al. (2002) Icarus 156, 399; [2] Bottke, W.F. and Morbidelli, A. (2006), *Planetary Chronology Workshop*, LPI publ., abstract #6019. [3] Trigo-Rodríguez J.M. et al. (2014) *MNRAS*, 437, 227-240. [4] Trigo-Rodríguez et al. (2009) *EPSC* Vol.**4**, abstract #739. [5] Jewitt D. (2012) *The Astronomical J. 143,* 66. [6] Cikota S. et al. (2014) A&A 562, id.A94. [7] Trigo-Rodríguez J.M. et al. (2010) *MNRAS*, 409, 1682-1690.

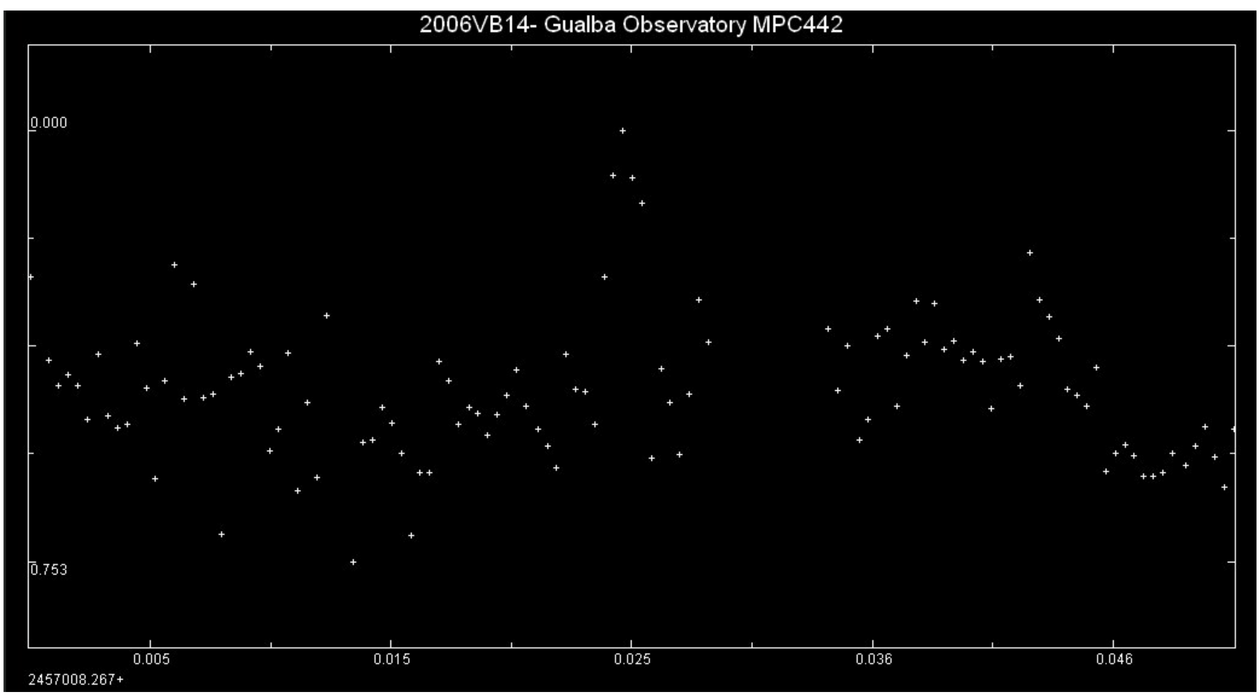

Figure 3. Julian Date versum differential magnitude for 2006 VB14 as monitored from MPC