Sub-populations among the Jupiter Trojans

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The Jupiter Trojans are a significant population of minor bodies in the middle Solar System. Lying in a 1:1 mean-motion resonance with Jupiter and concentrated in two swarms centered about the L4 and L5 Lagrangian points, their peculiar location and dynamical properties place the Trojans at the intersection of several of the most important topics in planetary science. The origin and evolution of this population have been a subject of particular interest. While earlier theories proposed a scenario in which the Trojans formed at the same heliocentric distance as Jupiter, a recent theory, known as the Nice model, suggests a more complex picture in which the Trojan population originated in a region beyond the primordial orbit of Neptune. Through interactions with neighboring planetesimals, the gas giants underwent a rapid migration, setting off a period of chaotic dynamical alterations in the outer Solar System. It is hypothesized that during this time, the primordial transneptunian planetesimals were disrupted, and a fraction of them were scattered inwards and captured by Jupiter as Trojan asteroids, while the remaining objects were thrown outwards to larger heliocentric distances and eventually formed the Kuiper belt. If this is the case, a study of the nature of the Trojans may shed light on the relationships between the Trojans and other minor body populations in the outer Solar System, and more broadly, crucially constrain models of late Solar System evolution.

Several past spectroscopic studies of Trojans have revealed notable bimodalities with respect to near-infrared spectra, infrared albedo, and color, which point toward the existence of two distinct groups among the Trojan population. In our work, we have carried out an analysis of the magnitude distributions of these two groups, which we refer to as the red and less-red color populations. By compiling spectral data from previous works and photometric data from the Sloan Digital Sky Survey, we show that the observed bimodalities are self-consistent and categorize 220 of the 842 Trojans with absolute magnitudes in the range $H < 12.3$ into the two color populations. We demonstrate that the magnitude distributions of the two color populations are distinct to a high confidence level, suggesting that the red and less-red Trojans were created in different locations and/or experienced different evolutionary histories. This observation has broad implications for the formation and composition of the Trojans as well as the details of their purported inward migration.

Much can be learned about the evolution of the Trojans since formation by examining the faint objects, which have undergone significant collisional alteration. To explore this, we have collected color measurements of a large number of Trojans using the Suprime-Cam instrument on the Subaru telescope. The new data extend the known magnitude-color distributions of both Trojan sub-populations to much smaller sizes. This enables a fuller comparison between the two sub- populations as well as with attested sub-populations within the Kuiper Belt, thereby giving insight into the formation and evolutionary history of minor bodies in the outer Solar System.