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Study of the surface composition and dynamical evolution of two retrograde objects in the outer Solar System.

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Abstract

In this work we present observations of 2005 VD ($q/e/i = 5.012AU/0.249/172.902°$) and 2008 YB_3 ($q/e/i = 6.486AU/0.444/105.035°$). Both objects move in retrograde orbits and have perihelion distances in the region of the giant planets. We study their surface composition and dynamical evolution to put them in the context of the actual knowledge about "peculiar" minor objects in extreme orbits.

1. Introduction

The origin of icy minor bodies in retrograde or high-inclination orbits, with semi-major axis in the region of the giant planets is puzzling. Most of the TNOs and Centaurs move in orbits with inclinations below 40°. Duncan & Levison (1997, [1]) explain that inclinations up to 50° could be produced in "normal" evolution that scatters TNOs after encounters with the giant planets to large distances. Eventual evolution brings back these scattered objects into the region of the giant planets becoming Centaurs. But they as well explain that it is very difficult to reach higher inclinations by this process. Gladman et al. (2009, [2]) report the recent discovery of the first retrograde TNO and discuss different scenarios for its origin. Furthermore, the population of objects with inclination larger than 70° and large perihelion ($q \geq 15$ AU) has been studied by [3]. Both works agree in suggesting an origin in the Oort could for these objects or in a currently unobserved reservoir of TNOs with large eccentricities.

Finally, there is another population that contains objects moving in orbits with high inclination, these are the Damocloids [4]. These minor icy objects are supposed to be the nuclei of Halley-type comets.

The goal of this work is the study of two interesting objects, 2005 VD and 2008 YB_3. Both have a, q and i values that make them compatible with being both, Centaurs or Damocloids.

2. Observations and Analysis

We obtained photometric measurements of both, 2005 VD and 2008 YB_3, while spectroscopy was only obtained for the latter. The observational campaign involved several telescopes: SOAR Telescope, 1-m telescope at Cerro Tololo Inter-American Observatory (CTIO), Telescopio Nazionale Galileo (TNG), WISE Observatory and the ESO-Very Large Telescope Unit-2. These observations allow us to calculate color indexes in the visible for both objects, the light-curve of 2008 YB_3 and UV-Vis-NIR spectra (at two different dates) for the last one. All of them were reduced and analyzed using standard photometric and spectroscopic techniques.

A detailed analysis of these data [5] allows us to extract some information on the surface composition of these peculiar objects. We put this information in comparison with the colors and spectra of other minor icy objects as it can be seen in Figures 1 and 2.

3. Dynamical Evolution

Trying to asses the possible origin for these objects we integrated their orbital elements to the past up to 10^8 years. We also integrated the orbits of 100 clones for each of them and generated residence time maps as a function of semi-major axis and inclination and also as a function of aphelion and perihelion distance.

4. Summary and Conclusions

Colors and spectra of 2005 VD and 2008 YB_3 are compatible with a surface covered by a mantle of slightly red dust. No evidence of ices on the surface has been found. The dynamical evolution is different

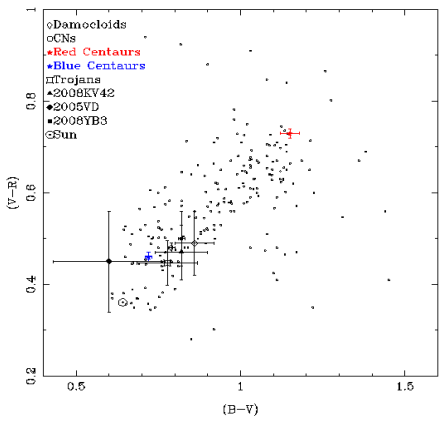

Figure 1: (B-V) vs (V-R) color indexes of 2008 YB_3 and 2005 VD. We include colors of some other primitive minor bodies, including 2008 KV_{42}, a retrograde TNO.

for each object but both are compatible with an origin in the outer realms of the Solar System, even the very distant region of the Oort Cloud.

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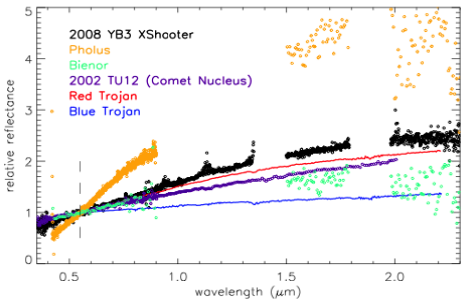

Figure 2: We show the comparison of the spectrum of 2008 YB_3 obtained with X-Shooter and some other primitive minor bodies available in the literature.

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