EPSC Abstracts
Vol. 6, EPSC-DPS2011-1029, 2011
EPSC-DPS Joint Meeting 2011

The Relative Sizes of Transneptunian Binaries: Evidence for Different Populations from a Homogeneous Data Set

K. Noll (1), W. Grundy (2), S. Benecchi (3), H. Levison (4)
(1) Space Telescope Science Institute, Baltimore, MD, US, (noll@stsci.edu) (2) Lowell Observatory, Flagstaff, AZ, US (3) Carnegie Observatory of Washington, Washington, DC, US, (4) SwRI, Boulder, CO, US

Abstract

A unique feature of Transneptunian Objects is the prevalence of binaries made up of comparably-sized components. Nearly-equal-brightness binaries are especially common in the low inclination Cold Classicals where all companions differ by $\Delta_{mag} < 1.5$. With the assumption of equal albedos, this translates to secondaries with radii half that of the primary or greater. By contrast, members of the dynamically hot population, Hot Classical, Resonant, and Scattered Disk, have a larger range of secondary sizes. Detection of satellites with magnitude differences of $\Delta_{mag} > 5$, corresponding to secondary radii less than 10% of the primary, are rare. This is explained, in part, by detection biases that limit the detectability of faint secondaries and secondaries that are close to their primary. However, the lack of companions with $\Delta_{mag} > 1.5$ at separations of more than 0.1 arcsec (2900 km at 40 AU), independent of dynamical classification, is strongly constrained with the current data. This limit constrains the overall population of such secondaries.

1. Introduction

The relative brightnesses of components in transneptunian binaries is a fundamental measurable property of these objects [1,2]. The distribution of relative sizes may reflect fundamental physics at the time the binaries were formed and/or subsequent evolution of binaries subject to collisions and scattering events. Observational bias is a critical factor that must be controlled when trying to extract a size distribution from observed pairs. In this work we focus on a large set of homogeneous observations obtained with the now defunct ACS High Resolution Camera (HRC) on the Hubble Space Telescope (HST).

2. Observations and Analysis

Between July 2005 and January 2007 we observed 111 transneptunian objects with the HRC. These objects were divided about equally between dynamical classes with 34 Cold Classicals, 11 Hot Classicals, 34 Resonant, 32 Scattered. In this sample we identified 25 binaries, 15 of these being Cold Classicals, 4 Resonant, and 6 Scattered. No Hot Classical binaries were found.

PSF fitting was used both to measure the relative positions of binary components and to perform photometry. The methodology we used is described in [3] and references therein. All of the apparent singles were tested for unresolved binaries and found not to have detectable companions.

3. Bias Factors

The detectability of companion objects is a function of the separation. At separations smaller than ~2 resolution elements or ~0.1 arcsec, the PSF of the brighter component is an additional background source that limits the detectability of faint secondaries. At wider separations, faint secondaries are progressively more detectable. At a separation of ~0.2 arcsec the background is essentially the same as that for an isolated objects. We have indicated in the figure below the detection limits for these two different cases as determined both by implanting artificial secondaries.

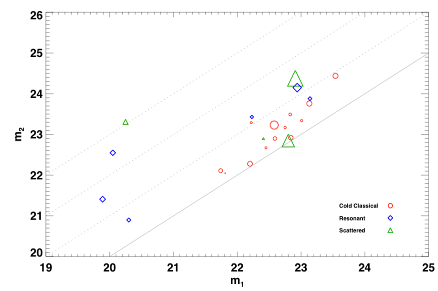

Figure 1: The magnitudes of primary and secondary components detected in the ACS/HRC sample are shown. Dynamical classes are indicated by symbol shape and color. The symbol size is scaled by the apparent angular separation of the components. The symbols in the legend correspond to separations of 0.1 arcsec or approximately four HRC pixels.

Two other factors can bias the detection of binary companions, both related to the increased probability of a secondary at smaller separation (scaled to the Hill radius; Noll et al. 2008b). The distance of the object at the time of observation relative to perihelion is a potential variable but one that does not show a wide variation. Most transneptunian objects are found near their perihelia.

The remaining factor is the size of the primary. The Hill radius scales directly with primary radius. Assuming constant albedo, this can be derived from the observed brightness as $r_H \approx 10^{-0.2Hv}$. In order to make a direct comparison of detection probabilities it is then necessary to scale the detection probability by an assumed radial probability function. We adopt a cumulative function that is a power law of index 0.75.

4. Summary and Conclusions

As noted in previous work, the lack of small secondaries among the Cold Classical population is a striking feature of this survey. As we show here, fainter secondaries would have been detectable if they existed. In contrast, the dynamically hot populations, the Scattered and Resonant objects, have a wider range of secondary brightness relative to the primary and a distribution that clearly differs from than in the Cold Classical population.

The difference between the hot and cold populations may be a product of formation or of different dynamical histories. If the Cold Classicals formed near their current location in the protoplanetary disk, they may have survived relatively unperturbed and thus retain the original size distribution of secondaries. The dynamically hot populations have lower binary fractions than the Cold Classicals. This suggests that modification of the secondary size distribution by loss processes related to migration.

References

[1] Noll, K., Grundy, W., Chiang, E., Margot, J-L., Kern, S.: Binaries in the Kuiper Belt, in *The Solar System Beyond Neptune,* eds. Barucci, M., Boehnhardt, H., Cruikshank, D., Morbidelli, A., University of Arizona Press, Tucson, 592 pp., p.345-363, 2008.

[2] Noll, K., Grundy, W., Kern, S., Barker, E.: The Relative Sizes of Transneptunian Binaries: Differences Between Dynamical Classes?, Asteroids, Comets, Meteors 2008, 8298.pdf, 2008.

[3] Benecchi, S., Noll, K., Stephens, D., Grundy, W., Rawlins, J.: Optical and Infrared Colors of Transneptunian Objects Observed with HST, Icarus, in press 2011; arXiv::1103.2175.