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Calibrating Ultracool Atmospheres with Benchmark Companions from WISE+2MASS

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Abstract. The complexities of ultracool atmospheres are best confronted by observations of ultracool dwarfs (UCDs) with well known physical properties (luminosity, mass, T_{eff}, log(g), [M/H]), so-called "benchmark objects." We present two discoveries from a new WISE+2MASS search for benchmark wide companions to Hipparcos and Gliese stars. This survey combination provides a powerful tool to confirm new companions using color-magnitude and common proper motion selections, and also yield full NIR-MIR measurements of the ultracool emission. These primary companions are providing important constraints on the age and composition of the benchmark brown dwarf, and the new discoveries add to our growing population of benchmarks that is providing crucial tests of ultracool physics.

Keywords. ultracool dwarfs, binaries

1. Introduction

For field stars and brown dwarfs in particular, ages are one of the most difficult parameters to estimate. This is true for brown dwarfs especially, because they cool over time and it is extremely difficult to break the degeneracy between some parameters like age, mass, T_{eff}, and luminosity. Currently, the radii of brown dwarfs has to be calculated using evolutionary models, and their T_{eff} strongly depends on how accurately this can be done. Also, metallicity effects on the spectral energy distribution (SED) of UCDs is still not well understood. All this combines to make it extremely important to study ultracool dwarfs with well constrained ages and composition, and these objects we refer to as benchmark objects. Wide binaries that contain a UCD and a main sequence (MS) star are ideal to study how UCD SEDs depend on these properties, as we assume both components are coeval and we can infer the properties of the secondary by studying the primary.

2. New binaries

Our first binary is a newly confirmed L dwarf with a K8 star as a companion. The proper motion for this binary was calculated using 2MASS and WISE epochs, with a 10 yr baseline. The primary star has a measured parallax distance of 35.87 ± 1.47 pc. Using the color-magnitude M_k vs V-K and the relations in Johnson & Apps (2009), we have estimated a metallicity of 0.03 dex for the K8 star.

An optical low resolution spectrum was obtained for the L dwarf with DOLORES at the TNG, La Palma. We have compared our spectrum with two templates and using a reduced χ^2 fit, we conclude that this is an L1± 0.5 dwarf. To determine the bolometric luminosity, we have combined our optical spectrum, with wavelengths ranging from 5.0 μm to 1.1μm, with the 2MASS and WISE W1 and W2 photometry. We also considered that the L dwarf was at the same distance as its companion. For a surface gravity log(g)=4.5 and metallicity of -0.3 dex, we have estimated a bolometric luminosity L_{bol} = 1.67±0.17 ×10^4 $L_\odot$.

The second new binary is part of a triple system as the companion is actually a double system with an M4 and K5 star. The UCD companion is a known L4 ± 2 dwarf. The proper motion for this object has been measured by Jameson *et al.* (2008). We used these values to calculate that it has a common proper motion with the binary system. Taking the parallax distance of the binary system, we estimated the absolute magnitude M_J for the L dwarf, and used the Marocco *et al.* (2010) relation to estimate a spectral type of L6 for this UCD. This result is still in agreement with previous classifications if we take into account the error bars.

We also obtained an optical spectrum for the L dwarf and are now in the process of reducing the data and estimating a more accurate spectral type. The bolometric luminosity will also be calculated for this UCD, in order to estimate an accurate $T_{\rm eff}$.

3. Conclusions and future work

Ongoing efforts are taking place to find more of these benchmark binaries. Exploring the WISE database will allow us to find more, and colder UCD candidates. These will be combined with main sequence stars in the PPMXL catalog, where proper motion measurements for the primaries are available. We will also include the two binaries presented here along with future discoveries in the current sample of benchmark UCD systems. Constraining the UCD's properties (e.g., age and metallicity) from their companion stars will help improve the current models and extend our knowledge of ultracool atmospheric physics.

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