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Detailed study of the stability of a planetary system captured by a massive stellar remnant

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To date, several planetary systems around pulsars are known. While those systems could be relics, another formation channel has recently been proposed. Massive stellar remnants (i.e., neutron stars and black holes) likely receive a natal supernova velocity kick due to the asymmetry of their birth event, propelling them through space at high speed. We study the hypothetical encounters between planetary systems and such remnants to explore the possible formation of planetary systems around massive remnants through capture. We also investigate their long-term dynamical stability on the time scale of Gyrs.

We use a suite of N-body models (integrated with IAS15 from REBOUND) of the Solar system where a massive object was launched towards it (varying its mass, incident angle, velocity, and impact parameter). Here, we focus on one of these simulated encounters between the Solar system and a 10-solar-mass interloper (10 km/s heliocentric velocity, 60° incidence angle from the ecliptic, 2 au impact parameter) which results in the capture of all planets. The initially chaotic system gradually stabilises during the first 500 Myr by ejecting planets via close planetary encounters until only Mercury, Earth and Jupiter remain. A late ejection of Mercury around 3 Gyr then leaves a stable three-body system, supporting the hypothesis of capture events being viable formation scenarios for planetary systems around stellar remnants.

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