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HST Search for Binary Neptune Trojans: Upper Limits and Comparison to Other Transneptunian Populations

Keith S. Noll (1) and William M. Grundy (2)
(1) NASA Goddard Space Flight Center, Greenbelt, MD, (keith.s.noll@nasa.gov)
(2) Lowell Observatory, Flagstaff, AZ

Abstract

Six of the twenty two known Neptune Trojans (NT) have been observed with the Hubble Space Telescope and these observations can be used to search for binaries. None of the six NTs, ranging in absolute magnitude from $7.5 < H_V < 9.0$, have a detectable companion. This sets an upper limit on the frequency of HST-detectable binaries in the NTs in this magnitude range at $f_{bin} \leq 23\%$ (1-sigma).

1. Introduction

Neptune Trojans are small bodies orbiting in a 1:1 resonance with Neptune. The first such object was found in 2001 and since that time a total of 22 NTs have been found. The brightest of these is 2013 KY_{18} with an absolute magnitude of H=6.8, which, for an assumed albedo of p=0.15 corresponds to an object with a diameter of 150 km.

The colors of most NTs are moderately red with a color distribution similar to that found in Jupiter Trojans [3]. At least one very red object, like those common in the low-e, low-i Cold Classical transneptunian population has been found in the NT. The color distribution of NTs does not match that found in other transneptunian populations which raises potentially important questions about their origins.

The frequency of binaries offers another observable property that can be used to compare NTs to other comparable populations. Here we review the current status of observations and evaluate the potential for better constraints on binary frequency to help identify the source of NTs.

2. Observations

Six NTs were observed with HST from 2006 to 2012, one of them twice (2001 QR_{322}). Four different HST observing programs, GO 10800, 11113, 11644, and 12468 included at least one NT target. Images were taken with the Clear (HRC) or F606W (WFPC2, WFC3) filter and were dithered. Observations are summarized in Table 1.

Table 1: HST Observations of Neptune Trojans

object	H_V	GO	date	inst.
2004 UP_{10}	8.8	10800	2006-07-28	HRC
2006 RJ_{103}	7.5	11113	2007-10-03	WFPC2
2005 TO_{74}	8.5	11113	2008-06-09	WFPC2
2001 QR_{322}	8.2	11113	2008-07-21	WFPC2
"	"	11644	2009-12-02	WFC3
2007VL_{305}	8.0	11113	2008-12-16	WFPC2
2005 TN_{53}	9.0	12468	2012-09-21	WFC3

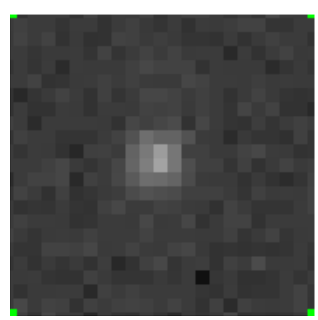

Figure 1: A 1 arcsec region of an HST image of 2006 RJ_{103} is shown. The object was centered on the PC and exposed for 260 sec in the F606W filter. This was part of a four-image dithered sequence. No secondary is detected.

3. Discussion

The population of NTs can be compared with HST-observed objects in different populations over the same range in absolute magnitude as shown in Table 1. We also show the result of binary searches in these populations over an expanded absolute magnitude range up to H_V=6.8 that includes the brightest known NTs, including those not observed by HST. There are also fainter known NTs, but there are no known binaries in any class of objects fainter than the range already considered, in part because of observational limitations, so comparisons at fainter absolute magnitudes are not constraining.

The lack of detection of a binary companion in the six NTs observed so far with HST is not inconsistent with the detectable binary fraction in the dynamically hot populations (Scattered, Centaurs, Hot Classicals) Resonants, or Cold Classicals in the same absolute magnitude range.

Table 2: Binary fractions in transneptunian populations compared to NTs.

Class*	$7.5 \leq H_V \leq 9.0$		$6.8 \leq H_V \leq 9.0$	
	obs	bin	obs	bin
NT	5	0	5	0
CC	11	2	51	10
Hot	27	0	67	3
HC	*2*	*0*	*12*	*0*
Scattered	*7*	*0*	*29*	*2*
Centaur	*18*	*0*	*26*	*1*
Resonant	56	2	106	2

*Neptune Trojans (NT) are compared to Cold Classicals (CC), Hot Classicals (HC), Scattered, Centaurs, and Resonant populations. We have grouped HCs (i > 5.5°), Scattered (Near, Extended), and Centaurs into a single Hot category to derive a more statistically interpretable result. Dynamical groups follow the Deep Ecliptic Survey taxonomy [2].

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It is also possible to compare to Jupiter Trojans (JT). There are 27 JTs with H≤9.0. Among this group, only Patroclus has observed with HST, and an undefined fraction of others have been observed with high resolution AO systems [5,6]. Two of these 27 bodies have detected binary companions. Fainter JTs have also been searched with HST resulting in one additional binary detection [7]. The known JT binaries are at similar separations in terms of a/R_{Hill} as binaries in the transneptunian populations. However, binaries with the same physical separation as the JTs at transneptunian distances are undetectable with direct imaging. Thus, a comparison of the origins of these binaries requires an understanding of how semimajor axis evolves when a binary system migrates in heliocentric semimajor axis.

4. Summary

More sensitive searches of a larger number of NTs, particularly the brightest members of the population, could constrain which populations have analogous binary fractions. However, a statistically meaningful survey would require a factor of 3-5 more NTs than are currently known. Estimates of the total number of bright NTs [1,4] suggest that it may be necessary to discover nearly all of the bright NTs to reach this number of objects. Future all-sky and dedicated surveys may eventually make this possible.

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