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The Discovery of a Low-Mass Binary Companion to HD130948

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Abstract. We report the discovery of a low mass binary companion to the nearby (17.9 pc) main sequence star HD130948 (HR5534, HIP 72567) using the Hokupa'a adaptive optics instrument mounted on the Gemini North 8 meter telescope. Both companions have the same common proper motion as the primary star as seen over a 4 month baseline. The JHK' photometry of the companions, when placed on a near-IR color-magnitude diagram and compared with theoretical models places them at the bottom of the M-dwarf sequence. Preliminary near IR spectra have been obtained with SpeX mounted on the NASA IRTF 3 meter telescope are consistent with the photometric results and show carbon monoxide bandheads and water absorption features indicative of an early L-late M spectral type. The X-ray activity and Lithium abundance of the primary star indicate that the system is probably less than 1 Gyr old. Assuming a young age, these objects are less than 80 $M_{jupiter}$. With further astrometric observations carried out over an estimated orbital period of 10-20 years, a dynamical mass will be obtained.

1. Introduction

The past decade of near-IR sky surveys and technological advances in high dynamic range imaging has resulted in the identification of a number of low-mass, ultra-cool objects as free floating objects and as companions to higher mass stars. This has brought about classification schemes (Kirkpatric et al. 1999, Martin et al. 1999) attempting to organize and understand the new class of objects in the same way as we understand the well studied OBAFGKM main sequence stars. However, the interpretation of physical parameters from the classification of low-mass objects is a more complicated exercise. The lack of a sustained hydrogen burning core creates a degeneracy between mass and age as the luminosity fades in time. Also, the spectra of these objects are significantly affected by the presence of dust in their atmospheres (Schweitzer et al. 2001). It is clear that a thorough understanding will only be reached after a number of objects in different environments are studied with the luminosity, age, mass, and composition obtained independently of the radiative transfer models and spectral classification schemes.

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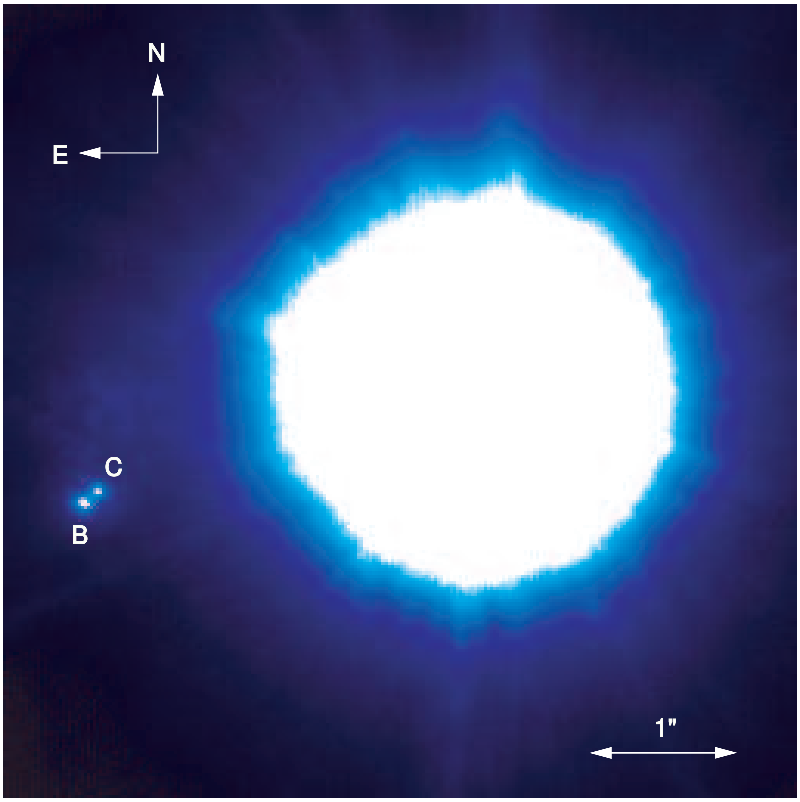

Figure 1. The discovery image from the night of February 24, 2001 clearly shows the binary companion. The binary pair is 2.7" from HD130948A with the companion furthest from the primary the brightest, thus we label it as HD130948B and the closer, fainter companion as HD130948C. The primary has a Lithium abundance and X-ray activity which indicate it is most probably less than 1 Gyr old (Giados 2000).

We have found a system similar to the close binary companion of GL569B (Martin et al 2000, kenworthy et al 2001, Lane et al 2001), that will eventually provide a dynamical mass measurement to compare with mass estimates obtained through theoretical models.

2. Observations

The companions were discovered using the Hokupa'a (Graves et al 1999) curvature sensing AO system mounted on the Gemini North Telescope in the Wollaston prism mode (Potter et al. 2001). The system provides near diffraction limited images in the J, H, and K' bands. The companions were discovered on the night of 2001 February 24 (Figure 1). Follow-up observations were obtained on April 19 to measure the photometry (Table 1 and Figure 2), and on June

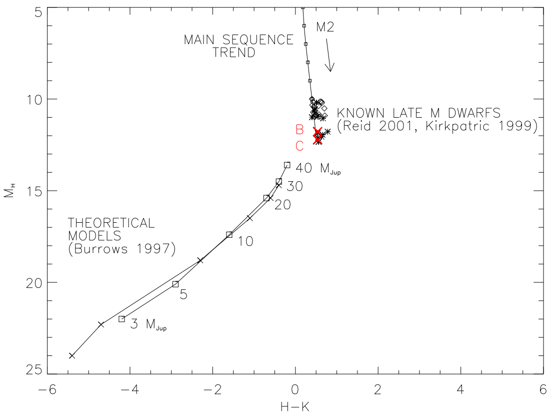

Figure 2. The B and C companions to HD130948 are plotted on an H-K versus H color-magnitude plot and marked as red X symbols. The size of the X symbols are larger than the measured photometric error for the H-K color (see table 1). A comparison of our photometric results with the synthetic color-magnitude positions produced by the models of Burrows et al. 1997 places the companions at the bottom (late side) of the M- dwarf sequence. A number of late (M7-L7) dwarfs discovered from 2MASS (Reid et al. 2001, Kirkpatric et al. 1999) are plotted for further comparison.

28 to maximize the time baseline for astrometry (Table 2). All images analyzed were flat-fielded with the bad pixels were filtered.

The near-IR spectra of the binary pair (Figure 3) were obtained at the NASA IRTF 3.3 meter on the night of March 13, 2001 using the SpeX near-IR spectrograph (Rayner et al 2001).

3. Conclusions

We have found a binary companion to the Young (<1 Gy) solar analog star HD130948. The placement of the objects on near-IR color-magnitude diagrams, as well as the near IR spectrum of the combined light of the pair are consistent with the objects having a spectral type between L2 and M8, with a best fit at L0. The estimated masses for the companions based on the models of Burrows et al. 1997, assuming an age of 1Gyr places them at around 60-80 MJ. In less than 10 years, a dynamical mass can be determined from astrometric observations of the orbit. This independent mass estimate, as well as the age estimate from the primary star, will provide two well constrained calibration points for the theoretical models describing low-mass, ultra-cool objects.

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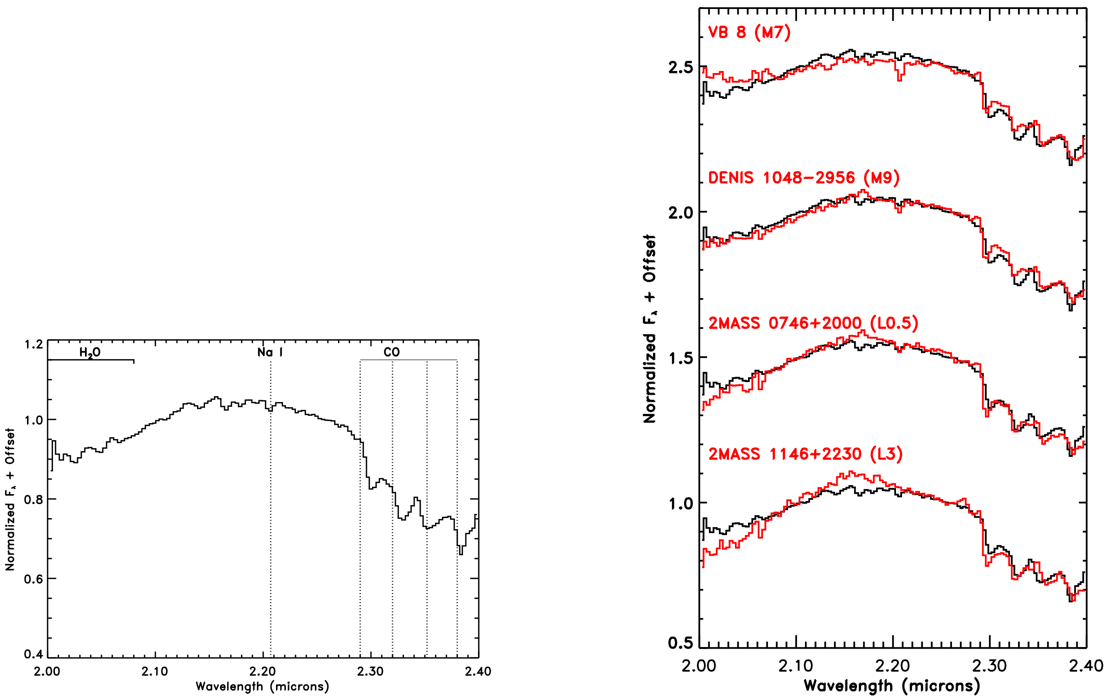

Figure 3. Low-resolution (R 380) K-band spectrum of the combined light from HD 130948 B and C (left). The spectrum shows absorption features commonly seen in the spectra of cool stars such as the blended Na I doublet (2.206 and 2.209 mm), the CO Dn = 2 overtone bands (2.29-2.42 mm), and the broad water absorption band from 1.7-2.1 mm. On the right, the K-band spectrum of HD 130948 B/C (black) and a spectral sequence of late M and early L stars (red). The spectral sequence consists of an M7, M9, L0.5, and L3 obtained with SpeX at a resolution of R=2000. The spectra have been smoothed to the resolution of the HD 130948 B/C spectrum and resampled onto its wavelength scale. The spectrum that bests fits the HD 130948 B/C composite spectrum has a spectral type of M9-L0.5

Table 1. Photometry* of Companions

HD130948 component	J	H	K_s
B	12.2	11.8	11.2
C	12.6	12.2	11.7

*preliminary aperature Photometry

Table 2. Astrometry of Companions

Date	Sep(pix)*	PA(Deg)
Feb. 24, 2001	6.6+/−0.2	317.1+/−1.4
Apr. 19, 2001	6.9+/−0.2	315.4+/−1.0
Jun. 28, 2001	6.7+/−0.2	317.7+/−5.2

*0.0199 arcsec/pix

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