P312b Investigating the existence of a new planet in the outer solar system

Patryk Sofia Lykawka (Kindai University), Takashi Ito (NAOJ)

Do the orbits of trans-Neptunian objects (TNOs) indicate the existence of a new planet in the outer solar system today or in the past? Previous research without considering such hypothetical Kuiper Belt planets (KBPs) cannot explain three important properties: 1) TNOs with very high orbital inclinations (i > 45-50 deg); 2) A large population of TNOs with orbits too distant from Neptune's gravitational influence, the so-called detached TNOs with perihelia q > 40 au; 3) TNOs on peculiar orbits, such as Sedna and other extreme objects in the outer solar system. Here, we performed N-body computer simulations to investigate the effects of a new planet on the orbital structure beyond Neptune. First, we considered the currently known orbital structure of distant TNOs beyond 50 au. We also identified the stable distant resonant TNOs based on up-to-date observations. Finally, we tested several combinations of masses (Mars to Earth-like) and orbits of potential KBPs that could satisfy the aforementioned constraints. First, we identified the best KBP candidates in terms of orbits and masses that would preserve the stable resonant TNOs. Overall, KBPs should be located beyond 100 au (or 200 au) for Mars-like masses (or Earth-like masses). In addition, detached TNOs were formed thanks to the gravitational perturbations of a KBP. In particular, Earth-like KBPs can create a substantial detached population and objects with i > 50 deg. We provide observationally testable predictions for distributions of distant TNOs that indicate specific orbits and masses of a KBP. Overall, these results will guide future astronomical surveys in the search of new planets located beyond Neptune and new populations of TNOs.