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Compositional Diversity among Binary Asteroid Population

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Abstract

Composition of binary asteroids has important implications for their formation mechanism and impact hazard assessment. Constraining the composition can shed light on other physical parameters like albedo, bulk density, porosity and physical strength. Currently, it is possible to identify the surface mineralogy and estimate the mineral chemistry, mineral abundance, and petrologic history of binary asteroids using near-IR (0.75-2.5 μm) spectroscopic observations.

While no mineralogical characterization projects have been completed on the binary asteroid population to date, a few authors [e.g., 1 and 2] have attempted to constrain the composition of individual components in binary system using innovative resolved spectroscopy with limited success. Here we present results from our mineralogical study of 30 main belt, Trojan and near-Earth asteroids (NEA) binaries and triplets to answer some simple questions about compositional trends.

1. Introduction

Binary and multiple asteroid systems have been discovered in all populations of small bodies from near-Earth objects to Kuiper Belt objects. These systems show a plethora of physical and dynamical combinations and several formation mechanisms have been proposed. The most efficient mechanism for binary formation among small asteroids (<10km) is rotational fission due to YORP effect [3]. For larger asteroids further away from the Sun, other mechanisms have been proposed including Escaping Ejecta Binaries (EEBs) [4]. Compositional studies of binaries could provide important clues about their formation and any selection effects. Here we present results from our mineralogical study and provide some preliminary answers to the questions: Do asteroids with a certain composition dominate the binary asteroid population? Is there a relationship between composition and formation mechanism? Are there compositional differences between main belt and NEA binaries?

2. Observations

Near-IR spectral data (0.7-2.5 microns) was obtained using the SpeX instrument on the NASA IRTF on Mauna Kea, Hawai'i [5]. A majority of the data was obtained in remote observing mode. Apart from the asteroids, local standard stars and solar analog stars were also obtained to correct for the effects of telluric absorption and solar continuum. Of the 30 asteroids we observed, spectra of 7 of them were affected by bad weather conditions and did not meet the standards for mineralogical characterization.

3. Data Reduction

Spectral data was reduced using Spextools software, which is provided by the IRTF [6]. Spectral band parameters were extracted using methods described in Reddy (2009).

4. Composition Selection Effect

The first question we focused on is if asteroids with certain composition dominate the binary asteroid population? The answer is no. Composition does not seem to play an important role during the formation process of the binary asteroids we observed. Of the 37 NEA binaries discovered so far, 25 of them have taxonomic classification and 12 of them have high-quality spectra allowing for mineralogical characterization. These taxonomies and inferred mineralogies span the whole range of types observed in the larger NEA population (Fig. 1). However, V-type NEA binaries seem to be much more abundant (16% of binary NEAs) compared to the larger NEA population (1%) [7]. This could be either an

observational effect, given the high albedo of V-type asteroids, or simply a statistical artifact due to limited sample size.

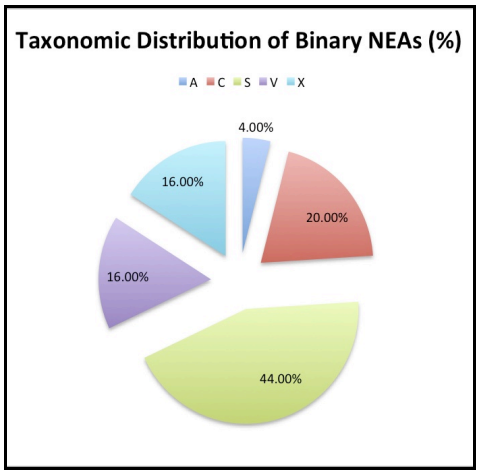

Figure 1: Taxonomic distribution of binary NEAs.

5. Composition vs. Formation

[8] studied the photometric parameters of NEA binaries and concluded that a majority of them formed via YORP fission. However, our study points out that there is no relationship between YORP formation mechanism and composition because we see the whole range of taxonomic types among NEA binaries (Fig. 1). Besides, the NEA binary taxonomic distribution correlates well with the larger NEA population. We are currently investigating if this compositional degeneracy extends to smaller main belt asteroids with physical parameters similar to NEA binaries [8]. This will also help us answer our last question whether there are any compositional differences between main belt and NEA binaries.

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