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The scattered disk and hot classical belt, two sides of the same coin.

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Abstract

The Canada-France Ecliptic Plane Survey (CFEPS) and High Latitude Extension (HILat)[] obtained characterized observations of nearly 800 sq.deg. of sky to depths in the range ~23.5 - 24.4 AB mag, providing a database of nearly 200 trans-neptunian objects (TNOs) with high-precision dynamical classification and known discovery efficiency. Using this database, we find that the high-inclination component of the inner ($a < 40$ AU) main (a=40–47 AU) classical and outer ($a > 47$ AU) belt are well represented by a continuous density distribution coming from a constrained q range ($35 < q < 40$). This range of peri-center is similar to the range which some researchers associated with the scattered disk. In our modeling of the orbital phase space of the Kuiper belt we find that there is no need for two distinct components (ie. both a scattered disk and a hot component to the classical belt). The historical separation of the high-inclination component of the Kuiper belt into these two distinct structures appears to have been mis-guided.

1. Introduction

The discovery component of the CFEPS project [1, 2] imaged 321 square degrees of sky, almost all of which was within a few degrees of the ecliptic plane. Following on these observations we also conducted a survey of ~ 400 square degrees of sky, all at higher ecliptic latitudes, this is the High ecliptic Latitude extension (HiLat) of the CFEPS project. For both surveys, discovery observations were acquired using the Canada-France-Hawaii Telescope (CFHT) MegaPrime camera which delivered discovery image quality (FWHM) of 0.7 -0.9 arc-seconds in queue-mode operations.

We characterized the magnitude-dependent detection probability of each discovery block by inserting artificial sources in the images and running these images through our detection pipeline to recover these artificial sources. The TNOs in each block that have a magnitude brighter than that block's 40% detection probability are considered to be part of the CFEPS *characterized sample*. Tracking during the first opposition was done using the built-in followup of the CFEPS project. Subsequent tracking, over the next 3 oppositions, occurred at a variety of facilities, including CFHT.

2. The Hot and Scattered Components

The analytic representations of the scattered disk of the outer solar system has evolved. In the initial description of the 'Scattered Disk' of the Kuiper belt [Trujillo et al.(2000)] model this populations as having $34 < q < 36$ AU, representing a part of the Kuiper belt orbital phase space that is semi-stable and could be the source of the Jupiter family comets, as determined by [Duncan & Levison(1997)]. More recently, consideration of the scattered disk has extended to include objects with $36 < q < 40$ [Tirpák(2009)] to also be part of the scattered population. Mean while the term 'scattering' disk has been added to the nomenclature [] to more accurately describe those objects with actively evolving orbital elements, these objects tend to have $q < 35$.

The difference between the 'hot' component of the Kuiper belt and the more extended peri-center models of the scattered disk may, to some, be that the 'hot' component could exist over a larger range of peri-center space. Analytic representations of the 'hot' component (normally referring to the broader component of the two component inclination distribution described in [Brown(2001)]) however, now find that this component of the classical Kuiper is also well represented by an orbital distribution with a restricted q range ($35 < q < 40$) [3]. Thus, the 'hot' component of the classical Kuiper belt and the 'scattered' disk share the same orbital phase space and are, ineffect, the same structure with the nomenclature describing two sides to this coin.

If the 'hot' component is in-fact the scattered disk component then one might expect that the radial distribution of the hot component objects should follow a surface density relation that is consistent across the boundaries between the inner, main and outer Kuiper belts. The CFEPS+HiLat project provides the opportunity for precise population estimates for the various sub populations of the Kuiper belt and we have examined the surface density distribution of the various parts of the 'hot' belt. Figure 1 presents our analysis of this radial distribution. We find the these tree structures can, indeed be well represented as all be part of the same whole.

In this presentation we will describe the analytic model of the Kuiper belt that provides a robust model for the hot/scattered Kuiper belt extending between $35 < a < 350$ AU with $35 < q < 40$ AU.

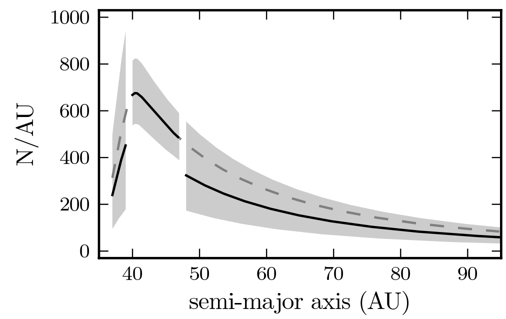

Figure 1: The linear number density (/AU) for three Kuiper Belt components: the inner belt ($a < 39AU$), the hot main belt ($40 < a < 47$) and the outer plus detached belts ($a > 48$ AU). Each region's total population is scaled to the number with $H_g \leq 8$, as determined by our model population estimates. The inner belt's population has been scaled up by a factor of 1.85 to account for the ν_8 resonance. The solid lines represent the model population determined independently for each zone while the grey dashed line indicates the smooth extension of the hot main belt model to the semi-major axis range occupied by the inner belt and the outer+detached populations, where the inner-belt decay at lower a occurs because of the rapidly-shrinking stable (a, q) phase-space volume available. A continuous primordial $a^{-2.5}$ hot population could, within uncertaties, account for all three populations. This suggests that these three Kuiper Belt components are a single dynamical population.

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