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Physical characterization of near-Earth asteroid (159402) 1999 AP10 in support of the Arecibo Planetary Radar Program within the NEOROCKS project.

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Introduction. The near-Earth object (NEO) population is composed of asteroids and comets that have orbits close to the Earth. This population is the most accesible vestige from the building blocks that formed the Solar System, for spacecrafts, and for detailed observations from ground-based facilities. The proximity of these objects give us advantages, but also risks. The NEO Rapid Observation, Characterization and Key Simulations (NEOROCKS) project has been recently funded (2020-2022) through the H2020 European Commission programme to improve the knowledge on NEOs by connecting expertise in performing small body astronomical observations and the related modelling needed to derive their dynamical and physical properties. The IAC, and in particular members of the Solar System Group, participate in the NEOROCKS project and are currently leading one specific task to do observations of NEOs in support of the Arecibo Planetary Radar Program, using the facilities located at the Observatorios de Canarias (OOCC) and managed by IAC. These observations include times-series photometry (light curves), visible to near-infrared spectroscopy, and color photometry. We are focusing in those targets observed in the past by the Arecibo telescope and which have high signal-to-noise (SNR) radar data. In this work we present the results obtained for asteroid (159402) 1999 AP10.

Observations. Our observations included spectroscopy and time-series photometry – over the visible wavelength. Spectroscopic data were obtained with the ALFOSC spectrograph at the 2.5-m Nordical Optical Telescope (NOT), located at the El Roque de Los Muchachos Observatory (La Palma). A solar analogue star was observed at the same airmass as that of the asteroid. Data reduction followed standard procedures and was done using IRAF tasks. The spectra were bias and flat-field corrected before extracted and collapsed to one dimension. We wavelength calibrated both the spectra of the asteroid and solar analogue using ThAr+Ne+He lamps. In a final step, we divided the spectrum of the asteroid by the spectrum of the solar analogue to obtain the asteroid reflectance. In the attempt to obtain the rotational properties as rotational period, spin direction and shape model for the asteroid (159402) 1999 AP10, we did light curve observations between 2020 and 2021 using the TAR2 at TAR (Remote Open Telescope, *Telescopio Abierto Remoto*) installation. This telescope is a robotic observatory with two 42 cm diameter Centurion telescopes (TAR1 and

TAR2), equipped with high-sensitivity FLI-Kepler sCMOS cameras and located at Teide Observatory (Tenerife). The observations at TAR2 were performed using the clear filter. To process the photometric images and to obtain the magnitudes we used the Photometry Pipeline (PP) developed by Mommert (2017). We used the software MPO Canopus to obtain the rotational period from the light curves. For the determination of the photometric shape model, we used the programs described by the model from Kaasalainen and Torppa (2001) and Kaasalainen et al., (2001).

Results. In Fig. 1, we present the spectrum over the visible wavelengths of the asteroid (159402) 1999 AP10, it is normalized to unity at 0.55 µm (black points). We used the M4AST Tool (Popescu et al. 2012; http://spectre.imcce.fr/m4ast/index.php/index/home) to obtain a taxonomical classification of this object, finding that it best fits into the S-complex (DeMeo et al. 2009), i.e., it is composed mainly of silicates.

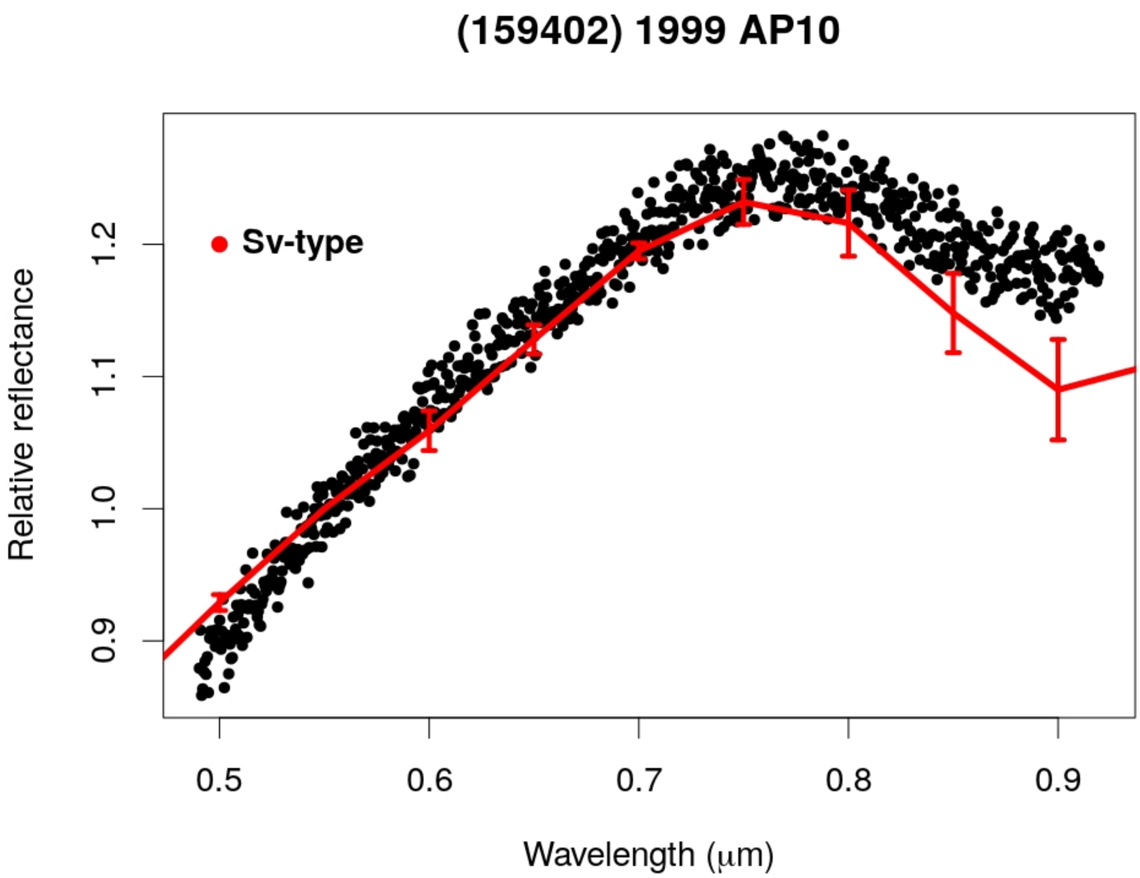

Figure 1: The spectrum of (159402) 1999 AP10 (black points). The spectral curve is normalized to unity at 0.55 µm. Using the M4AST we have the curve of the best fit in red lines from taxonomic classification of Sv-type.

Time-series photometry is a very efficient technique to obtain asteroid physical properties like rotation period, spin orientation, size, and shape. In the JPL webpage (https://ssd.jpl.nasa.gov/sbdb.cgi) the rotational period for the asteroid (159402) 1999 AP10 is 7.908 h. Using our light curves (with MPO Canopus), we obtain a rotational period of 7.9176 +/- 0.0152 h, and a light curve amplitude of 0.28 mag. The Fig.2 shows the light curves used to find the best fit and the rotational period. The obtained value for the period is in good agreement with the one listed at JPL.

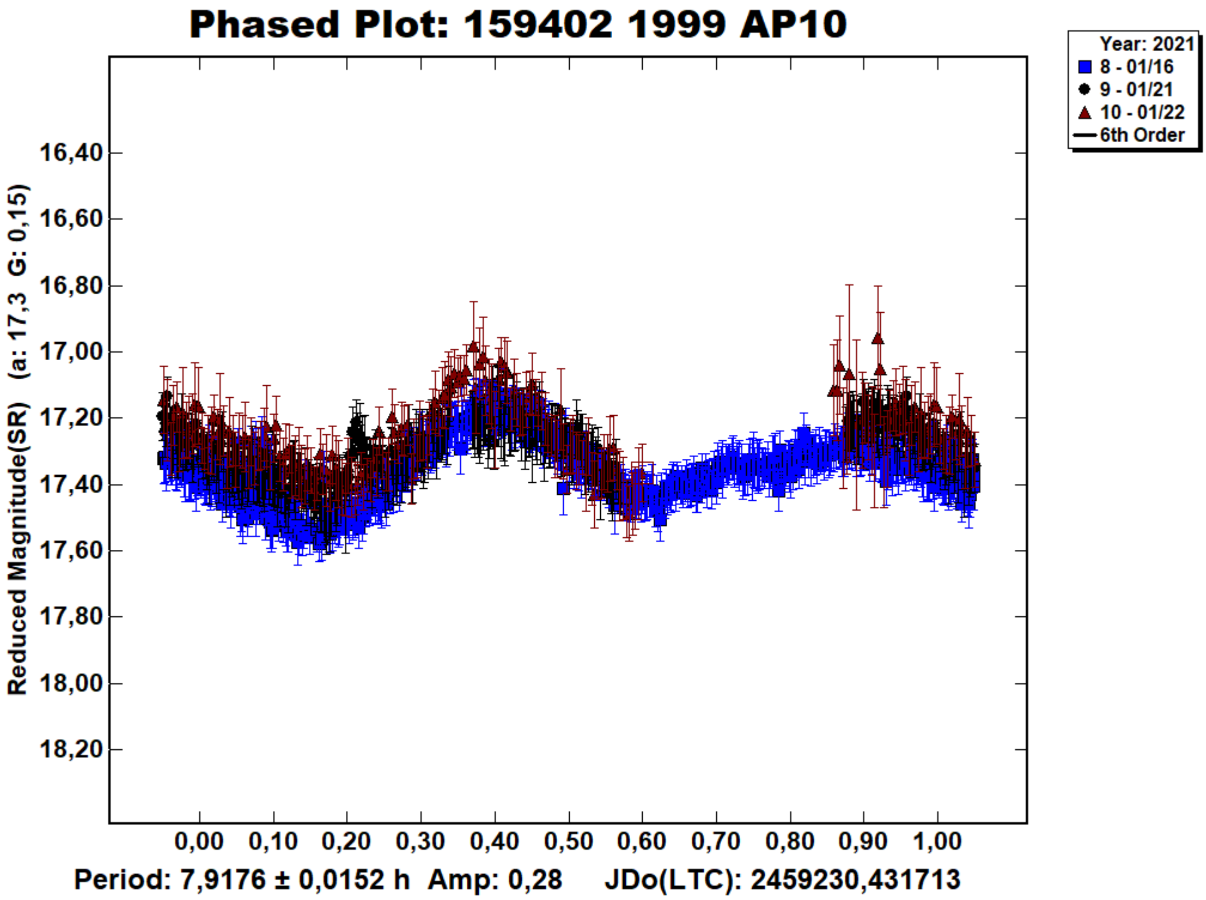

Figure 2: Three light curves of the asteroid (159402) 1999 AP10 from January, 2021. We did the fit on MPO Canopus and we obtained the rotational period of 7.917 +/- 0.0152 h and a light curve amplitude of 0.28.

By obtaining rotational data from an asteroid at different viewing geometries allows to determine its photometric shape model (Kaasalainen and Torppa 2001; Kaasalainen et al. 2001). We observed the asteroid (159402) 1999 AP10 at several viewing geometries. Thus, we will present two preliminary photometric shape models, the first with only the data obtained by us and the second with our data plus data from the Asteroid Lightcurve Photometry Database.

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