National Aeronautics and Space Administration

Provenance of the Plutinos

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Objectives

The "Plutinos" are a prominent dynamical subgroup of the Kuiper belt, locked in the 3/2 mean motion resonance with Neptune. Plutinos are thought to have been captured by a migratory Neptune in the early history of the Solar system. In this project, we will investigate the Plutinos' distribution within the resonance zone. Is there evidence of the theoretically expected dynamical structures within the resonance? Were the Plutinos sourced from a narrow or a wide range of radial distances within the Solar nebula? Are their sizes/colors/binarity peculiar or homogeneous across the resonance zone? Are there systematic variations of their physical properties with orbital eccentricity and inclination? The results of the investigation will lead to insights on the Plutinos' origins within the Sun's protoplanetary disk, will test theoretical predictions, and will inform models of the solar system's origin and dynamical evolution.

Preliminary Results (manuscript submitted to AJ)

We have performed a new calculation for the midplane of the Kuiper belt. If the mean plane of the Kuiper Belt is the Laplace plane enforced by only the known planets, then warps in the Laplace plane at large semimajor axes may signal external perturbations such as unseen distant planets. We use a gradient boosting classifier to identify 2317 non-resonant Kuiper Belt objects, then compute their mean plane in the semimajor axis range of 35--150 au and estimate the error in each measurement with a parametric bootstrapping technique. We find that the mean plane of the non-resonant Kuiper Belt is consistent with both the Laplace plane and the invariable plane of the solar system to greater than 3-sigma confidence except in the semimajor axis bin 40.525-42 au, just above the ν_{18} nodal secular resonance. These results, based on a larger observational sample, do not support the previously reported warp at semimajor axes above 50 au.

Significance/Benefits to JPL and NASA

This research will expand the expertise of the JPL small bodies research group to the study of the dynamics of the Kuiper belt. This work will also allow JPL to establish leadership in the study of the outer Solar system, which is a field that will soon experience rapid growth in the era of next-generation telescopes, including the Vera C. Rubin Observatory. KBOs are a foundational destination for potential future JPL missions, and the University of Arizona has extensive experience with spaceflight missions making this partnership both natural and strategic for capturing future Discovery and New Frontiers proposals.

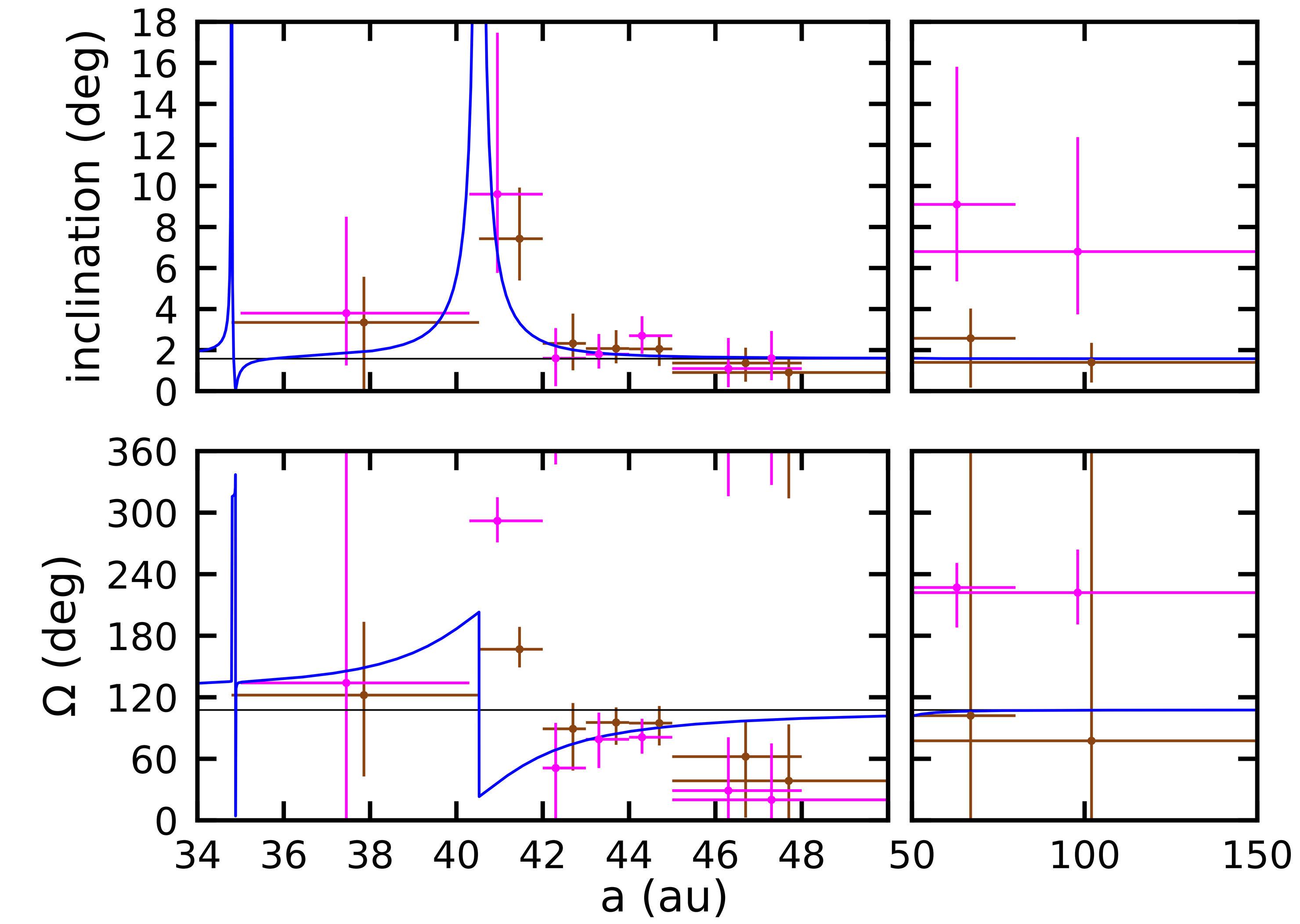

Fig. 1 Kuiper Belt midplane and 1-sigma confidence intervals by semimajor axis bin. The semimajor axis-varying Laplace plane is blue. The invariable plane is a horizontal black line. The best-fit midplanes and confidence intervals from Volk & Malhotra 2017 are in magenta, and those from this work are in brown. For the sake of readability, the vertical magenta and brown lines have been slightly offset from each other in semimajor axis when they would otherwise overlap.

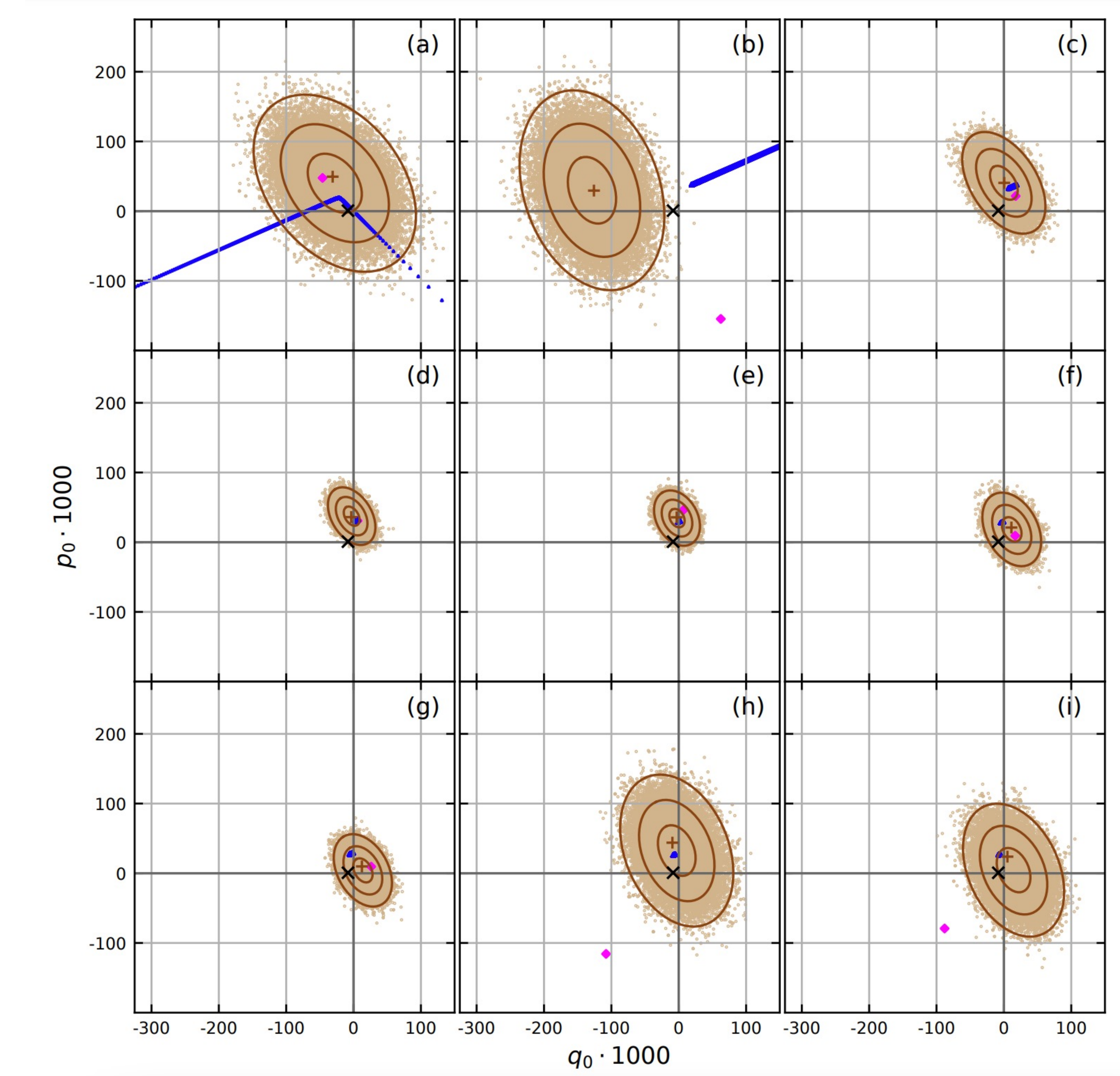

Fig. 2 Kuiper Belt midplane confidence ellipses by semimajor axis bin. The best-fit midplane is the brown +. The invariable plane is the black x. The J2000 ecliptic/equinox pole is the origin. The semimajor axis-varying theoretical prediction for the Laplace plane is plotted in blue. The best-fit midplanes of 40,000 parametric bootstrap samples are in tan, and the 1-, 2-, and 3-sigma covariance ellipses for them are in brown. The best-fit midplane from Volk & Malhotra 2017 is the magenta diamond. Semimajor axis bins are (a) 34.79-40.525 au, (b) 40.525-42 au, (c) 42-43 au, (d) 43-44 au, (e) 44-45 au, (f) 45-48 au, (g) 45-50 au, (h) 50-80 au, and (i) 50-150 au.

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