Company for an ultra-short period sub-Earth: discovery of two additional planets orbiting GJ367

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Ultra-short period small planets ($R<2\ R_\oplus$, $P < 1$ d) are believed to be naked cores of former Neptunian planets that have lost their atmospheres during the migration process from beyond the ice line to their current close-in orbits. How this migration occurred is currently unclear and needs to be explored on a case-by-case basis once the inner architecture of the hosting system is known. GJ 367 is an M1 V star that has been recently found to host a transiting ultra-short period sub-Earth on a 8 h orbit (Lam et al. 2021). With the aim of improving the planetary mass and radius and unveiling the architecture of the system, we performed an intensive RV follow-up campaign with the HARPS spectrograph - collecting nearly 300 high-precision radial velocities. We followed a multi-dimensional Gaussian Process approach to characterise the stellar and planetary signals in our RV time-series and we combined our Doppler measurements with new TESS observations from Sectors 35 and 36. We found that GJ 367 b has a mass of $M_b=0.648 \pm 0.076\ M_\oplus$ (11 %), a radius of $R_b=0.699 \pm 0.024\ R_\oplus$ (3.4 %), implying a bulk density of $\rho_b = 10.5 \pm 1.7$ g cm-3. We revealed the presence of two additional low mass companions with orbital periods of ~11.5 and 34 days and minimum masses of ~4.5 and 6.6 $M_\oplus$, respectively, and explored the different secular migration scenarios that could account for the current architecture of the planetary system.