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A common origin for dynamically associated near-Earth asteroid pairs

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Abstract

We present spectroscopic data and analysis that supports the existence of two genetically related asteroid pairs in near-Earth space. The members of the individual systems, 2015 EE7 – 2015 FP124 and 2017 SN16 – 2018 RY7, are found to be of the same spectral taxonomic class, and both pairs are interpreted to have volatile-poor compositions. In conjunction with dynamical arguments, this suggests that these systems formed via YORP spin-up and/or dissociation of a binary precursor. Backwards orbital integrations suggest a separation age of < 10 kyr for the pair 2017 SN16 – 2018 RY7, making this pair one of the youngest multiple asteroid systems known to date. As the NEO catalog grows with current and future discovery surveys, the known population of NEO pairs will also increase.

1. Introduction

Asteroid pairs are a population of objects whose two components are not in a gravitationally bound configuration like binary asteroids, but do share extremely similar heliocentric orbits. Backwards orbital integrations suggest that asteroid pairs in the Main Belt separated recently, in most cases less than $\sim$1 Myr ago [1, 2, 3]. A shared origin for asteroid pairs is supported by the similar photometric colors and/or spectral properties of the two components [4, 5, 6, 7]. Several hundred candidate asteroid pair systems have been identified in the Main Belt [2]. The favored formation mechanism for Main Belt asteroid pairs is YORP spin-up and fission [8]

Due to complex dynamics and incompleteness in the catalog of known near-Earth objects (NEOs), such associations have largely evaded detection in near-Earth space [9, 10]. We present here the characterization and investigation of two NEO pairs: 2015 EE7 – 2015 FP124 and 2017 SN16 – 2018 RY7.

2. Observations

Visible-wavelength spectra were obtained of 2015 EE7, 2017 SN16, and 2018 RY7 with the GMOS instrument at Gemini South. The Goodman spectrograph and imager at the SOAR 4.1m telescope was used to obtain a visible spectrum of 2015 FP124. Both 2015 EE7 and 2015 FP124 were found to be within the S-complex with individual assignments of Sq and Q-type respectively. Both taxonomic types are consistent with low degrees of space weathering, thus suggesting young surface ages relative to space weathering timescales. Both 2017 SN16 and 2018 RY7 were found to be V-types. The fact that the components in each system are of the same spectral type, particularly finding a relatively rare V-type pair, suggests a common origin for each pair. Compositionally these spectral types suggest volatile-poor compositions.

3. Dynamics

The dynamical proximity of the members in these pairs is suggestive of a common origin and, due to the short coherence time of NEO orbits, could be a consequence of a recent break-up event. We perform backwards orbital integrations to assess the age or time of separation of these pair systems. These integrations were performed with 500 clones that randomly sampled each object's orbital errors. A separation age would be determined if both a small distance and a low relative velocity were seen coincident in time. We quantified distance with the Minimum Orbital Intersection Distance (MOID) between two randomly selected clones, and relative velocity as the difference of the two clone's velocity vectors. No age of formation was constrained for 2015 EE7 – 2015 FP124, however our integrations suggest a separation age around 8,000 years ago for 2017 SN16 – 2018 RY7 (Fig. 1).

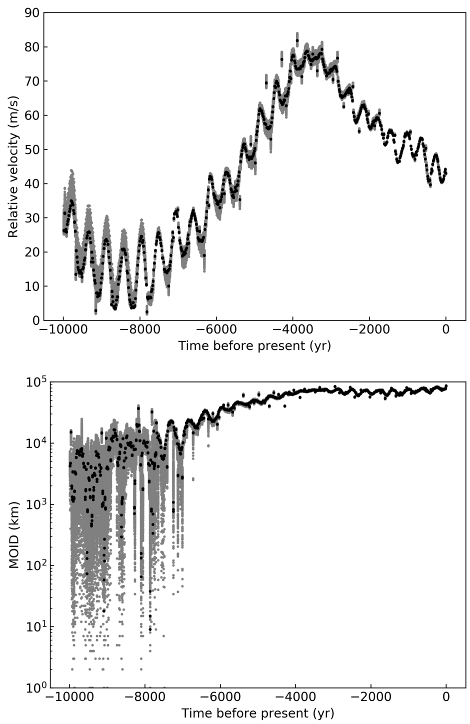

Figure 1: Backwards orbital evolution for the pair 2017 SN16 – 2018 RY7. Five hundred clones of each object sampled orbital uncertainties. Random pairs of clones (in grey) were selected to track the relative velocity (top) and MOID (bottom) between these two objects. Evolution for the nominal orbits is shown with black dots. Values of low velocity (< 1 m/s) and distance (<100 km) start to occur around 8,000 years ago.

4. Conclusions

Physical characterization data and dynamical integrations suggest that the NEO pairs presented here are in fact genetically related. Spectroscopic data show that the members of these pair systems have taxonomic types consistent with volatile-poor compositions, which in conjunction with dynamical arguments, suggests that these objects formed via YORP spin-up and/or dissociation of binary systems. We suggest a plausible separation age of < 10 kyr for the pair 2017 SN16 – 2018 RY7. The young ages of these systems provide a unique opportunity to probe timescales that are not well represented in small body populations. As the NEO catalog continues to grow with current and future discovery surveys, the known population of NEO pairs will also increase. Systematic identification and monitoring of these objects at the time of their discovery will be important to obtain physical characterization data when the objects are most readily accessible to telescopic study.

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