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Radar shape modeling and physical characterization of the PHA 1998 OR2

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On April 29th 2020, the potentially hazardous asteroid (52768) 1998 OR2 (herafter OR2) flew-by the Earth at a distance of 16.4 Lunar distances. OR2 is a near-Earth object of absolute magnitude H = 16 that can experience close approaches to Earth as close as 6 Lunar distances.

During this fly-by we obtained high SNR Arecibo S-band (2380 MHz; 12.6 cm) radar delay-Doppler images between Apr 13-23. We also obtained polarimetric observations with the ToPol polarimeter [1] mounted on the Omicron-West 1-m telescope from the Calern Observatory, Nice, France. These polarimetric observations span a range of phase angles from 30° to 77° allowing detailed characterization of the positive branch of 1998 OR2 phase-polarization curve. We also obtained new photometric observations with the Trappist-North telescope [2] located at the Oukaimeden Observatory in Morroco.

Using the radar delay-Doppler and the lightcurve observations, we derived a non-convex shape model of 1998 OR2. This model displays a typical top-shape (diamond-like) model with an equivalent diameter of 1.6 km. The spin axis solution is oriented toward 330° +- 10° of ecliptic longitude and 23° +- 10° of ecliptic latitude with a rotation period of 4.1084 +- 0.0001 hours. Top-shape asteroids are typical for near-Earth objects as it had been observed for the asteroids Bennu [3], Ryugu [4], or Moshup [5]. Radar shape modeling has already been proven to be effective in modeling these type of asteroid as the radar shape model of Bennu [3], that was obtained before the Osiris-Rex mission, proved to be highly accurate.

OR2 delay-Doppler images are characterized by the presence of a large feature visible on the leading edge of the echo. The shape model shows that this feature is a crater located near the equator. The shape model also shows that there are other craters/concavities formations mostly located on one-side of OR2 while the other side is lacking large scale structures.

The polarimetric observations of OR2 displays a phase-polarization curve typical of moderate albedo objects with a polarization of 8.3% at a phase angle of 77.5°. The degree of linear polarization (especially at large phase angles) of an asteroid is directly correlated with its albedo. At a similar phase angle, the low albedo asteroid (3200) Phaethon (pv = 0.107 +- 0.011 [6]) is displaying a

polarization of 27.3% [7] while the high albedo object E-type 1998 WT24 (pv = 0.654 +- 0.13 [8]) only displays a polarization around 1.5% [9].

Polarimetric observations were also collected over several hours during the same nights in order to obtain time-series. Folding the polarimetric data according to the rotation period of OR2, we observed that the degree of linear polarization is dependant on the rotation phase angle. Such variation means that the surface of OR2 displays heterogeneities that can be either due to a variation of albedo or grain size over the surface. We also observe that the maximum of the polarization occurs when crater is facing the observer.

In conclusion, we obtained new radar, polarimetric, and photometric data of 1998 OR2 during its close approach to Earth on April 2020. These observations allowed us to obtain a non-convex shape model displaying a spin axis orientation of (330°,23°) with a rotation period of P = 4.1084 +- 0.0001 hours. The shape model displays large scale structures like concavities and craters. The polarimetric observations display variation of the polarization locked with the rotation phase angle of 1998 OR2 that seems to be correlated with the large structures observed on the shape model.

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