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Discovery of Three Very Low Mass Binary Systems: An Adaptive Optics Survey of M6.0–M7.5 Stars

Nick Siegler, Laird M. Close, Eric E. Mamajek, & Melanie Freed

Steward Observatory, University of Arizona, Tucson, AZ, USA 85721
nsiegler@as.arizona.edu

Abstract. We have used the adaptive optics system Hōkūpa'a at Gemini North to search for companions from a flux-limited ($K_s > 12$) survey of 30 nearby M6.0-M7.5 dwarfs. Our observations, which are sensitive to companions with separations $> 0.1''$ (~ 2.8 AU), detect 3 new binary systems. This implies an overall binary fraction of 9±4% for M6.0-M7.5 binaries. This binary frequency is somewhat less than the 19±7% measured for late M stars and $\sim$ 20% for L stars, but is still statistically consistent. However, the result is significantly lower than the binary fractions observed amongst solar mass main sequence stars ($\sim$60%) and early M stars ($\sim$35%).

1. Introduction

The strategy of our survey is to take advantage of the lower brightness of very low mass (VLM) stars to look for companions (planets, brown dwarfs, other VLM stars) through the use of AO and a large ground-based telescope. By observing in the NIR, we utilize both near-diffraction limited resolution and image at the wavelengths where these objects' spectral energy distributions peak. The overall survey was carried out on a flux-limited (K_s <12) sample of 30 M6.0-L0.5 stellar primaries, spectroscopically identified as single stars by the 2MASS survey.

The ability to detect these faint companions is through the use of adaptive optics using a curvature wave-front sensor and a large aperture telescope. Because of the extreme optical faintness of very low mass stars and brown dwarfs (V$\sim$20), most AO systems cannot guide on such faint targets. The exceptions are curvature-based AO systems which employ red-sensitive, photon-counting, avalanche photodiodes (APDs) in their wave front-sensors. Such a sensor can guide on a target as faint as V=20, as long as the object is quite red (V-I=4). Consequently, this highly sensitive curvature AO system is well suited to guiding on nearby, faint, red M6-M9 stars and producing $0.1''$ K′ band images (which are close to the $0.07''$ diffraction limit).

The binarity of both M0-M6.0 and M8.0-L0.5 stars have been estimated by two different groups (Fisher & Marcy 1992 and Close et al. 2002c, respectively) leaving a narrow gap in which we can report a subset of our results targeting M6.0-M7.5 stars. For a more complete analysis of this data see Siegler et al. 2002.

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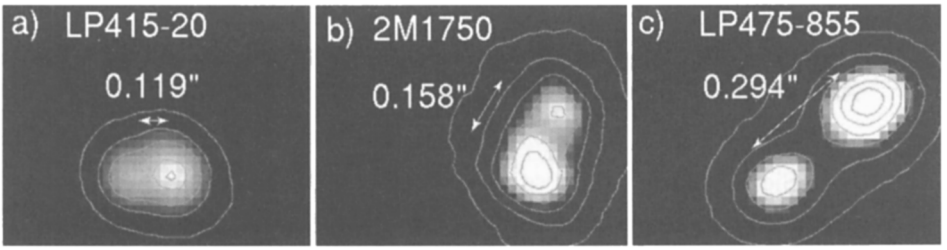

Figure 1. K′ images of each of the new systems.

2. Observations and Results

Table 1. The newly resolved binary systems, their photometry, and derived parameters split into A and B components:

Name	J	K_s	M_{K_s}	SpT
LP415-20A	13.09 ± 0.06	12.12 ± 0.04	9.78 ± 0.38	M7
LP415-20B	13.93 ± 0.16	12.78 ± 0.08	10.44 ± 0.39	L0
LP475-855A	13.21 ± 0.04	12.18 ± 0.04	9.94 ± 0.36	M7.5
LP475-855B	13.69 ± 0.07	12.66 ± 0.05	10.42 ± 0.36	M9.5
2M1750A	13.23 ± 0.06	12.24 ± 0.05	9.85 ± 0.39	M7.5
2M1750B	13.97 ± 0.16	12.88 ± 0.11	10.49 ± 0.40	L0

Name	Mass	D_{phot} (pc)	Sep (AU)	P (yr)
LP415-20A	$0.095^{+0.012}_{-0.011}$	29 ± 5	3.5 ± 0.7	16^{+7}_{-4}
LP415-20B	$0.079^{+0.009}_{-0.010}$			
LP475-855A	$0.091^{+0.012}_{-0.009}$	28 ± 5	8.3 ± 1.4	58^{+27}_{-14}
LP475-855B	$0.080^{+0.009}_{-0.009}$			
2M1750A	$0.095^{+0.011}_{-0.012}$	30 ± 5	4.8 ± 0.9	25^{+16}_{-13}
2M1750B	$0.084^{+0.005}_{-0.016}$			

3. Conclusions

Use of a highly sensitive curvature wave-front sensor, capable of producing 0.1″ images in K′, has allowed for the first time direct adaptive optics guiding on VLM stars to survey the nearest late M/early L stars:

• From direct observations in the J, H, and K′, we have surveyed 30 M6.0-M7.5 dwarfs and have discovered 3 new systems. When taking into consideration Malmquist bias and instrumental sensitivities, we estimate a binary frequency of 9±4%. This binary frequency is somewhat less than the 19±7% measured for late M stars (Close, Siegler, & Freed 2002) and (~20%) estimated for L stars

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(Reid et al. 2001) but is still statistically consistent. However, the result is significantly lower than the binary fractions observed amongst solar mass main sequence stars (~60%; Duquennoy & Mayor 1991) and early M stars (~35%; Fischer & Marcy 1992).

• None of these VLM binaries ($M_{tot} < 0.18 M_{\odot}$) have separations >20 AU giving support to the theory that all VLM binaries have semi-major axis distributions that peak at ~ 4 AU. This is a much tighter distribution than early M and G which have a broad peak at ~ 30AU.

• The 3 binary systems have q ratios between $0.83 < q < 0.90$, consistent with the findings that nature appears to have a preference for creating similar mass ratio distributions in low mass binaries.

References

Chabrier, G., Baraffe, I., Allard, F., & Hauschildt, P. 2000, ApJ, 542, 464

Close, L. M., Siegler, N., & Freed, M. 2002c, ApJ submitted

Dahn et al. 1992, ApJ, 124, 1170

Duquennoy, A., Mayor, M. 1991, A&A, 248, 485

Fischer, D. A., & Marcy, G. W. 1992, ApJ, 396, 178

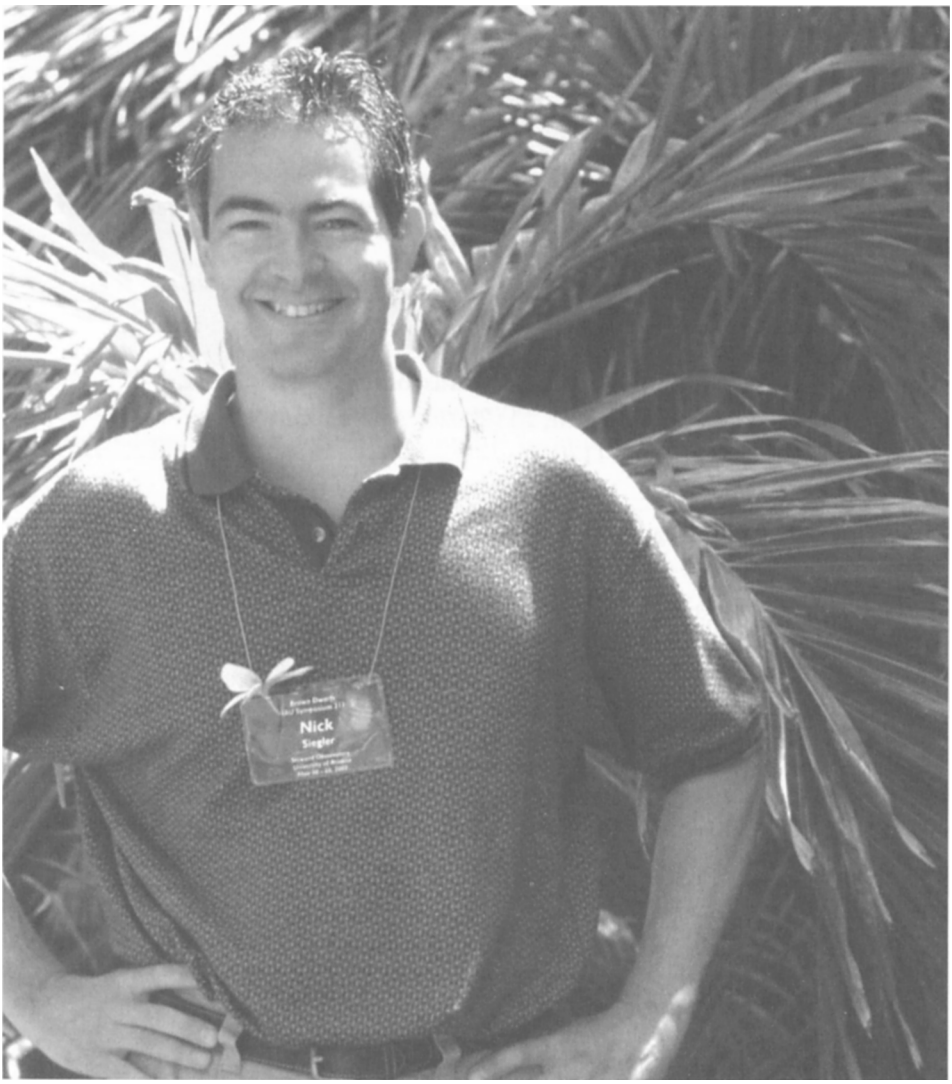
Freed, M., Close, L. M., & Siegler, N. 2002, ApJ submitted

Gizis et al. 2000, AJ, 120, 1085

Reid, I. N., Gizis, J. E., Kirkpatrick, J. D., Koerner, D. W. 2001a, AJ, 121, 489

Siegler, N., Close, L. M., Mamajek, E. E., & Freed, M. 2002, in preparation

https://doi.org/10.1017/S0074180900210681 Published online by Cambridge University Press



Nick Siegler and the plumeria flower

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