Brown Dwarf Companions to Young Solar Analogs with AO

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We present results from an adaptive optics (AO) survey conducted with the Palomar and Keck telescopes over 3 years, to measure the frequency of stellar and sub-stellar companions to Sun-like stars. The survey sample contains 266 stars in the 3 – 10000 Myr age range, at heliocentric distances between 8 and 200 parsecs, and spectral types between F5–K5. A sub-sample of 101 stars, between 3 – 500 Myr old, were observed in deep exposures with a coronagraph to search for faint sub-stellar companions. A total of 287 candidate companions were discovered around the sample stars, which were re-imaged at subsequent epochs to determine physical association with the candidate host stars by checking for common proper motion. Benefiting from a highly-accurate astrometric calibration of the observations, we were able to successfully apply the common proper motion test in the majority of the cases, including stars with proper motions as small as 20 milli-arcseconds year^{-1}.

The results from the survey include the discovery of three new 3–500 Myr brown dwarf companions, one companion at the stellar/sub-stellar boundary, and 43 new 3–3000 Myr stellar binary systems. Near-infrared (near-IR) spectroscopy and photometry indicate that the newly-discovered young brown dwarf companions span a range of spectral types between M5 and T0.5 (Figure 1). As such, they are of prime significance for the empirical calibration of future observations of young brown dwarfs and extra-solar planets.

Based on the 3 new detections of sub-stellar companions in the sub-sample of 101 young stars, and following a careful estimate of the survey incompleteness, a Bayesian statistical analysis shows that the frequency of 0.012–0.072 solar-mass brown dwarfs in 30–1600 AU orbits around

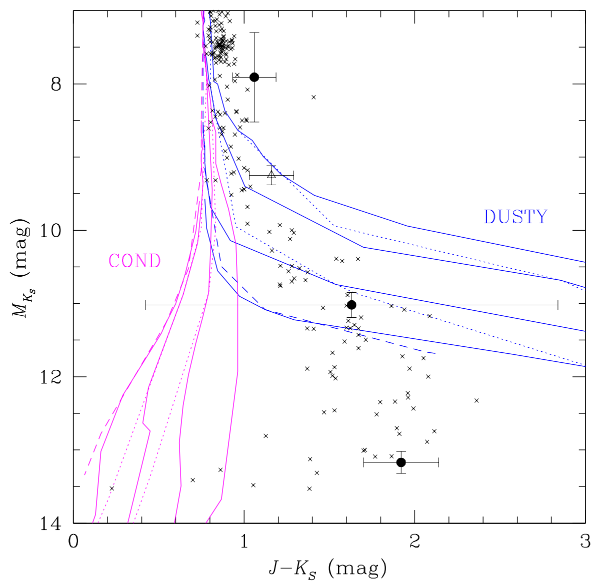

Fig. 1.— Near-IR color-magnitude diagram of the new bona fide (circles) and candidate (triangle) brown dwarfs. Predictions from the Lyon group DUSTY (Chabrier et al. 2000) and COND (Baraffe et al. 2003) models have been overlaid. Solid lines delineate 1, 10, 100, and 1000 Myr isochrones: from top to bottom in the DUSTY models, and from right to left in the COND models. Dotted lines show tracks of constant mass for 0.010 $M_\odot$ and 0.030 $M_\odot$ objects, whereas the dashed lines show the hydrogen-burning limit (0.072 $M_\odot$) at solar metallicity. Mass also increases from top to bottom in the DUSTY models, and from right to left in the COND models. The small × points represent M–T dwarfs with known parallaxes (Leggett et al. 2002; Dahn et al. 2002; Reid et al. 2004). At a photometrically estimated spectral type of T0.5, the coolest <500 Myr old brown dwarf companion has photospheric properties intermediate between those predicted by the DUSTY and the COND models.

young solar analogs is $6.8^{+8.3}_{-4.9}\%$ (2σ limits). While this is a factor of 3 lower than the frequency of stellar companions to G-dwarfs in the same orbital range, it is significantly higher than the frequency of brown dwarfs in 0–3 AU orbits, discovered through precision radial velocity surveys. It is also fully consistent with the observed frequency of 0–3 AU extra-solar planets. Thus, the result demonstrates that the radial-velocity "brown dwarf desert" does not extend to >30 AU separations around young solar analogs.

The sample of stars itself was adopted largely from the already compiled list of Sun-like stars in the same age range, studied by the Formation and Evolution of Planetary Systems (FEPS) *Spitzer* Legacy team (Meyer et al. 2005). The combination of high-angular resolution, high-contrast observations obtained in this survey with the sensitive mid-IR *Spitzer* data collected by the FEPS team will create an unprecedentedly comprehensive picture of the link between (sub-)stellar multiplicity and planet formation around Sun-like stars.

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We found two overactive solar analogs that had shown no evidence of stellar companions (i.e., photometrically single, no RV variation within uncertainties since 2007). If only we had precise light curves and radial velocitiesâ€¦ We will use a well-studied single, solar analog in R147 as a reference weâ€™ll call it ``R147Â¤Â¤â€™â€™. Chromospheric emission. Activity levels are so different, from R147 solar analogs.Â We therefore encourage the Spitzer TAC to accept our proposal to study this fascinating brown dwarf, found on an iPhone 6 at Disneyland, and located in the oldest nearby benchmark cluster. We thank the K2 Guest Observer Office for welcoming our call to re-point C7 to survey Ruprecht 147, Ball Aerospace for finding an optimal pointing, and NASA for the generous grant. Brown dwarfs are dense astronomical bodies compared to stars and their magnetic fields are even bigger than the strong ones that accompany sunspots. That is the reason why brown dwarfs are powerful emitters of radio emission. In this regard, it is infinitely important to remark, that the physical characteristics of red and brown dwarfs, contradict the most basic concepts of the Big Bang Cosmology Model.Â There is no brown dwarf companion to our sun. You better lay of the super marijuana and the crack pipe, Mr. Shrair. My bet is that your degrees are fictional, too. Brown dwarfs make rare companions to stars. This is the current belief in the eld of sub-stellar astronomy, based both on precision radial velocity (RV) surveys, probing orbital separations of <5 astronomical units (AU; Marcy & Butler, 2000), and on direct imaging eorts, prob-ing orbital separations >100 AU (Oppenheimer et al., 2001; McCarthy & Zuckerman, 2004).Â By targeting a large number of young Sun-like stars, we aim to establish a sample of young brown dwarfs with a well-determined age, whose physical properties can be used to improve our current knowledge of sub-stellar objects, and that can serve as reference in future studies. The introductory chapter continues with a brief overview of denitions and brown-dwarf properties (Â§1.1). A solar system with two stars. One a G3 bright star, and the other a dim brown dwarf companion? Well, here we look and study this concept.Â Walter Cruttenden suggests that the Northern Celestial Pole is actually a brown dwarf companion. And that this companions orbit is the 25,800 year precessional arc. Dr. Richard A. Muller, professor of physics at UC Berkeley and research physicist at Lawrence Berkeley National Laboratory, is an early proponent of a companion star to our sun; he prefers a 26 million year orbit period. A Brown Dwarf Binary Close to a Young Solar Analog. â€¢ Primary:HR5534,G2V,V= 5.9, Rotation P=7.8 days, active chromosphere, likely member of Ursa Major stream, age~300 Myr. â€¢ Companion discovered with Hokupaâ€™a AO/Gemini, separation 2.6â€, 8 magnitudes fainter than star in H-band (1.6 microns). AO Proper Motion and Spectroscopy of HR5534B and C. â€¢ AO observations 204 days after discovery confirm common proper motion. â€¢ Keck/AO NIRSPEC spectroscopy of each one of the two brown dwarfs (separation 0.13â€ or 2.3 AU) allow to derive spectral type ~L3. MMaarrccyyeettaal.l.22000000;;JJoorrisissseenneetta...