Imaging characterization of the radial-velocity brown dwarf HD18757B

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Aerospace engineering
Academic Year 2020-2021

Context. A long radial velocity survey that started with Elodie and then extended with Sophie spectrographs discovered a potential companion around a sun-like star of 11.4 Gyr, called HD18757 and situated at 24.2 pc. This survey outcomes a potential substellar companion revolving around HD18757 with an angular separation of 0.9±0.1 arcsec, a period of 109 yr and a minimal mass of 35.2±1.2 M_{jup}. Regarding these characteristics, the object is drawn as a brown dwarf candidate.

Aims. In order to verify the substellar nature of the object, it is essential to characterize the orbital parameters, the spectral type and to constrain the dynamical mass of the companion, named HD18757B. Identifying such a substellar object allows to increase our understanding on their formation, their composition and their nature.

Methods. To do so, several techniques are applied to retrieve the photometric and orbital information. At first, HD18757B is observed in the L' band with the imaging instrument LMIRCam mounted on the Large Binocular Telescope. This observation is based on the high contrast angular differential imaging method and is further processed with the Vortex Image Processing package. Secondly, imaging data is coupled with astrometric observation from Gaia/Hipparcos and radial velocity measurements from Sophie and Elodie to run in a Markov-Chain Monte Carlo simulation. Finally, the measured parameters are compared to the properties of brown dwarfs from evolutionary and formation models.

Results. The angular differential imaging analysis shows no detection of HD18757B which implies an old and faint substellar object. Regarding the Markov-Chain Monte Carlo study, it constrains all orbital parameters but the inclination and the longitude of ascending node leading to two sets of solutions: prograde and retrograde orbits. In addition to the orbit determination, the Markov-Chain Monte Carlo establishes the companion dynamical mass of $36.528^{+2.261}_{-2.134}$ M_{jup} and predicts its positions at different epochs for direct imaging observations. Most important, this study strengthens the substellar hypothesis and draws a high elliptic wide-orbit object with an edge-on orientation. The fact that the orbit tends to an edge-on configuration indicates that the true companion mass is close to the one estimated with radial velocity measurements.
Furthermore, the evolutionary model predictions are in agreement with the direct imaging study as they depict a faint, cold and old substellar companion. More specifically, by assuming an age of 11.4 Gyr, the companion temperature varies within [514, 534] K, its radius's is approximately of [0.0849, 0.0862] R_{jup} and the luminosity is varying within [-6.321, -6.283]. With these characteristics, the companion is estimated to be a late T- or early Y-type brown dwarf, thus having respectively strong methane or ammonia in its atmosphere.
Lastly, formation models' predictions do not clear the ambiguity on the nature of brown dwarfs. Whether the Gravitational disk instability formation scenario that is appropriate for planet formation or the Protostellar disk fragmentation scenario for stars, both are relevant for HD18757B.

Key words.techniques: radial velocity - high contrast angular differential imaging - astrometry - methods: Vortex Image Processing - Markov-Chain Monte Carlo - stars: HD18757 - brown dwarfs