Physical characterization of equal-mass binary near-Earth asteroid 2017 YE5: a possible dormant Jupiter-family comet

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Introduction

The identification of binary systems among the near-Earth asteroids (NEAs) has grown considerably in recent years, mainly due to detections made by radar observations and to the increase in the number of photometric lightcurves. It is estimated that about 15% of the NEAs population larger than 0.3 km are to be binaries, while other 15% can be contact binaries (Pravec et al. 2006; Margot et al. 2015). Most of these binaries consist of one larger primary component and a small secondary component (or satellite), with the primaries having almost spherical shapes and fast rotations. On the other hand, less than 1% of the binary asteroids discovered among the NEA population have components of almost equal size, such as (69230) Hermes, (190166) 2005 UP156, 1994 CJ1 and 2017 YE5. Here, we report a complete physical characterization of the 2017 YE5 system.

Observations and data reduction

Photometric lightcurve observations of the nearly equal-mass binary near-Earth asteroid 2017 YE5 were carried out at the Observatório Astronômico do Sertão de Itaparica (OASI, Brazil) and the Blue Mountains Observatory (BMO, Australia) between July and August 2018. Additionally, using the Observatorio Astronómico Nacional de San Pedro Mártir (OAN-SPM, Mexico), we observed 2017 YE5 system using photometry with four different broadband filters (BVRI Johnson-Cousins filters) to obtain its photometric spectrum and color indices. Data reduction was performed using the MaxIm DL software following the standard procedures of flat-field correction and sky subtraction. To generate the lightcurves, we obtained the reduced magnitude, i.e., the corrected magnitude to a unity distance by applying -5 log(rΔ) to the observed magnitudes with r and Δ being, respectively, the asteroid’s distances from the Sun and from the Earth in AU. To investigate binary periods we used the “Dual Period Search” tool in MPO Canopus software which is based on the method described by Pravec and collaborators (Pravec et al. 2006). To obtain the color indices and the photometric spectrum of 2017 YE5, we used standard field stars to calculate the zero-point of the night and, consequently, the calibrated magnitude of the asteroid. Thus, the photometric spectrum was derived from the observed color indices minus the solar color indices and transformed to normalized reflectance at the V filter.
Results

We found that 2017 YE5 system has a mutual orbital period of $P_{\text{orb}} = 23.7 \pm 0.01 \text{ h}$ and a secondary short period of $P_2 = 14.88 \pm 0.02 \text{ h}$, indicating a possible asynchronous component or non-principal axis rotator in this system (Monteiro et al., submitted). These results are in good agreement with those reported by radar observations (Taylor et al. 2018, 2019). Our result for the orbital period of the binary system is shown in the Figure below. We derived the mean density of 2017 YE5 is from 0.6 to 1.2 g/cm$^3$, implying a rubble-pile internal structure for the components.

Infrared data obtained at the NASA's IRTF, made available by the MIT-Hawaii Near-Earth Object Survey (MITHNEOS), exhibited a thermal emission in the 2.5 μm range for which we adjusted a low albedo of 2-4% by applying a thermal model (Rivkin et al. 2005). Figure below shows the original infrared spectrum of 2017 YE5 displaying a thermal emission at long wavelengths in the 2.5 μm range and also shows the corrected spectrum after removal of the thermal tail. In addition, we
classified the thermally corrected spectrum of 2017 YE5 as a D-type asteroid in the Bus-DeMeo taxonomy. All results presented in this section were recently submitted (Monteiro et al., submitted).

Conclusions

Our physical characterization of this binary system sheds light on its physical properties, including rotational and orbital period, albedo and taxonomic type. We suggest that 2017 YE5 has a cometary origin, due to its comet-like albedo and orbit ($T_J = 2.87$). It is important to mention that, while suggesting that 2017 YE5 is a dormant Jupiter-family binary comet, we do not reject that it came from the outer main-belt.

Acknowledgements

F.M. thanks the financial support given by FAPERJ (E-26/201.877/2020). E.R., M.S., M.C. and P.A. would like to thank CAPES and CNPq (Brazilian funding agencies) for supporting this work through diverse fellowships. Support by CNPq (305409/2016-6) and FAPERJ (E-26/202.841/2017) is acknowledged by D.L. The authors are grateful to R. Souza and A. Santiago for the technical support, and the OAN-SPM team. The authors are also grateful to Andy Rivkin for help with the correction of spectrum for thermal excess in order to constrain the albedo.

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