Circumstellar brown dwarfs found by combined RV and astrometry analyses and their detectability with SCExAO/CHARIS

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1. Introduction

Brown dwarfs (BD) reside in the gap between planets and stars, so the understanding of their formation, evolution, and population is crucially important to connect two different regimes. One powerful approach to reveal their nature is direct imaging of them, but it has been challenging to image then due to **their low luminosity and occurrence rates.** One possible direction is taking images of young stars, and it yielded successful detections. Another approach is to choose stars with radial velocities (RV) trends or astrometric signals, but either of them cannot constrain full orbital parameters. **Figure 1 shows dynamical masses of BDs and stellar temperatures for known systems (red), and it clearly shows lack of our observational knowledge.** Thus, a systematic survey for direct imaging of BDs is required to identify a population of them around various stars.

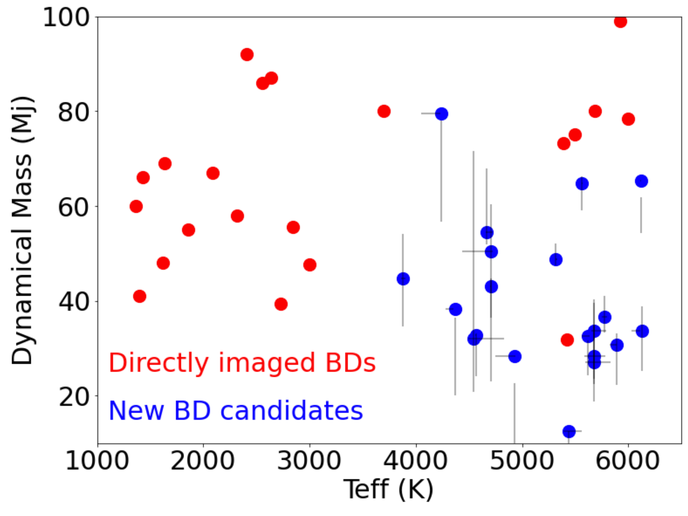

Fig .1 Dynamical masses of BDs and host star temperatures. Red points show known systems, and blue point shows BD candidates that are detectable in direct imaging from our analysis.

2. Combined RV and astrometry

Recently, our groups identified over 100 BD candidates using combined analyses of radial velocity data and astrometry from Gaia and Hipparcos. Specifically, constraints on positions and proper motions between Gaia and Hipparcos epochs, which correspond to ~ 20 years baseline, can be complementary used to constrain properties of the companion objects identified by RV methods. This technique has constrained the precise orbital parameters and mass of the nearest Jupiter analog eps Ind Ab, which can be one of best targets in direct imaging with JWST (Fig 2, see also Feng+2019). The follow-up direct imaging of these BD candidates give additional information on their population, formation, and evolution.

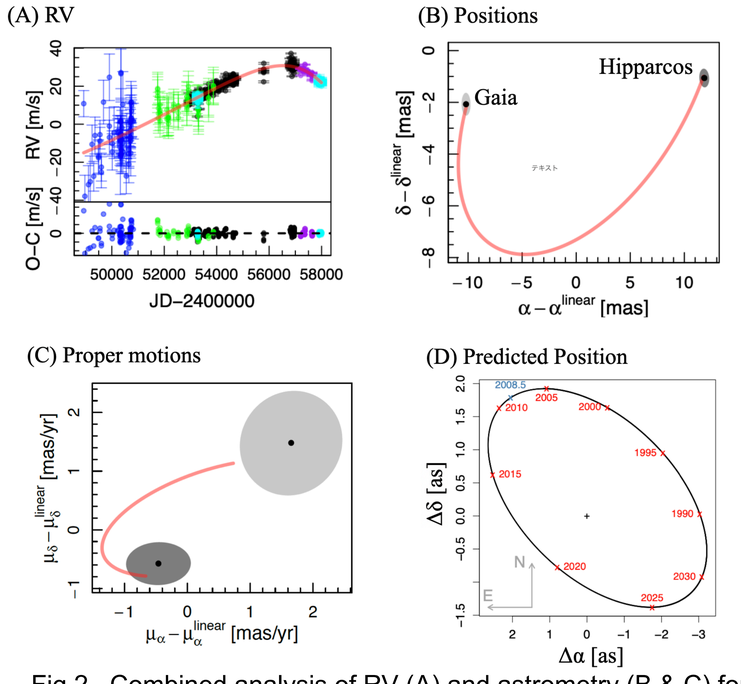

Fig 2. Combined analysis of RV (A) and astrometry (B & C) for eps Ind A, constraining the position of the companion (D). Figures are taken from Feng+2019.

3. Detectability of BD candidates in Direct Imaging

Assuming ages and cooling models (e.g. Phillips+2020), we could calculate expected contrasts of them from derived RV+astrometry masses. Figure 3 shows our estimated contrasts and angular separations for our selected targets in Oct 2021 along with expected contrast sensitivity of SCExAO/CHARIS. This figure suggests that these BD candidates can be detectable. We also plot them as blue points in Figure 1, and they reside in the gap that has not been previously discussed. Therefore, the follow-up observation of these BD candidates will give unique information of BDs' properties. These BD candidates will also help to understand an existing tension between dynamical and isochrone masses of BDs.

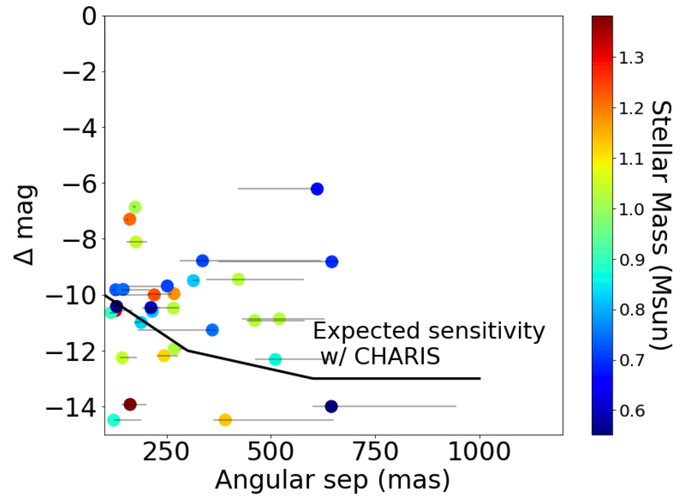

Fig .3 Predicted contrasts and angular separations of BD candidates from our analyses. We overplot expected sensitivity of SCExAO/CHARIS for moderate observational duration. Visibility from Hawaii is not considered.