A WISE Observation of a coolest brown dwarf, CFBDSIR 1458+1013.

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ABSTRACT

The Wide-field Infrared Survey Explorer (WISE) has detected the close binary brown dwarf system CFBDSIR 1458+1013AB as WISEP J145829.35+101341.8 with a combined magnitude at 4.6 \( \mu m \) of \( W2 = 15.488 \pm 0.147 \). This allows a comparison with another “coolest” brown dwarf candidate WD 0806-661B that has been observed at 4.5 \( \mu m \) with \( [4.5] = 16.75 \pm 0.05 \). Here we use the WISE data to show that 1458+1013B is almost certainly warmer and more luminous than WD 0806-661B.

Subject headings: stars: low-mass, brown dwarfs; infrared radiation

1. Introduction

The Wide-field Infrared Survey Explorer (WISE) (Wright et al. 2010) has surveyed the entire sky in four thermal infrared bands. The Spitzer 4.5 \( \mu m \) band and the WISE 4.6 \( \mu m \) (W2) band are very similar in wavelength, so no large color term is expected when comparing magnitudes in these bands. We have examined the set of spectroscopically confirmed T dwarfs seen by both WISE and Spitzer and see only a small color term, with mean \( [4.5] - W2 = 0.054 \) magnitudes and no apparent trend with color or spectral type.

We can use this to estimate the W2 magnitude of WD 0806-661B to be 16.7 based on the Spitzer data (Luhman et al. 2011), which is below the sensitivity limit for WISE. Given the 1.25 \( \mu m \) limit of J > 21.7 (Rodriguez et al. 2011), the color is J-W2 > 5.0. With the 19.2 \pm 0.6 pc distance (Luhman et al. 2011), the absolute magnitude is \( M_{W2} = 15.28 \).

2. Color-Magnitude Fit

The WISE data on the close binary 1458+1013 only give the combined light at 4.6 \( \mu m \), with a W2 magnitude of 15.488 \pm 0.147. The other WISE bands only give upper limits on the flux, with a 2\( \sigma \) limit on the combined magnitude at 3.4 \( \mu m \) of \( W1 > 16.84 \) magnitudes. The brightness of the secondary component of the binary depends on the assumed flux ratio \( f = F_A/F_B \). This ratio is 5.2, 8.6 & 7.6 at 1.25, 1.6 & 2.15 \( \mu m \) (Liu et al. 2011), but we expect the B component of the binary will be redder than the A component leading to a lower flux ratio at 4.6 \( \mu m \). We have estimated the flux ratio at 4.6 \( \mu m \) by fitting a straight line \( M_{W2} = a + b(J - W2) \) to a sample consisting of brown dwarfs with known distances (Patten et al. 2006) plus the A and B components of 1458+1013 with the flux ratio \( f \) as a third parameter of the fit. Figure 1 shows the best fit, which has \( a = 11.14 \) and \( b = 0.701 \). The scatter is larger than can be explained by observational errors, so the error on \( f \) from the fit is calculated assuming a intrinsic scatter of \( \pm 0.42 \) on \( M_{W2} \). This gives a flux ratio \( f = 1.85 \pm 0.61 \). For the best fit flux ratio 1458+1013B is as red as the lower limit on the color for WD 0806-661B, but also considerably more luminous at 4.6 \( \mu m \). For larger flux ratios the B component gets fainter but also bluer. If
the straight line fit to $M_{W2}$ to $(J - W2)$ were exact then $f(W2) = f(J)^{b/(1+b)} = 1.97$. For this flux ratio the color of 1458+1013B is $J-W2 = 5.01$ and the absolute magnitude is $M_{W2} = 14.85$, insignificantly different from the plotted solution.

3. Discussion

Given that WD 0806-661B is both 20% closer to the Sun and its flux is 3 times fainter than the combined light of 1458+1013 at 4.6 $\mu$m, our conclusion that WD 0806-661B is the cooler and less luminous of these two “coolest” brown dwarfs is straightforward. The same conclusion can be made in the J band where the Rodriguez et al. (2011) limit on WD 0806-661B is fainter than the measured magnitude of 1458+1013B (Liu et al. 2011). This conclusion is also reflected in the estimated effective temperatures: $370 \pm 40$ K for 1458+1013B (Liu et al. 2011) and $\approx 300$ K for WD 0806-661B (Luhman et al. 2011). But the fitted line predicts that the color of WD 0806-661B is $J-W2 = 5.9 \pm 0.6$. If this prediction is correct then the apparent J magnitude of WD 0806-661B will be $J = 22.6$, and followup spectroscopy to confirm that this object is a brown dwarf will be impossible using ground-based telescopes and quite difficult even with the Hubble Space Telescope. The WISE all-sky survey should find objects this red and redder that are much closer to the Sun and thus much more suited for detailed study.

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REFERENCES

Liu, M. C., Delorme, P., Dupuy, T. J., Bowler, B. P., Albert, L., Artigau, E., Reyle, C., Forveille, T., & Delfosse, X. 2011, ArXiv e-prints

Luhman, K. L., Burgasser, A. J., & Bochanski, J. J. 2011, ApJL, 730, 9

Patten, B. M., et al. 2006, ApJ, 651, 502

Rodriguez, D. R., Zuckerman, B., Melis, C., & Song, I. 2011, ArXiv e-prints

Wright, E. L., et al. 2010, AJ, 140, 1868