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Reality and origin of the Kernel of the classical Kuiper Belt

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The Canada-France Ecliptic Plane Survey (CFEPS) obtained characterized observations of 321 sq.deg. of sky to depths in the range g=23.5–24.4 AB mag, providing a database of 169 trans-neptunian objects (TNOs) with high-precision dynamical classification and known discovery efficiency.

Our data demand that the main classical Kuiper belt (a=40–47 AU) is represented by a 'hot' population with a wide inclination distribution superposed on top of a 'cold' population with narrow inclination component. With the qualifier that there will be mixing from the low-i tail from the hot component, we must split the 'cold' population of the main classical belt into two sub-components to account the transition in the e/i distribution beyond a = 44.4 AU clearly visible in the data. The 'stirred' population have orbits with a narrow-inclination distribution with semi-major axes starting at a=42.5 AU and extending to roughly 47 AU, with a range of eccentricities that increases with increasing a. There are more low-i and moderate-e TNOs per unit semimajor axis at a=44–44.5 AU than at smaller and larger semi-major axis, indicating that a third component is required. We thus insert a dense low-inclination concentration, which we call the 'kernel', near a=44 AU to account for this intrinsic population. We favor the idea that this cold component is primordial.

The primordial distance range of the cold population is difficult to constrain. The inner boundary at a=42.4 AU may have been eroded via scattering by massive bodies and resonance migration; any sequence of events cannot allow either the inner belt, or the mean-motion and secular resonances that probably migrated through it, to have preserved a cold component today. The coincidence of the stirred population's outer edge with the 2:1 resonance suggests to us that the kernel marks the original outer edge and that the larger-a cold objects have either (i) been dragged out of the a<44.4 AU region via trapping and then drop-off in the 2:1 as it went past or (ii) due to weak scattering out of the 40<a<44.4 AU region. Perhaps the edge of the original cold population around 45 AU may be explained by the global evolution of solid matter in turbulent protoplanetary disks, although an even-more extreme density contrast may be needed at about 30 AU to prevent Neptune's continued migration outward. Sharp drops in surface density are commonly observed in protoplanetary disks at about this 30–50 AU scale.

There is an issue with a primordial origin of the cold population at this location. The on-ecliptic mass density of this population is extremely low and it would be difficult to form multi-hundred km TNOs in a low surface density environment. This may not be impossible due to recent work on forming planetesimals big, which can be favored by external photoevaporation, and may be supported by the fact that it appears that there are simply no cold objects larger than H=5; all the larger objects are in the other populations which may come from closer to the Sun where the mass density was higher.