The size-frequency distribution of H>18 NEOs and ARM targets detected by Pan-STARRS1

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Abstract

We estimate the detection efficiency of the Pan-STARRS1 survey (e.g. Kaiser 2004; Hodapp et al. 2004) and then determine the size-frequency distribution (SFD) for NEOs with absolute magnitudes (H) in the range $18 < H < 30$ and potential targets for NASA's Asteroid Retrieval Mission (ARM) with $27 < H < 31$. Our predicted detection rates for both NEOs and ARM targets are within a factor of 2 of the number of actual detections by Pan-STARRS1 when calculated with Harris (2013) and Brown et al. (2013) SFD respectively. Our results thus suggest that the further best describes the NEO population between $18 < H < 29$ and also confirm that small NEOs and their their population subset of ARM targets follow a steep slope distribution which was previously measured only from the infrasound detections (Brown et al. 2002, 2013).

Method

We developed a data processing pipeline to measure the performance of simulated PS1 surveys for detecting NEOs and ARM targets. First we generated synthetic ARM and NEO populations according to the Greenstreet et al. (2012) NEO model. We assigned each ARM target an absolute magnitude (H) according to the Brown et al. (2002) SFD, while we used Harris (2013) SFD for the NEO population. Synthetic NEOs and ARM targets that met a size-dependent Minimum Orbit Intersection Distance (MOID) requirement with Earth were injected into the Moving Object Processing System - MOPS (Denneau et al. 2013) to simulate the survey. The synthetic detections identified by MOPS were then filtered to account for weather, tracklet identification efficiency and trailing losses to faithfully mimic the real Pan-STARRS1 survey. The filtered synthetic detections were then used to calculate the PS1 NEO and ARM target identification efficiency.

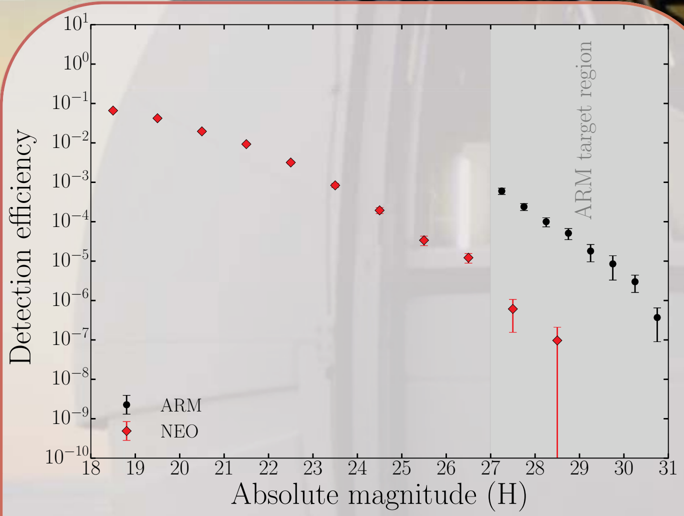

Figure 1: Detection efficiency of NEOs and ARM targets by the Pan-STARRS1 telescope. The higher detection efficiency of ARM targets relative to the NEOs is the result of their Earth-like orbits and relatively small apparent motion on the sky compared to NEOs of the same-size.

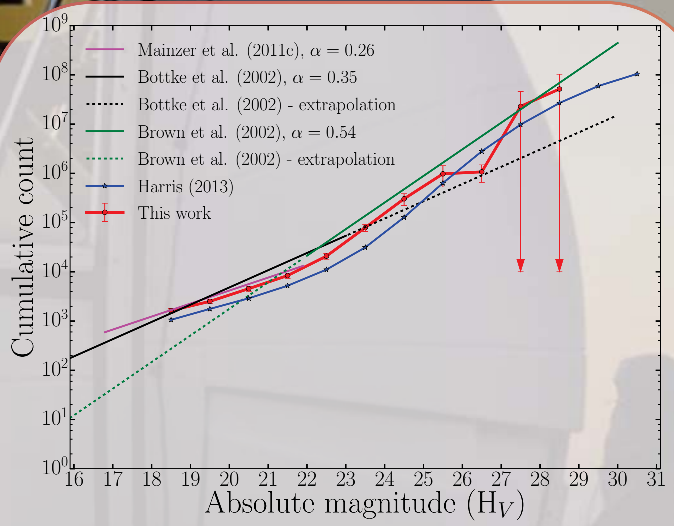

Figure 2: Our derived NEO size-frequency distribution from Pan-STARRS1 data in comparison to other contemporary models.

SURVEY	Pan-STARRS1	Pan-STARRS1 simulation
FOV (deg²)	7	7
V_{lim} (mag)	21.5 (w_p)	21.5
Survey area (deg²/night)	4 x 900	4 x 900
Total predicted annual detections		
NEOs (18<H<30) per year	≈640*	≈800#
ARM targets per year	2*	1.7⊙/ 0.3#

* Calculated from actual Pan-STARRS1 data over 1 year of established NEO-dedicated survey pattern
# Calculated with the Harris (2013) SFD which best represents the observed NEO SFD.
⊙ Calculated with the Brown et al. (2002) SFD which best represents the NEO SFD in the ARM size range.

Debiased NEO SFD from Pan-STARRS1 data

The debiased NEO absolute magnitude distribution exhibits a transition in the $21 < H < 23$ interval from a shallow to steep slope consistent with other recent works (e.g. Mainzer et al. 2011c; Brown et al. 2013; Harris 2013). Our best fit yields $10^{(0.25\pm0.01)H}$ for NEOs with $18 < H < 22$ and $10^{(0.52\pm0.01)H}$ for the smaller objects with $22 < H < 29$. The 2 ARM target candidates detected by Pan-STARRS1 over 1 year have a corrected size-frequency distribution with a slope $\alpha = 0.38+0.33/-0.44$ (i.e. $10^{\alpha H}$).

References:

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