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The Successful Search for a Post-Pluto KBO Flyby Target for New Horizons Using the Hubble Space Telescope

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Abstract

After four years of ground-based searching for a Kuiper Belt object flyby target for the New Horizons (NH) spacecraft beyond Pluto, a large search with the Hubble Space Telescope in 2014 discovered two KBOs reachable by NH. The spacecraft will be diverted towards one of these objects in late 2015, after the Pluto encounter, and a close flyby in 2018 – 2019 will be proposed as part of a potential NH extended mission.

1. Introduction

The New Horizons mission [1], which will make the first flyby of the Pluto system in July 2015, has the expected longevity and fuel reserves to continue deeper into the Kuiper Belt and fly by at least one additional small Kuiper Belt object (KBO). Additional KBO flybys were recommended as a key component of the Pluto mission by the 2003 Planetary Decadal Survey [2]. The first closeup observations of typical KBOs from a flyby spacecraft are likely to revolutionize our understanding of this major component of the solar system.

New Horizons' available fuel provides a KBO targeting budget of ~130 m/sec delta-V, which provides access to a narrow cone of space within the Kuiper Belt that was predicted to contain several KBOs brighter than R magnitude 27.0 [3]. No previously-known KBOs pass through this region, so a dedicated search for suitable targets was required.

An intensive ground-based search was carried out from 2011 to 2014, using primarily the SuprimeCam camera on the Subaru telescope in Hawaii, and the Megacam camera on the Magellan telescopes in Chile. Extremely crowded background star fields (the search area is near the galactic center) limited search depth to R ~ 26.0 even in optimal seeing. The ground-based search discovered about 50 faint new KBOs. However, none is reachable by NH: the most accessible groundbased discovery would require 1.6× more fuel than the NH targeting delta-V budget.

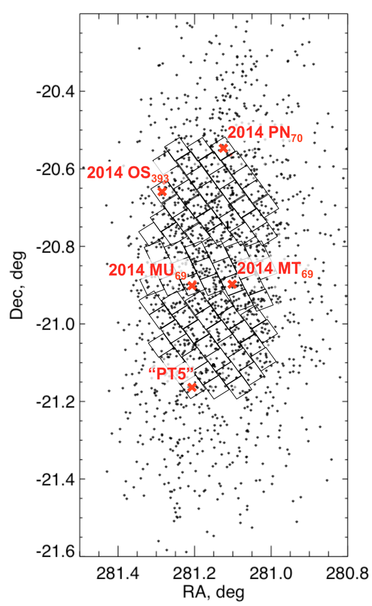

Figure 1. HST search design. Each square shows a WFC3 field, superposed on the expected distribution of targetable cold classical KBOs (dots). Red crosses identify the fields containing our five robust HST KBO detections. Positions are shown for July 1st 2015

2. Searching with HST

In 2014 we turned to the Hubble Space Telescope (HST) for a deeper search. HST provides unmatched sensitivity to faint objects in crowded fields due to its combination of high spatial resolution and stable imaging performance. We were granted 194 orbits of HST time in the Cycle 22 Guest Observer program in June 2014 (program GO-13633), including 40 orbits of Director's Discretionary time. We also added 6 orbits from HST KBO programs GO-13311 and GO-13663 [S. D. Benecchi, PI]. Advance planning by

STScI allowed our program to begin execution less than three days after being awarded time.

We searched an area of 0.17 deg^2, covering the locations of roughly half the potentially targetable KBOs (Fig. 1) and moving at their expected mean rate, using 83 pointings of HST's Wide Field Camera 3 (WFC3) with the very broad F350LP filter, with 2 visits per pointing to detect motion. Rapid data reduction and follow-up of promising discoveries allowed orbit refinement.

We obtained astrometric solutions with < 20 mas precision for each image using a custom star catalog based on CFHT images [4]. We then stacked images at sidereal rates to generate star background templates, and subtracted these from individual frames to remove background stars. We stacked the star-subtracted images of each search field at 20 – 80 different rates [5], corresponding to the range of possible motions for cold classical KBO orbits (the class of KBOs expected to include almost all targetable KBOs). Automated routines then identified point sources in the stacked images, and we determined the reality of these sources by visual vetting (Fig. 2). We estimate search limiting magnitude, at 50% detection efficiency, to be approximately R = 27.5, determined by the recovery of synthetic KBOs implanted in the data.

3. Search Results

We made five robust discoveries of cold classical KBOs in the HST data set (Table 1). Two of these objects, 2014 MU_{69} and 2014 PN_{70}, are reachable by New Horizons [6]. With diameters of 25 – 55 km, depending on assumed albedo, they represent a previously unexplored class of objects, geometrically midway in size between typical comet nuclei and larger Trans-Neptunian objects like Pluto.

It is not possible for NH to fly by both objects. The choice between them, which is not straightforward (2014 MU_{69} requires less fuel but 2014 PN_{70} is brighter) will be made in time for a targeting burn towards the chosen object in Fall 2015, after the Pluto encounter. The KBO encounter, and distant observations of other KBOs found in the HST and ground-based searches, will be proposed to NASA as part of a New Horizons extended mission.

Because this is the widest KBO survey to this depth yet accomplished, the results have important implications for the population of small KBOs [7].

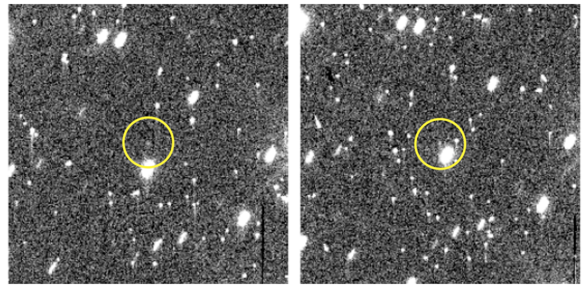

Figure 2. A small portion of two consecutive raw HST images showing 2014 MU_{69} (circled), along with numerous background stars and cosmic rays. Stars are trailed because HST was tracking at the expected mean KBO motion.

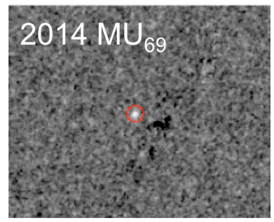

Figure 3. 2014 MU_{69} (circled) after processing to combine images and remove background stars and cosmic rays

Table 1: The five robust KBO discoveries made in our HST search program. The two objects that require less than our 130 m/sec delta-V budget, and which are thus expected to be reachable by New Horizons, are highlighted in green.

Name	R Magnitude	Estimated Diameter Albedo = 0.15	Estimated Diameter Albedo = 0.04	Targeting Delta-V, m/sec	First Seen, 2014	Arc Length, Days	Encounter Date
2014 MU69	26.8	25 km	45 km	59	26-Jun	118	12/30/2018
2014 OS393	26.3	30 km	55 km	181	30-Jul	83	
2014 PN70	26.4	30 km	55 km	118	6-Aug	76	3/16/2019
2014 MT69	27.4			n/a	24-Jun	40	
"PT5"	26.9			n/a	8-Jul	< 1	

References

[1] Stern, S. A. (2008) *Space Sci. Rev.* **140**, 3–21.
[2] Space Studies Board, National Research Council (2003) *New Frontiers in the Solar System: An Integrated Exploration Strategy.* National Academies Press.
[3] Spencer J. R. et al. (2003) *Earth, Moon, Planets* **92**, 483–491.
[4] S. D. J. Gwyn (2015). arXiv:1411.3344 http://arxiv.org.
[5] Parker, A. H. and J. J. Kavelaars (2010) *PASP* **122**, 549–559.
[6] Porter, S. B. et al. (2015), LPSC 2015.
[7] Parker, A. H. et al. (2015), LPSC 2015.