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# THE HOT AND COLD MAIN KUIPER BELT SHARE A COMMON SIZE FREQUENCY DISTRIBUTION

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**THE HOT AND COLD MAIN KUIPER BELT SHARE A COMMON SIZE FREQUENCY DISTRIBUTION:** J. Kavelaars<sup>1,2,3</sup>, J.-M. Petit<sup>4</sup>, B. Gladman<sup>2</sup>, M.T. Bannister<sup>5</sup>, M. Alexandersen<sup>6</sup>, K. Volk<sup>7,8</sup>, Y.-T. Chen<sup>9</sup>, <sup>1</sup>NRC-Canada, jj.kavelaars@nrc-cnrc.gc.ca, <sup>2</sup>UBC, <sup>3</sup>UVic, <sup>4</sup>UTINAM-CNRS, <sup>5</sup>University of Canterbury, <sup>6</sup>CfA|H&S, <sup>7</sup>PSI, <sup>8</sup>LPL Arizona, <sup>9</sup>ASIAA.

**Summary:** The Outer Solar System Origin Survey [1] (OSSOS) finds that for sizes  $5.5 < H < 8.3$  the Hot and Cold main Kuiper belt size frequency distributions are well represented by the same tapered exponential functional form [2], similar to that found in streaming instability modelling of planetesimal formation [3]. This similarity of the size distributions in this range has significant cosmogonic implications

**Method:** Using the absolute detection calibration and abundant detections of the OSSOS (Outer Solar System Origin Survey) project and the OSSOS Survey Simulator<sup>4</sup> we show that main belt transneptunian objects with  $5.5 < H_r < 8.3$  (rough diameters 400--100km, for albedos of 0.06) have indistinguishable absolute magnitude (size) distributions, regardless of being in the cold classical Kuiper belt (thought to be primordial) or the 'hot' population (believed to be implanted after having formed elsewhere).

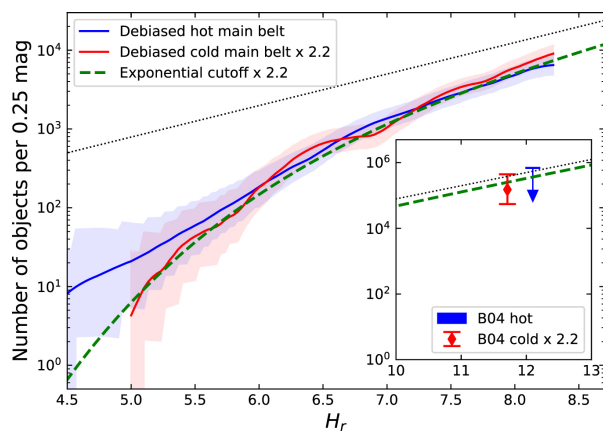
We also provide population measurements for the main Kuiper Belt. For absolute magnitude  $H_r < 8.3$ , we find that there are 31,000  $\pm$  4,000 non-resonant main-belt objects, with twice as many hot-component objects than cold. Although due to unknown albedos and bulk densities, a mass estimate is uncertain to a factor of 3, this implies a total mass of 0.014  $M_{\text{Earth}}$ , only 1/7 of which is in the cold belt (assuming a cold-object albedo about double that of hot component objects).

**Additional Insights:** We will discuss how this result was not apparent in previous examinations of the size distribution due to the complications of fitting assumed power-law functional forms to the detections at differing depths.

Importantly, the shared size distribution is surprising in light of the common paradigm that the hot population planetesimals formed in a higher density environment much closer to the Sun, in an environment that also (probably later) formed larger (dwarf planet and bigger) objects. If this paradigm is correct, this result implies that planetesimal formation was relatively insensitive to the local disk conditions and that the subsequent planet-building process in the hot population did not modify the shape of the planetesimal size distribution in this 50--300-km range. In addition, if in the shape for  $H > 5.5$  seen here is a signature of the planetesimal formation process, then in the evolving paradigm of the hot objects forming closer to the Sun they must have been ejected from this zone soon after formation, before any intense collisional grinding could modify the small object size

distribution. This has direct implications for the delay between stable formation phase and scattering phase in the Jupiter-Saturn region.

**References:** [1] Bannister M. T., Gladman B. J., Kavelaars J. J. *et al.* 2018 *ApJS* **236** 18 [2] Petit *et al.* 2023 *ApJL* **947** 4 [3] Schäfer U., Yang C.-C. and Johansen A. 2017 *A&A* **597** A69 [4] Lawler S. M., Kavelaars J. J., Alexandersen M. *et al.* 2018 *FrASS* **5** 14 [5] Kavelaars J. J., Petit J.-M., Gladman B. *et al.* 2021 *ApJL* **920** L28



*Figure 1 The observed hot (blue line) and 2.2\*cold (red line) main Kuiper belt size distributions<sup>2</sup> compared to an exponential cutoff function that has been fit to the cold distribution alone<sup>3</sup> and scaled by 2.2 to match the population numbers in the hot. The grey line shows a uniform power-law size distribution with index -0.4. Figure from [2]*

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