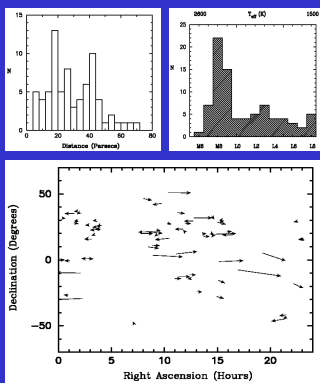


A Search for Brown Dwarf Companions to Low-Luminosity Dwarfs

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We present the results of a deep infrared search for substellar companions to low-luminosity dwarfs. K-band imaging of a sample of late M and L dwarfs was carried out at the Keck telescope down to a limiting magnitude of $m_K = 20$. Companions were distinguished from background stars by common proper motion as identified in a double-epoch study with a 1 to 3 year timeline. We found no companions at separations of 1" to 15" in a sample of 90 targets. We are testing this result further with an IRTF survey of a larger sample over a wider field of view. Preliminary results of the latter are also presented here. Four close companions were detected in the Keck survey with luminosities similar to the primaries. Angular separations of 0.3" to 0.5" corresponded to linear separations of 5-10 AU, assuming trigonometric parallaxes recently obtained by USNO. This result accords well with the number of similar-luminosity companions detected in a recent HST survey of low-luminosity dwarfs (Reid et al. 2001). The detection rate of both studies falls short of that for earlier spectral types, but sensitivity to high luminosity contrast was reduced at these separations. High-contrast companions may in fact be abundant at the shorter separations. Thus we can conclude only that companions to low-luminosity dwarfs are absent at the separations for which they are most abundant in earlier spectral types (~30 AU for G dwarfs). This signifies either a lower companion rate overall for low-luminosity dwarfs, or a separation distribution peaked closer to the primary.

Sample Description and Methodology

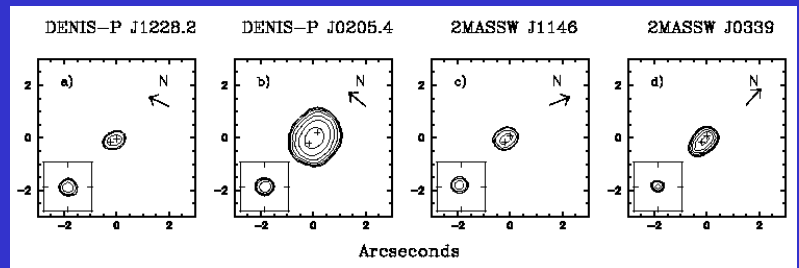


Our target sample was culled from the 2MASS and DENIS near-infrared sky surveys and consists of objects spectroscopically confirmed to be L dwarfs together with a smaller sample of nearby late M dwarfs. The sample was collected by photometric surveys in sky regions avoiding the galactic plane. Survey parameters are presented in the figures to the left, including a range of distances, spectral types, and sky coverage. The survey is sensitive to companions brighter than $m_K = 21$ at separations greater than 1" (5-50 AU in the sampled range of distances) within a 20" x 20" square aperture (out to 100-1000 AU), and is capable of detecting components with luminosity close to that of the primary ($m_K \sim 13$) at ~0.3" separation. Repeat observations in a second epoch, one to three years later, were taken to determine if any of these share a common proper motion with the target.

Proper motions were determined in the survey by measuring the movement of the background stars with respect to the target. Relative magnitude and direction of the proper motions are shown as arrows in the figure displaying the sky coverage. Although solar motion has not been accounted for in the plot at left, there is still evidence for some non-random motion, perhaps in L dwarf associations.

Detected Binaries

Four binary systems were detected in our survey and are displayed in the figure at right. All have projected separations near the limit of our resolution and flux ratios near unity. These were identified by inspecting the core of each of the sources in our sample and searching for extended emission consistent with the presence of a marginally resolved binary. Second-epoch observations were relied on to confirm that an elongation in the core was not due to time-dependent systematic effects, such as errors in phasing of the segmented primary mirror. Point-like sources observed nearby in the sky and within an hour of the target observations were used as PSFs to deconvolve the extended emission and derive the binary component parameters. Contour plots of K-band imaging for each of the binary systems are shown to the right, with the "PSF" star located in the subset frame.

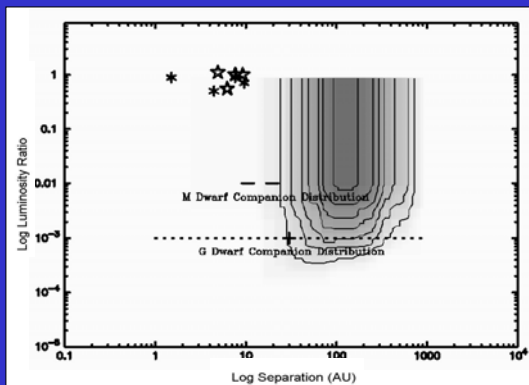


	Separation	Position Angle	Flux Component Ratio
DENIS-PJ 1228.2	$0.27'' \pm 0.03''$	$33^\circ \pm 15^\circ$	1.1 ± 0.4
DENIS-PJ 0205.4	$0.51'' \pm 0.03''$	$92^\circ \pm 18^\circ$	1.0 ± 0.4
2MASSWJ 1146	$0.29'' \pm 0.06''$	$206^\circ \pm 19^\circ$	1.0 ± 0.3
2MASSWJ 0339	$0.27'' \pm 0.03''$	$206^\circ \pm 19^\circ$	0.5 ± 0.05

Properties of the L Dwarf Companion Distribution

The results of our study strongly support the following conclusion:

Companions to extremely faint dwarfs differ markedly in separation and mass ratio from their counterparts around Sun-like stars.



The evidence for this is apparent in a plot of the sensitivity of our survey to ranges in luminosity ratio and linear separation shown in the figure at left. The number of frames with sensitivity to companion detection is plotted in grayscale and contours as a function of luminosity ratio and separation in AU. Virtually all of our target observations are sensitive to the detection of a companion at a linear separations between 100 and 200 AU, with upper-limit luminosities that range from 1% to 0.01% of the primary. In contrast, the small number of detected companions lie between 5 and 10 AU of the primary, as indicated by open stars in the figure at left. Results from the survey of Reid et al. (2001) are plotted as asterisks for comparison. Together, these data argue for a peak in the distribution of L-dwarf companion separations that lies much closer to the primary than for M Dwarfs (Dashed line gives range as indicated by Fischer and Marcy 1992) or G Dwarfs (dotted line from Duquenooy and Mayor 1991). Our detected companions also have flux ratios which cluster near unity. However, our survey is not sensitive to high-contrast flux ratios at that separation. Consequently, a fainter companion population may still exist at stellocentric distances less than 10 AU.