Constraints to the Cold Classical KBO population from HST observations of faint objects

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KBO populations

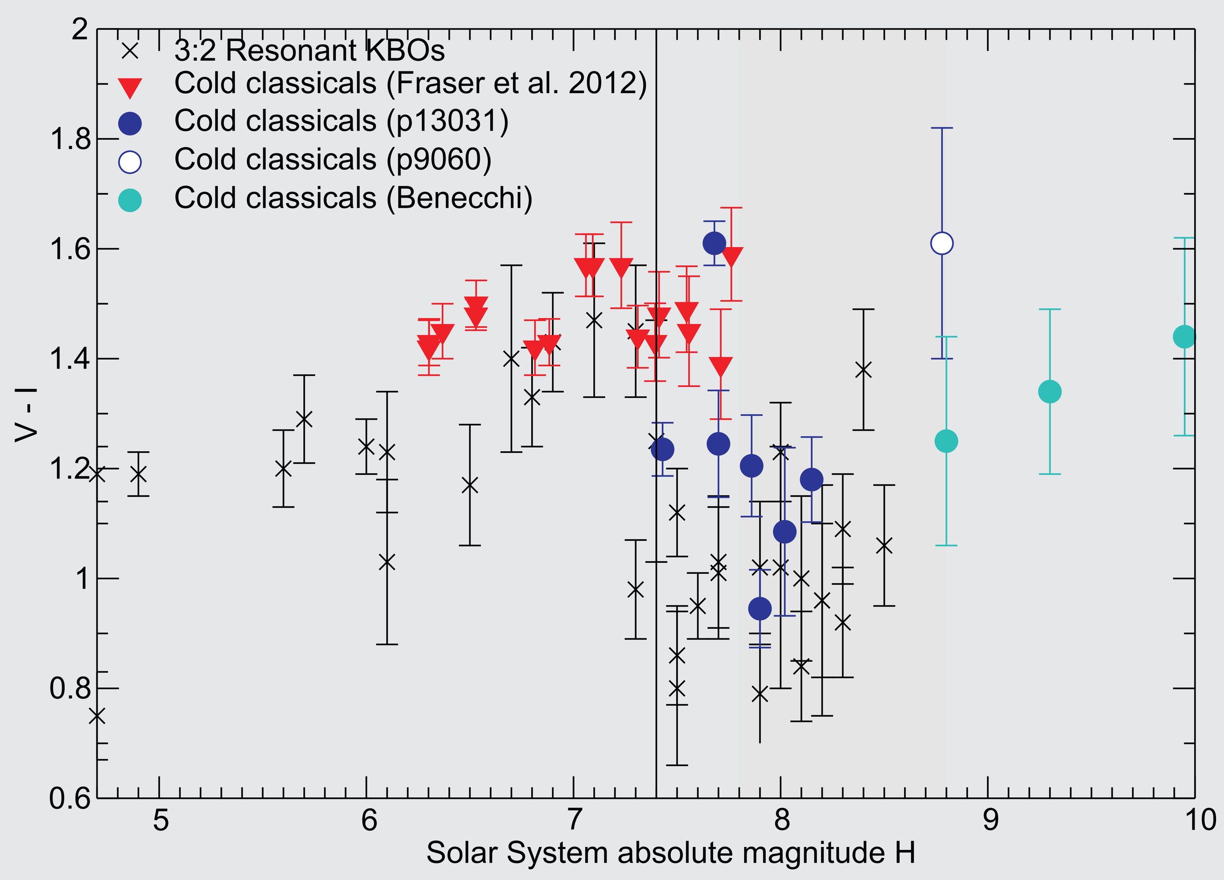
The size distribution of the known Kuiper Belt Objects has been described by a double power law, with a break at R magnitude ~25. There are two leading interpretations to this break:

1) It is the result of the collisional evolution among these KBOs, with the objects smaller than the break being the population most affected by collisional erosion.

2) The size distribution break is primordial, set during the Kuiper Belt formation.

The low inclination Kuiper Belt Objects, the Cold Classical population, is thought to have been dynamically isolated since the formation of the Solar System, and thus only collisions between Cold Classicals would have affected their size distribution. If the size distribution is collisional, it probes parameters of the Kuiper Belt history: strengths of the bodies, impact energies and frequency, and the number of objects. If the distribution is primordial, it reveals parameters of the Kuiper Belt accretion, as well as limits on its subsequent collisional history.

We obtained new HST observations of 5 faint Cold Classicals, which we combine with our previous HST observations of 11 other objects and archival data, to examine the distribution of two properties of the smallest KBOs: colors and binary fraction. These two properties can differentiate between a primordial and a collisional origin of the size distribution break. If the smaller bodies have been through extensive collisional evolution, they will have exposed materials from their interiors, which has not been exposed to weathering, and thus should be bluer than the old surfaces of the larger bodies. An independent constraint can be derived from the fraction of binary objects: the angular momentum of the observed binaries is typically too high to result from collisions, thus a collisionally-evolved population would have a lower binary fraction, due to the easier separation of binaries, compared to the disruption of similar-sized bodies, and the easier disruption of the binary components, due to the smaller size.



References

Fraser, W.; Brown, M. 2012. The Hubble Wide Field Camera 3 Test of Surfaces in the Outer Solar System: The Compositional Classes of the Kuiper Belt. http://dx.doi.org/10.1088/0004-637X/749/1/33

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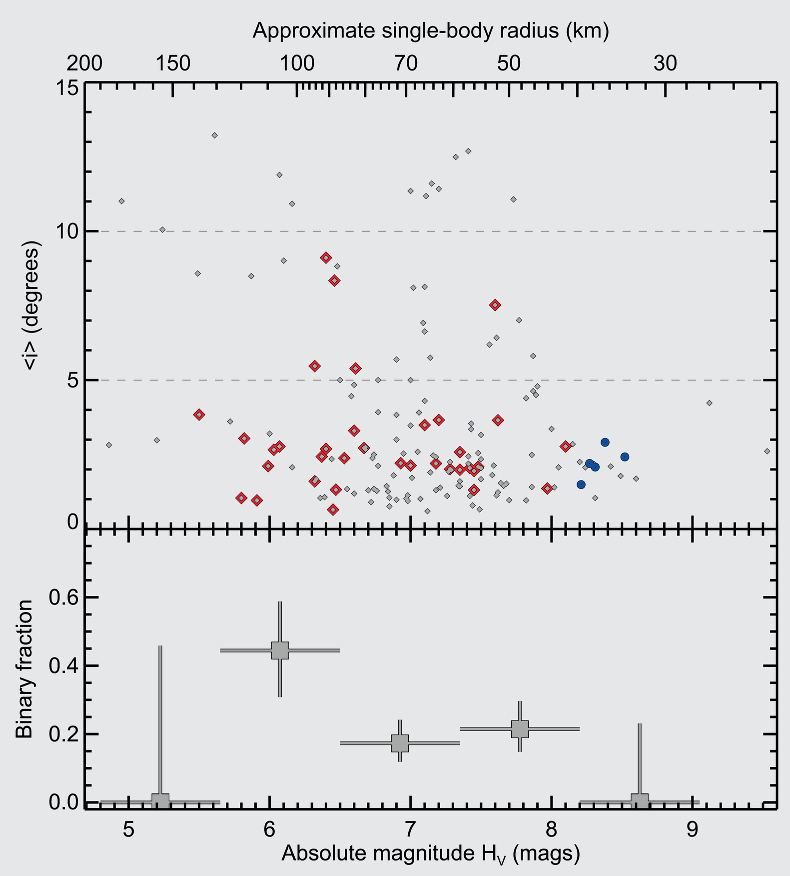
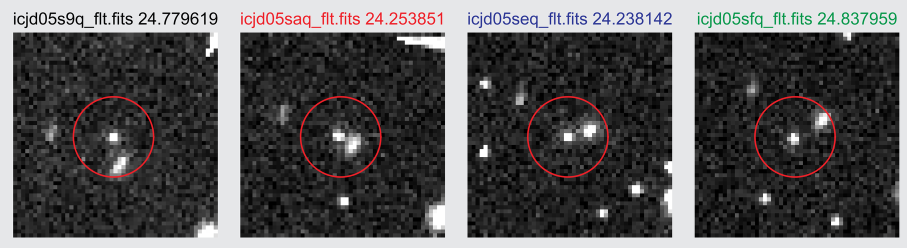


Observations and processing

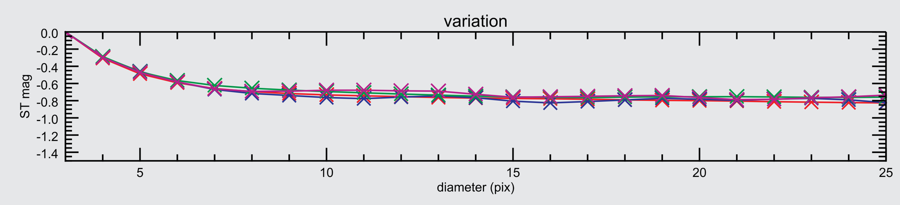
Our observations were taken in two programs, 13031 and 13716, with HST/WFC3, on filters F606W and F814W. These broadband filters allow us to obtain the visible to near infrared color with maximum signal to noise ratio, and are similar enough to Johnsons V and I filters to allow comparison with ground-based observations of other bodies, without a large uncertainty in the color conversion.

The objects were observed in sequences of 3 (13031) and 8 (13716) images, both to measure magnitudes and colors, and to identify binaries. Here we present the photometry, while the binarity of these objects is still being determined, by PSF fitting.

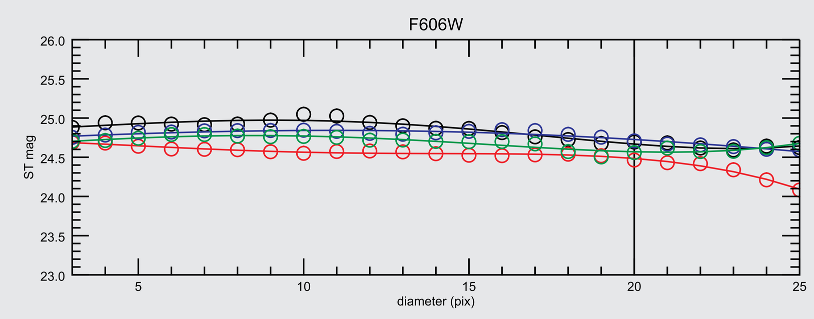


Sequence of 4 images of one of the targets. The red circle has 0.4" radius, and is centered on the object.

To decrease the photometry errors, we measure magnitudes for 23 circular apertures of isolated, brights stars on several positions on the field of view. We use the variation in magnitude to derive the aperture correction functions shown below.



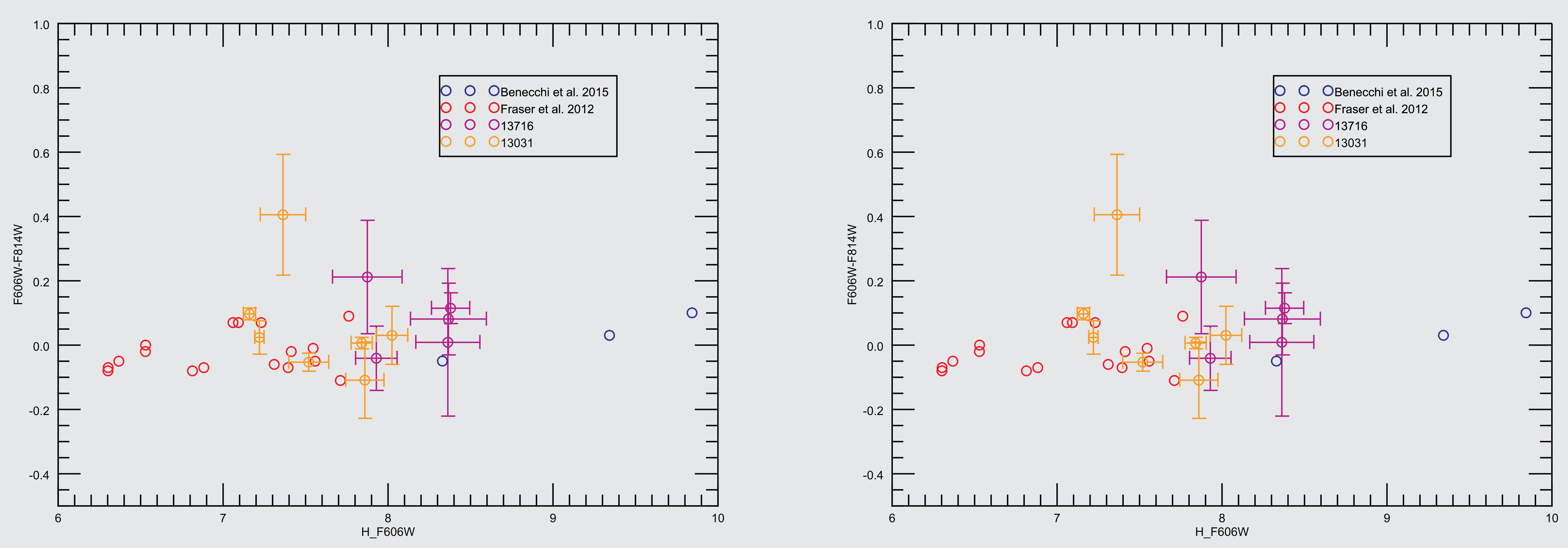
With these aperture corrections, we convert the object's magnitude measure on each of the 23 apertures, to the magnitude for a 0.4" aperture, for which the WFC3 zero points have been measured. The result is, for each image, a set of 23 magnitudes for the object:



Which are combined into a single magnitude by taking their mean, after removing the points more than 3 standard deviations from the median, to account for those images where a neighboring object or cosmic rays affect the magnitudes for some of the apertures.

Results: Magnitudes and colors

These are preliminary magnitudes and colors for most objects, compared to previous HST observations.



More precise magnitudes, and magnitudes for the objects with contamination from cosmic rays and neighboring objects, are still being derived.

Poster available at
http://www.ppenteado.net/ast/pp_dps2015.pdf