WISE J135501.90-825838.9 is a Nearby, Young, Extremely Low-mass Substellar Binary

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ABSTRACT

We present a parallax solution for WISE J135501.90-825838.9, a spectral binary with spectral types L7+T7.5 and candidate AB Doradus member. Using WISE astrometry, we obtain a distance of \(d = 16.7 \pm 5.3\) pc. This preliminary parallax solution provides further evidence that WISE J135501.90-825838.9 is a member of AB Doradus (130–200 Myr), and when combined with evolutionary models predicts masses of 11 \(M_{\text{Jup}}\) and 9 \(M_{\text{Jup}}\) for both components.

Keywords: binaries: general; brown dwarfs; stars: individual (WISE J135501.90-825838.9); stars: low-mass

INTRODUCTION

Very low-mass \((M < 0.1M_\odot)\), young \((\lesssim 300\) Myr) binaries are important benchmarks for evolutionary models. Dynamical masses can help break the mass-temperature-age degeneracy due to the constant cooling of objects not massive enough to fuse hydrogen. The lowest-mass known binary is 2MASS J11193254-1137466AB, with a total estimated mass of \(\sim 7.4\) \(M_{\text{Jup}}\) and an estimated age of \(\sim 10\) Myr (Best et al. 2017). Systems such as these are extremely rare, with no estimates on their occurrence rate due to the difficulty in locating and identifying extremely faint, very low-mass binaries.

Bardalez Gagliuffi et al. (2018) identified WISE J135501.90-825838.9 (hereafter WISE J1355-8258) as a spectral binary, an object with a blended light near-infrared spectrum of a late-M/L primary and a T dwarf secondary (Burgasser et al. 2010; Bardalez Gagliuffi et al. 2014). The estimated spectral types of the components are L6–7 for the primary, and T3–7.5 for the secondary. The largest source of uncertainty in the temperature/spectral type estimate is the age of the system, which is required to constrain the mass-temperature-age degeneracy. Using the Bayesian Analysis for Nearby Young Assoiciations II (Malo et al. 2013; Gagné et al. 2014), Bardalez Gagliuffi et al. (2018) found that the UVW kinematics and position of WISE J1355-8258 are consistent with the AB Doradus moving group (130–200 Myr; Bell et al. 2015) with a > 95% probability. However, their age determination was based on a spectrophotometric distance estimate. This is problematic as the distance depends on the assumed luminosity of the object, which changes with age, and with the assumption of binarity. A trigonometric parallax distance, which is model-independent, would help inform the true age/luminosity of this system. This object does not have an entry in Gaia Data Release 2 (DR2; Gaia Collaboration et al. 2018), likely due to its extreme optical faintness \((G > 21\) mag). Here we present a trigonometric parallax solution for WISE J1355-8258 using astrometry from the Wide-field Infrared Survey Explorer (WISE; Wright et al. 2010).

METHODS AND DISCUSSION

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Figure 1. *WISE* parallax solution for WISE J1355-8258 (solid lines). *Left:* The $\alpha$ and $\delta$ solutions are offset by 1" for visibility. Individual positions for each exposure are shown as translucent gray points. Blue points and cyan triangles display the uncertainty-weighted mean positions for each epoch. The light gray bands show 300 random realizations from the MCMC posterior distributions. *Right:* the astrometric solution with the proper motions removed. The distance is constrained to $d = 16.7 \pm 5.3$ pc, which favors a young, extremely low-mass binary ($M_{\text{tot}} \lesssim 20 M_{\text{Jup}}$; Bardalez Gagliuffi et al. 2018).

We used the single-epoch astrometry from the Level 1b frames from the original *WISE* mission and the reactivated NEOWISE mission (Mainzer et al. 2011, 2014) to compute the parallax solution for WISE J1355-8258, as outlined in Theissen (2018). Figure 1 shows the best-fit solution for the parallax and proper motion, constraining the parallax to $60 \pm 19$ mas, or $d = 16.7 \pm 5.3$ pc. This solution is consistent with the with Case 3 from Bardalez Gagliuffi et al. (2018), where the spectral types of each component are L7 and T7.5 with an estimated age of 130–200 Myr (from AB Doradus membership), a spectrophotometric distance of $d = 17 \pm 2$ pc, and estimated masses of 11 $M_{\text{Jup}}$ and 9 $M_{\text{Jup}}$, respectively. Using the updated parallax with the kinematics information from Bardalez Gagliuffi et al. (2018), we used BANYAN Σ (Gagné et al. 2018) to reassess the probability that WISE J1355-8258 is a member of AB Doradus. We find using BANYAN Σ that WISE J1355-8258 has a 95.6% probability of being a member of AB Doradus, a 3.4% probability of being a member of $\beta$ Pic, and a 1% probability of being a field object.

With a total mass of $\sim 20 M_{\text{Jup}}$, WISE J1355-8258 is the second lowest mass binary known, with 2MASS J11193254-1137466AB being the lowest-mass binary currently known ($M_{\text{tot}} \approx 7.4 M_{\text{Jup}}$; Best et al. 2017). Our parallax solution also disfavors Case 1 ($M_{\text{tot}} \approx 133 M_{\text{Jup}}$) and Case 2 ($M_{\text{tot}} \approx 112 M_{\text{Jup}}$) from Bardalez Gagliuffi et al. (2018) at the 3-$\sigma$ and 2-$\sigma$ levels, respectively. A more precise parallax solution is required to definitively rule out higher-mass components.

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This research made use of Astropy, a community-developed core Python package for Astronomy (Astropy Collaboration et al. 2013). Plots in this publication were made using Matplotlib (Hunter 2007).

1 https://github.com/ctheissen/WISE_Parallaxes
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Facilities: IRSA, WISE

Software: Astropy (Astropy Collaboration et al. 2013), Matplotlib (Hunter 2007), emcee (Foreman-Mackey et al. 2013), WISE Parallaxes (Theissen 2018),

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