



Sensitivity of Saturn's orbit to a hypothetical distant planet

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Several distant scattered Kuiper belt objects have similar perihelion directions that might be aligned due to the influence an unknown planet well outside the orbit of Neptune (Batygin & Brown, 2016 *Astronomical J.* 151:22). Such a planet, with a mass up to an order of magnitude larger than the Earth, would affect the rest of the solar system. Saturn, which is well observed from radio range and VLBI observations of the Cassini spacecraft, provides an opportunity to look for these perturbations. An unknown large planet would be expected to affect the orbit of Saturn, but the effect might be partially absorbed in the estimation of parameters used to fit the planetary ephemerides. Ephemeris parameters include the planetary orbital elements, the mass of the Sun and the masses of asteroids that perturb the orbit of Mars. Earlier analysis of the Cassini data showed no effect as suggested by the Modified Newtonian Dynamics theory (Hees et al., 2014 *Phys. Rev. D* 89:102002). We present an updated Cassini data set, with the accuracy of ranges to Saturn improved through updated estimates of the Cassini spacecraft orbit, and an analysis of the largest possible perturbing distant planet mass consistent with the ranging.