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Contact binaries in the trans-Neptunian population: location, physical and rotational properties.

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Abstract

We are searching for and characterizing contact binaries in the trans-Neptunian populations through an extensive survey with the 4.3 m Lowell's Discovery Channel Telescope and the 6.5 m Magellan-Baade telescope. We aim to derive their rotational and physical properties, to constrain their fractions in several sub-populations of trans-Neptunian objects, understand their formation and evolution as well as improve our knowledge of the binary population and by extension the entire trans-Neptunian belt. In this work, we will summarize our findings about the contact binary population. At this meeting we will summarize our findings to date about the contact binary population, where much of it has been published in refereed journals, see [1, 2, 3, 4, 5, 6].

1. Introduction

As in most of the area of astronomy, binary systems are important and the trans-Neptunian belt is not different. In the trans-Neptunian belt, the first binary system (except Pluto-Charon) known as 1998 WW_{31} was discovered by chance with the Canada-France Hawaii Telescope ([7]). Unfortunately, the discovery of binary systems in this belt from the ground is subject to observational limitations, as large telescopes under excellent weather and seeing conditions are required and it is also highly biased towards equal-sized objects with a large separation. Over the years, the efficiency of the *Hubble Space Telescope* (HST) has been well demonstrated with the discovery of about 80 resolved wide binary/multiple systems [8]. These resolved wide binaries have been used to propose several formation and evolution models of binaries as well as to constrain their fractions across the trans-Neptunian belt. However, one sub-group of binaries is missing: the contact/close binary population.

The definition of contact/close binaries includes bilobed objects, which consist of two objects touching at one point or two objects almost in contact. Due to the small to inexistent separation between the two components of a contact binary, the HST is not able to resolve these peculiar trans-Neptunian objects (TNOs) ([8]), and thus they have never been taken into account, and so our understanding of the binary TNOs is biased towards resolved wide binaries. Finally, the recent flyby of 2014 MU_{69} demonstrated that we crucially need to study this sub-group of binaries ([9]).

2. Our survey

As said the contact/close binaries are not resolvable with the HST, and even if stellar occultations can detect them, multi-chords detection is required as well as an optimal configuration of the system during the occultation. Therefore, the most efficient technique to identify them is through lightcurve studies as they may display a large amplitude and a V-/inverted U-shape at the minimum/maximum of brightness as they rotate ([10]). Therefore, we designed a survey to search and characterize contact binaries in several sub-populations of the trans-Neptunian belt with medium and large size telescopes, see [1, 2, 3, 4, 5, 6] for the full results. By obtaining the lightcurves of a large number of TNOs, we are able to estimate the percentage of flat, moderate and high lightcurve amplitudes and thus infer the TNO shape distribution. But also estimate the percentage of contact binaries and study the rotational properties of several TNO sub-populations. Once a contact binary is identified, we model the system to derive basic properties of the system and each objects (separation, axis ratios, density), and we also obtain its colors to potentially trace its region of formation.

3. Some preliminary results

So far, through our survey we have found 10 contact binaries (or candidates to contact binaries) in the dynamically Cold Classical population, and several Neptune's resonances ([1, 2, 3, 4, 6]). In Figure 1, all the likely contact binaries known so far are plotted, including from other works ([10, 11, 9]). Even if the sample is still limited, one can start to look at this overall sample for trend(s) and try to understand these systems. They have rotational period from ∼6 h up to ∼35 h and display a large variety of large amplitude suggesting a large variety of orientation. The nearly equal-sized contact binary fractions have been estimated to 10-25% in the dynamically Cold Classical population and up to 50% in the Plutino resonant group ([3, 4]). The fraction estimate for some other sub-populations is a work in progress, but based on Figure 1, one can appreciate that the resonances seem to have decent number of contact binaries compared to the unperturbed Cold Classicals ([4, 6]). Therefore, it seems that the dynamical interactions likely experienced by the resonances favor the formation of these systems.

4. Summary and Conclusions

Binaries across the trans-Neptunian belt have been the topic of several studies over the past two decades, from formation and evolution, to orbit determination and mutual event observations. Unfortunately, up until recently, only the resolved wide binaries were taken into account creating a biased understanding of the binary population by excluding the contact binaries. Through a survey dedicated to the rotational properties of the TNOs, we have discovered and characterized several contact binaries in several sub-populations. We derived their rotational and physical characteristics thanks to their rotational lightcurves and surface colors, as well as estimate their fractions. One of our main results is that the dynamical environment and evolution of the TNOs seems to have strongly affected their current binary state since we find the likely highly perturbed resonant objects appear to have a large number of equal-sized contact binaries (40-50%) while the more stable and less stirred up Cold Classical population has a low number of equal-sized contact binaries (10-25%), see [4]. More details and main results about this work have been/will be published in [1, 2, 3, 4, 5, 6]

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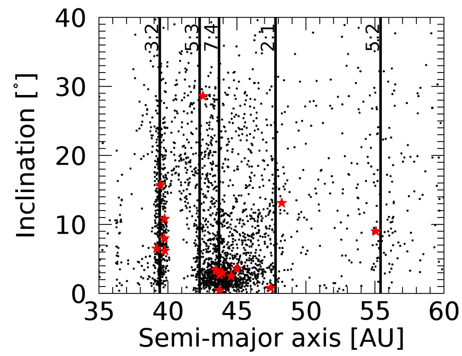

Figure 1: Basic figure is from Thirouin and Sheppard (2019). Contact binaries in the trans-Neptunian belt are indicated with red stars whereas known TNOs are plotted with black dots. Vertical lines are the main mean motion resonances with Neptune.

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