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HIP 41378 b & c: Unveiling the nature of the two sub-Neptunes with transit timing variations using CHEOPS

Super-Earths and sub-Neptunes, planets ranging in size between Earth and Neptune, are prevalent in our Galaxy, serving as a link between terrestrial and giant planets found in our Solar System.

Concerning the internal composition of the largest of the two populations, sub-Neptunes (1.7 R⊕ ⊠ Rp ⊠ 3.5 R⊕), much remains to be understood. Proposed compositions for these worlds range from ocean planets with water mantles and steam atmospheres to ultrahot rocky planets with molten lava-rich surfaces and heavyweight envelopes (Winn et al., 2018; Otegi et al., 2020).

With its two transiting sub-Neptunes, close (~1.8%) to a 2:1 mean motion resonance (MMR) exhibiting anti-correlated transit timing variations (TTVs), the multi-planet system HIP 41378 represents the perfect dynamical laboratory to investigate both dynamical and atmospheric evolution processes. We combined several photometric datasets of transit photometry (CHEOPS, TESS, HST, and Spitzer) and radial velocity (RV) (HARPS) to reassess the characteristics of the system and precisely measured the radii and masses of the planets. We find the planetary radii and masses of HIP 41378 b and c to be Rb= 2.509 ± 0.024 R⊕, Mb= 7.04 ± 0.59 M⊕, Rc= 2.635 ± 0.091 R⊕, and Mc = 2.18 ± 0.21 M⊕. Our precise determination of the masses and radii of the planets allowed us to study the interior composition of the planets and the evolution of the planetary system.

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