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A new OSSOS-based model of the classical Kuiper belt

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Abstract

Outer Solar System Origin Survey (OSSOS) probed the Kuiper belt's dynamical structure and size distribution to unprecedented precision from CFHT. With over 620 objects in the classical belt (including our previous survey detections), of which ~ 550 are in the main belt, we are in a good position to explore its dynamical structure. We will present a detailed view of the main classical belt, and size distribution to at least $H_r \sim 8.5$.

Introduction

Theoretical and observational efforts in outer Solar System science have provided a wealth of new facts, but have left many basic questions unanswered. At the tri-annual trans-neptunian object (TNO) meeting in 2010, the scientists of this community came to the conclusion that further progress on fundamental questions could only be made with a large concerted effort to acquire a new well-understood TNO sample focused on the most cosmogonically-important subpopulations, which could be exploited in various ways.

The TNOs on low-eccentricity (e) low-inclination (i) orbits with semimajor axes (a) between 35-48 au were originally referred to as 'the Kuiper belt'; our knowledge quickly grew and complexity of the orbital distribution became apparent, this population is now called the classical Kuiper belt. This low-inclination component appears to be a primordial feature. CFEPS exposed, and OSSOS has confirmed, that there is radial structure in the classical Kuiper belt that must be explained. The main belt from a = 42.5–47.5 au is dominated by the narrow inclination component (of width $\sim 2.5°$) that exists only in this small semimajor axis range; this so-called cold belt is redder, has more binaries, and has a steeper size distribution for large TNOS than the rest of the Kuiper Belt [4, 2].

In contrast, all other Kuiper Belt components share a colour distribution which is bluer, a shallower size distribution for $D = 200\check{~}2000$ km, and have TNOs with bigger orbital eccentricities and a much broader inclination distribution (Gaussian width $\sim 15°$, with outliers beyond $i = 40°$).

1. The OSSOS survey

The Outer Solar System Origin Survey (OSSOS) was designed to discover and track the necessary new sample of TNOs in a way that allows the underlying populations' orbit distribution to be determined [**?**]. TNO discovery is inherently prone to observationally induced biases [3]. To be detected, an object has to be brighter than a survey's flux limit, while moving within the area of sky that the survey is examining. Owing to the steep TNO size distribution, most TNOs detected in a given survey will be small and near the flux limit. Minimal loss of objects following their discovery and accurate survey debiasing are necessary to ascertain the dynamical and size structures of this hard-to-sample population.

OSSOS builds on the experiences and lessons of data acquisition from the more-than-sixty discovery surveys in past decades that have brought us to our current understanding of the trans-Neptunian region. Crucially, we aim to acquire a TNO sample free from the challenging problem of ephemeris bias: selection effects due to choices of orbit estimation and of recovery observations. OSSOS was conducted as a queue-mode Large Program with the MegaPrime imager on the 3.6 m Canada–France–Hawaii Telescope (CFHT) to discover and to follow up our discoveries.

2. OSSOS view of the classical Kuiper belt

By the end of operations, OSSOS had detected 952 objects, of which 843 are characterized, meaning they can be used for comparing model predictions to real observations. In this sample, there are 11 classical objects in the region Sunward of the 3:2 MMR (inner belt), 427 objects between teh 3:2 and the 2:1 MMR (main belt) and 34 objects spaceward of the 2:1 MMR (outer belt). With a quarter of the survey going deeper than magnitude $m_r = 25$, we are able to probe the main classical belt to absolute magnitude $H_r \sim 9$. This represents the deepest large sample of main classical belt objects, making the detected structures statistically relevant.

Fig. 1 shows that OSSOS is sensitive to objects as small as $H_r \sim 9$ in most of the main classical phase space. Only the nearly circular orbits at large semimajor axis a are not probed to that depth.

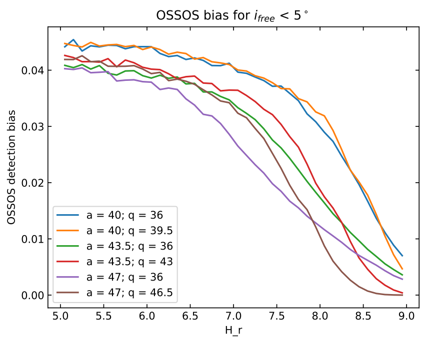

Figure 1: Detection bias of OSSOS for various locations in the (a, q) phase space for the cold population.

Fig. 2 exposes the fine dynamical structure of the main belt, both for the cold population (red dots) and the hot population (blue squares). This also indicates that OSSOS is sensitive to roughly $H_r \sim 9$ for the kernel and the full region interior to it. With over 200 cold objects in that region, we can for the first time address the question of the absolute magnitude distribution 1.5 magnitudes fainter than the alledged break around $H_r \sim 7 - 7.5$ [1].

We will present our modeling of the dynamical structure of the classical belt, and implications on the actual H_r (proxy for size) distribution in the yet unexplored range $[7.5 - 9.]$

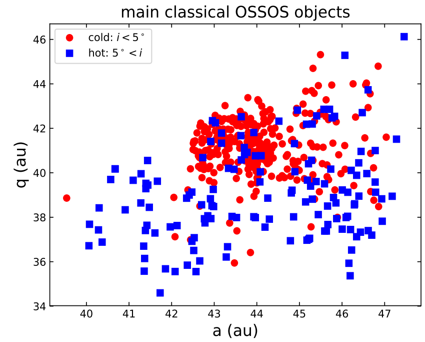

Figure 2: (a, q) distribution of the main classical belt seen by OSSOS.

Acknowledgements

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