SOUTHERN VERY LOW MASS STARS AND BROWN DWARFS IN WIDE BINARY AND MULTIPLE SYSTEMS

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ABSTRACT
The results of the Königstuhl survey in the Southern Hemisphere are presented. I have searched for common proper motion companions to 173 field very low mass stars and brown dwarfs with spectral types >M5.0 V and magnitudes \( J \leq 14.5 \) mag. I have measured for the first time the common proper motion of two new wide systems containing very low mass components, Königstuhl 2 AB and 3 A-BC. Together with Königstuhl 1 AB and 2M 0126–50 AB, they are among the widest systems in their respective classes (\( r = 450–11,900 \) AU). I have determined the minimum frequency of field wide multiples (\( r > 100 \) AU) with late-type components at 5.0% \( \pm \) 1.8% and the frequency of field wide late-type binaries with mass ratios \( q > 0.5 \) at 1.2% \( \pm \) 0.9%. These values represent a key diagnostic of evolution history and low-mass star and brown dwarf formation scenarios. In addition, the proper motions of 62 field very low mass dwarfs are measured here for the first time.

Subject headings: binaries: visual — stars: formation — stars: individual (2MASS J23310161–0406193 AB, HD 221356, LP 655-23) — stars: low-mass, brown dwarfs

Online material: color figures, machine-readable table

1. INTRODUCTION
Very low mass (VLM) dwarfs have masses of about one-tenth of the solar mass or less and spectral types later than M5 V \( (T_{\text{eff}} \lesssim 3000 \text{ K}) \). Many of them are found in binary and multiple systems with a large number of separations and mass ratios. Proxima Centauri (M5.5 V), with a mass of \( 0.11 \pm 0.02 M_\odot \), is the nearest and most famous example of a VLM dwarf in a multiple system. Given its large separation from α Cen AB of more than 15,000 AU, Proxima is close to being gravitationally unbound (Wertheimer & Laughlin 2006 and references therein). The binary BL Cet + UV Cet (M5.5 V + M6.0 V), the sixth closest star system to the Sun, is on the contrary a tight binary separated by only \( \sim 5 \) AU (Heintz 1987). There are even some VLM field dwarfs that are both tight binaries and companions to more massive stars, e.g., c Ind BC (T1 V + T6 V) at \( \sim 1500 \) AU from the nearby K4.5 V star c Ind A (Scholz et al. 2003; McLaughren et al. 2004).

The systems containing VLM components can be dichotomized according to their mass ratios. One group comprises systems with mass ratios \( M_2/M_1 \gtrsim 0.5 \) and includes from radial velocity, transit, and microlensing exoplanet candidates to late-type stars and brown dwarf companions to FGK-type stars detected in direct imaging (see the Extrasolar Planets Encyclopedia2 and Burgasser et al. [2005] for comprehensive compilations of planetary and late M-, L-, and T-type companions to stars, respectively). The other group contains late-type stars and brown dwarfs in double systems with mass ratios \( q > 0.5 \). Throughout this work, I refer to them as equal-mass VLM binaries (or simply VLM binaries; see the Very Low Mass Binaries Archive maintained by Nick Siegler3 containing an up-to-date list of stellar and substellar binary systems with estimated total masses \( M_1 + M_2 < 0.2 M_\odot \)).

The vast majority of the equal-mass VLM binaries yet found have relatively small angular separations (of less than \( 1^\circ \)) and can only be resolved with the Hubble Space Telescope or adaptive optics systems (e.g., Bouy et al. 2005; Siegler et al. 2005). If the [SE2004] 70 + S Ori 68 system in the σ Orionis cluster is not considered (since it lacks proper-motion confirmation; Caballero et al. 2006), there are only six known VLM binaries with \( M_1 + M_2 < 0.2 M_\odot \), separated by more than 50 AU. Three are in very young star-forming regions (Ophiuchus, Chamaeleon I), which probably will not survive the tidal disruption field within the clusters, and three are field VLM binaries. The latter are DENIS-P J055146.0–443412 (DE 0551–44 AB, \( r \approx 220 \) AU; Billères et al. 2005), Königstuhl 1 AB (Kö 1 AB, \( r = 1800 \pm 170 \) AU; Caballero 2007), and 2MASS J01270282+5023210 (2M 0126–50 AB, \( r = 5100 \pm 400 \) AU; Artigau et al. 2007). Their mass ratios and total masses vary in the intervals \( 0.77 \leq q \leq 0.97 \) and \( 0.17 M_\odot \leq M_1 + M_2 \leq 0.19 M_\odot \), respectively. There are other known VLM multiple systems in the field with separations larger than 1000 AU. However, their total masses are several times larger than those of the equal-mass VLM binaries, and their mass ratios \( q \) significantly deviate from unity. For example, the mass ratio between vB 8 (M7.0 V, \( r \sim 1400 \) AU) and GJ 644 A-BD + GJ 643 in the V1054 Oph quintuple system is \( q \approx 0.065 \), and its total mass is about 1.3 \( M_\odot \) (Kuiper 1934; Weis 1982; D’Antona 1986; Söderhjelm 1999; Mazeh et al. 2001).

2M 0126–50 AB and Kö 1 AB, whose secondary has a mass at the substellar boundary, are by far the widest equal-mass VLM binaries yet found in the field and are part of a new differentiated binary class. Their separations are orders of magnitude larger than those of the VLM tight binaries. They represent a challenge for the widely accepted idea that lighter systems tend to have smaller separations (Sterzik & Durisen 2004) and for the “embryo ejection” scenario of formation of substellar objects (Reipurth & Clarke 2001; Bate et al. 2003). Large hydrodynamic simulations can produce wide low-mass binary systems, albeit rarely. Bate & Bonnell (2005) showed an exotic situation in which two low-mass M dwarfs
(about 0.18 \( M_\odot \) each) were almost simultaneously ejected with similar velocities from a small group of protostars. As the two objects moved away from the group, it turned out that they were weakly bound into a wide binary system. Their binding energy was, however, \( \sim 4.4 \) times larger than that of \( \text{KO} \quad 1 \quad AB \) and \( \sim 12 \) times larger than that of \( 2M \quad 0126 \quad 50 \quad AB \). Further discussion on how wide equal-mass VLM binaries represent a key diagnostic of star formation theories can be found in Biller et al. (2005), Phan-Bao et al. (2005), Burgasser et al. (2007), Caballero (2007), and Artigau et al. (2007). Caballero (2007) suggested that the wide separation between the components of \( \text{KO} \quad 1 \quad AB \) might be also due not only to the formation mechanism but also to perturbation resulting from encounters with more massive objects as they traveled in the Galaxy.

Both \( 2M \quad 0126 \quad 50 \quad AB \) and \( \text{KO} \quad 1 \quad AB \) are exceptional binaries, but it is not known yet how rare they are. In this work, I present the results of the Königstuhl survey of wide VLM dwarf binaries in the Southern Hemisphere and measure for the first time the frequency of equal-mass VLM systems. It complements the near-infrared proper motion search for companions to \( K \quad 5.0 \quad V - M \quad 7.0 \quad V \) stars at separations \( \sim 100 - 1400 \) AU carried out by Hinz et al. (2002) and the Cerro Tololo Inter-American Observatory Parallax Investigation of nearby multiples, primarily M dwarfs, by Jao et al. (2003).

2. THE KÖNIGSTUHL SURVEY

I have performed a proper-motion survey, called Königstuhl, using the United Kingdom Schmidt Telescope (UKST) and Palomar Observatory Sky Survey I (POSS-I) plates and the SuperCOSMOS Science Archive (SSA; Hambly et al. 2001a). The survey is limited to declination \( \sim +3^\circ \), where SSA data are only available. I have investigated 173 VLM field dwarfs with spectral types between \( M \quad 5.5 \quad V \) and \( L \quad 8.0 \quad V \) and brighter than \( J \quad 14.5 \) mag. Their names, coordinates, proper motions, and spectral types are provided in Table 3 (for tight binaries, only one spectral type is given). The bulk of them were taken from Cruz et al. (2003) and Phan-Bao & Bessel (2006). The SSA proper-motion measurements are accurate to \( \sim 10 \) mas yr\(^{-1}\) at photographic \( B_T \), \( R \sim 19 - 18 \) mag and to \( \sim 50 \) mas yr\(^{-1}\) at \( B_J \), \( R \sim 22 - 21 \) mag (Hambly et al. 2001b), which are the expected magnitudes of...
the faintest investigated VLM dwarfs. Three nearby stars are, however, too bright in the SuperCOSMOS images (Proxima Cen, BL Cet + UV Cet, and EZ Aqr, which saturate in the digitized photographic plates and whose proper motions are not tabulated by SuperCOSMOS). I have taken the values of their proper motions from Perryman et al. (1997) and Salim & Gould (2003). In addition, I have not identified in the SSA data L143-23 (M5.5 V, with a low Galactic latitude), HD 16270 B (L1.0 V, in the glare of the faintest investigated VLM dwarfs. Three nearby stars are, however, too bright in the SuperCOSMOS images (Proxima Cen, BL Cet + UV Cet, and EZ Aqr, which saturate in the digitized photographic plates and whose proper motions are not tabulated by SuperCOSMOS). I have taken the values of their proper motions from Perryman et al. (1997) and Salim & Gould (2003). In addition, I have not identified in the SSA data L143-23 (M5.5 V, with a low Galactic latitude), HD 16270 B (L1.0 V, in the glare of the K3.0 V primary), and several mid-L dwarfs fainter than J ~ 13.0 mag.

The survey procedure was similar to that in Caballero (2007). I downloaded the astrometric and photometric SSA data of all the sources in a 10" radius centered on each field dwarf and searched for stars or brown dwarfs with similar proper motions to those of the main targets. The threshold, ΔΔt, of the “similarity” was at about 4 times the error in the proper motion of the program field dwarfs [ΔΔt ≈ 4δμ, where δμ = (κ2μ2, cos δ + κ2μ2)1/2]. The error δμ increased for faint objects with late spectral types and large proper motions. Once a common proper motion candidate was selected, it was astrometrically followed up using multiepoch digitized plates from POSS-I red, UKST blue, red, and infrared, and data from the Two Micron All Sky Survey (2MASS) and Deep Near Infrared Survey of the Southern Sky (DENIS) catalogs (and the Spitzer Science Archive, if available). The time baseline was typically from first epochs 1950–1954 to last epochs 1999–2000, covering about half a century. Spurious SSA detections at only two blue optical bands without near-infrared counterparts were discarded from the study. The total survey area was 15.1 deg2. Figure 1 illustrates the proper-motion diagrams of four representative VLM dwarfs under study.

### 3. RESULTS

In the Königstuhl sample, there are 15 known tight binary and triple systems unresolved in the SSA images (nor in the 2MASS data). They are marked as “AB (C)” in column (2) of Table 3. Besides those, there are only five previously known resolved common proper motion multiple systems: α Cen AB + Proxima Cen, V1054 Oph ABCDE, G124-62 A-BC (r ~ 1500 AU [BC: DENIS-P J144137.3–094559 AB]; Seifahrt et al. 2005), GJ 1001 A-BC (r ~ 180 AU; Goldman et al. 1999), and 2M 0126–50 AB.

#### 3.1. Königstuhl 1, 2, and 3

Three new common proper motion systems have arisen from the Königstuhl survey. Their basic properties (ρ, θ, d, r, M1, and M2) are summarized in Table 1. The uncertainties in the determination of the common proper motions of the two components in the three systems, measured with the value σ/Δt (where σ is the standard deviation of the mean angular separation, Δt

| Name | Primary | Secondary | ρ (arcmin) | θ (deg) | d (pc) | r (AU) | M1 (M_☉) | M2 (M_☉) |
|------|---------|-----------|------------|--------|-------|-------|--------|--------|
| Ko₃ 1 AB .......... | LEHPM 494 | DE 0021–42 | 1.2956 ± 0.0012 | 316.97 ± 0.08 | 23 ± 2 | 1800 ± 170 | 0.103 ± 0.006 | 0.079 ± 0.004 |
| Ko₃ 2 AB .......... | LP 655-23 | 2M 0430–08 | 0.328 ± 0.004 | 339.9 ± 0.4 | 22.9 ± 1.9 | 450 ± 40 | 0.26 ± 0.04 | 0.086 ± 0.004 |
| Ko₃ 3 A-BC .......... | HD 221356 | 2M 2331–04 AB | 7.530 ± 0.007 | 261.77 ± 0.06 | 26.2 ± 0.6 | 11900 ± 300 | 1.02 ± 0.07 | 0.088 ± 0.002 |

a Errors in distance estimates have been adopted from the literature.
b Mass errors are from theoretical fits to available data, and are not realistic.
is the time baseline, and $\mu$ is the modulus of the mean proper motion, are at the level of only 1.1%–3.3%. Images centered on two of the new common proper motion systems are shown in Figures 2 and 3.

3.1.1. Königstuhl 1 AB (Kö 1 AB)

Kö 1 AB, formed by LEHPM 494 and DENIS-P J0021.0—4244, was presented in Caballero (2007). In this work, I provide a new imaging epoch obtained with the IRAC instrument on board the Spitzer Space Telescope. I downloaded the images in the four channels, taken on J2003.970 (four years after the last epoch in Caballero 2007), and performed standard astrometry. The new measurement of the angular separation, $77.74''\pm 0.10''$, perfectly agrees with what was expected. I compute more accurate average separation and position angle of Kö 1 AB, given in Table 1. The expected semimajor axis of the parallax ellipse is $\sim 0.04''$.

3.1.2. Königstuhl 2 AB (Kö 2 AB)

The second new common proper motion system is formed by LP 655-23 and 2MASS J04305157–0849007 (Kö 2 AB). They maintain a constant angular separation of $19.7''\pm 0.2''$ during six epochs from J1954.005 to J2000.005. The VLM field dwarf target was the secondary, an M8.0 V at 22.9 ± 1.9 pc (Cruz et al. 2003). The primary, LP 655-23, was tabulated in the Luyten-Palomar and New Luyten Two Tents catalogs (Luyten 1979) of high proper motion stars. Improved astrometry, identical within the error bars to that presented here, was published by Salim & Gould (2003). None of them have been further investigated. Assuming that the binary is older than 1 Gyr, the NextGen98 models of Baraffe et al. (1998) and the Dusty00 models of Chabrier et al. (2000) provide masses of $0.26\pm 0.04$ and $0.086\pm 0.004 M_\odot$ for the primary and the secondary, respectively ($q = 0.33 \pm 0.05$). The colors and the theoretical effective temperature from the models of LP 655-23 correspond to early M spectral type. Using the distance estimate by Cruz et al. (2003), both M dwarfs are separated by $450 \pm 40$ AU. This value makes Kö 2 AB the second widest system in the field with $M_1 + M_2 < 0.4 M_\odot$, after Kö 1 AB and 2M 0126–50 AB, and together with the M4.5 V + L6.0 V binary LP 261-75 + 2MASS J09510549+3558021 ($\rho = 450 \pm 120$ AU; Reid & Walkowicz 2006).

3.1.3. Königstuhl 3 A-BC (Kö 3 A-BC)

The third and last new common proper motion system, Kö 3 A-BC, is formed by the F8 V star HD 221356 A and the M8.0 V + L3.0 V binary HD 221356 BC (BC: 2MASS J23310161–0406193 AB). In the discovery paper of 2M 2331–04 (as a single object), Gizis et al. (2000) reported that the derived photometric distance to the M8.0 V was consistent with the Hipparcos distance to the nearby star HD 221356. However, the proper motion of the secondary tabulated by them, $(+401, -231)$ mas yr$^{-1}$, clearly deviated from the Hipparcos proper motion of the F8 V, $(+178.6 \pm 1.0, -192.8 \pm 0.8)$ mas yr$^{-1}$. The M8.0 V was afterward found to be a $0.573''$ double by Gizis et al. (2003).

During the astrometric follow-up, I have used six epochs from J1951.583 to J1999.882 and measured the mean separation between HD 221356 and 2M 2331–04 AB/Kö 3 BC. Using the Hipparcos trigonometric parallax of HD 221356 A, the age of $5.7^{+0.9}_{-0.2}$ Gyr tabulated by Nordström et al. (2004), the combined 2MASS J magnitude of Kö 3 BC (Cutri et al. 2003), the $\rho$ and $\Delta J$ given by Gizis et al. (2003), and the Dusty00 models, I have determined new accurate theoretical masses for the M8.0 V + L3.0 V binary (given in Table 1). The L3.0 V has an estimated mass larger than previously estimated. The error bars in the masses only account for the uncertainties in the distance, age, and $J$-band magnitudes, not for the systematic errors of the theoretical models. The determination of the dynamical masses of Kö 3 BC through astrometric and radial velocity monitoring will help in estimating those systematic errors. The orbital period of Kö 3 BC, $P \approx 146$ yr ($a \approx 15.0$ AU; I assume a circular, face-on orbit and adopt the separation as the semimajor axis of the orbit), is quite similar to that predicted by Gizis et al. (2003). The orbital period of the binary surrounding the F8 V is a bit larger than 1 Myr. Finally, the metallicity of the primary and therefore of the system is also known ($[\text{M/H}] = -0.23$; Karataş et al. 2005), which may help with further spectral classification of the L3.0 V component (Kirkpatrick 2005).

3.2. Probable Background Noncompanions

I have found 14 stars at angular separations less than 10$''$ from the investigated dwarfs (12,000 AU at a typical heliocentric distance of 20 pc) with proper motions within the $4\Delta \pi$ threshold and that seem to be background stars with spectral types earlier than M5 V. Their basic data are given in Table 2. BD –20 3682 is an early F star located at 200 ± 70 pc from the Sun from its Hipparcos parallax and at 7.0$'$ from 2M 1237–21, which in contrast is an M6 dwarf at only 32 ± 6 pc (Cruz et al. 2003). BD –20 3682 was classified as a low-metallicity subdwarf by Ryan & Norris (1991). HD 117332, the brightest background noncompanion, is a G0-type star whose X-ray counterpart was detected
by Schwone et al. (2000). It is located far beyond the 27.0 ± 2.2 pc estimated by Cruz et al. (2003) for 2M 1330–04. Of the remaining 12 stars, six are fainter than the VLM target dwarfs but have bluer optical–near-infrared colors (e.g., \( J - K_s \) ≤ 1.6 mag), in contrast to what was expected if they formed a common proper motion pair. Three other stars are brighter than the VLM targets, but the distances roughly estimated from their colors and magnitudes do not match those of the VLM dwarfs.

I have made astrometric follow-up of the three remaining companions, which are brighter than their respective VLM dwarfs: 2MASS J0127047.5–5017112, LP 679-39, and LP 798-19. On the one hand, LP 679-39 is a background G-type star (SIMBAD) whose projected physical separation of 6.4″ from 2M 1413–04 varied 6″ in a time baseline of 42 yr, and therefore they do not share a common proper motion. On the other hand, I failed to ascertain the common proper motion status of LP 798-19 and 2M 1339–17 (\( \rho = 9.489 ± 0.010′′; \theta = 342.88 ± 0.09′′ \)) and of 2MASS J0127047.5–5017112 and 2M 0126–50 AB (\( \rho = 5.656 ± 0.006′′; \theta = 344.933 ± 0.06′′ \)). 2M 1339–17 is an M7.5 V located at 31 ± 3 pc (Cruz et al. 2003), while LP 798-19 seems to be an early M at 30–40 pc, based on their optical and near-infrared magnitudes. 2M 0126–50 AB is the wide equal-mass binary found by Artigau et al. (2007), with a photometric distance of \( d \approx 62 \) pc, while 2MASS J0127047.5–5017112, with a red color \( I - K_s \approx 2.2 \) mag and about 2 mag brighter in \( J \) than 2M 0126–50 AB, is investigated here for the first time. I have measured marginal variations of \( \Delta \upsilon \approx 1′′ \) of the two systems during 43 and 20 yr baselines. Additional imaging epochs are needed to discard or confirm their common proper motions.

3.3. Miscellaneous

As a by-product of the survey, I have measured for the first time the proper motions of 62 VLM field dwarfs (marked as “1” in col. [9] of Table 3). Accurate, homogeneous coordinates are also provided for the 173 dwarfs and eight resolved proper-motion companions.

I have determined the mean angular separation between 2M 0126–50 A and B (Artigau et al. 2007) at 81.93′′ ± 0.18′′, constant within the uncertainties during my time baseline of 18.0 yr (2M 0126–50 B is not visible in the UKST B_J digitization).

In addition, the double 2M 0429–31 1B (M7.5 V + L1.0 V; Cruz et al. 2003; Siegler et al. 2005) is at only 7.2″ from the fainter
4. THE FREQUENCY OF WIDE VERY LOW MASS BINARIES

Of the 173 investigated VLM dwarfs, 13 have large $\delta\mu$-to-$\mu$ ratios (marked as “3” in col. [9] of Table 3), which prevented me from searching for common proper motion companions surrounding them. Therefore, 160 dwarfs remain for statistical purposes. If the 15 unresolved systems, the five previously known resolved systems, and the three new Königstuhl systems are taken into account, then the frequency of multiplicity in the magnitude-limited sample of VLM dwarfs in the spectral-type interval M5.5 V–L8.0 V is $\gtrsim 14\%$. This value is a lower limit because most of the program targets have not been yet investigated with high spatial resolution facilities. I refer to Close et al. (2003), Siesler et al. (2005), Burgasser et al. (2005), and references therein for accurate frequencies of close multiples ($r < 30$ AU) at the 10%–30% level. These values must be compared to the upper limit of the relatively wide companion frequency at $2''$–$31''$ from M7–L8 dwarfs recently determined by Allen et al. (2007) of 2.3%. In contrast to these works, the Königstuhl survey is the only one able to study the frequency of very wide multiples ($r > 100$ AU) up to 6000–30,000 AU (at heliocentric distances $d = 5$–50 pc). In the aforementioned spectral-type interval, the minimum frequency of VLM dwarfs in wide multiple systems is as low as 5.0% ± 1.8% (8 of 160, Poissonian errors). The actual frequency could be larger because this survey is not sensitive to the detection of very faint companions.

There are only two wide binaries in my survey with mass ratio $q > 0.5$, Köl 1 AB and 2M 0126–50 AB (the other known field wide equal-mass VLM binary, DE 0551–44 AB, although it is in the Southern Hemisphere, is too faint for the magnitude-limited Königstuhl survey). The frequency of wide equal-mass VLM binaries is therefore 1.2% ± 0.9%. Despite the fact that it is not clear whether the origin of the wide separations between Köl 1 A and B and 2M 0126–50 A and B resides in the formation mechanism or in the gravitational tidal disruption within the Galactic disk (or in both), my survey has confirmed the low frequency of wide equal-mass VLM binaries. Further theoretical studies of formation in collapsing molecular clouds and of the interaction of low binding energy binaries with the gravitational field of the Galactic disk must account this low frequency.

To derive a more accurate frequency of wide equal-mass VLM binaries, the Königstuhl survey should be complemented in the future with new very wide photometric and astrometric searches in both the Southern and Northern Hemispheres.

5. SUMMARY

I have investigated 173 very low mass stars and brown dwarfs during a proper-motion survey, named Königstuhl, of resolved binary and multiple systems with very low mass components. The studied field dwarfs have spectral types $>\text{M5.0 V}$, magnitudes $J \leq 14.5$ mag, and declinations $\delta < +3^\circ$. I looked for common proper motion companions within a radius of 10$'$ centered on the dwarfs using astrometric data from the SuperCOSMOS Science Archive. Of the investigated very low mass dwarfs, 160 could actually be searched. I first provide the proper motions of 62 dwarfs. I have identified five previously known wide multiples, confirmed the common proper motion of two wide very low mass binaries with mass ratio $q > 0.5$ (Königstuhl 1 AB and 2M 0126–50 AB), and measured for the first time the common proper motion of two new wide systems containing very low mass components, Königstuhl 2 AB and 3 A-BC. Königstuhl 2 AB is formed by the early M, high proper motion star LP 655-23 and the M8.0 V dwarf 2M 0430–08. Their low total mass ($M_1 + M_2 \approx 0.35 M_\odot$) and relatively large separation ($\rho = 450 \pm 40$ AU) and mass ratio ($q = 0.33 \pm 0.05$) make the system one of the lowest mass, widest binaries yet found. The components of Königstuhl 3 A-BC are the F8 V star HD 221356 and the M8.0 V + L3.0 V tight binary 2M 2331–04 AB. They are separated by $\approx 7.5'$ ($\approx 12,000$ AU at the Hipparcos distance of the primary), which makes Königstuhl 3 A-BC by far the widest system containing an L-type dwarf. The knowledge of the basic properties of the primary (distance, age, and metallicity), and therefore of the very low mass binary companion, will allow us to test theoretical models and classification schemes of ultracool dwarfs with very late spectral types.

Finally, I have determined the minimum frequency of field wide multiples ($r > 100$ AU) with very low mass components at 5.0% ± 1.8% and the frequency of field wide very low mass component binaries with mass ratios $q > 0.5$ at 1.2% ± 0.9%.

Note added in manuscript.— In Table 3, there are 77 dwarfs with note (1) instead of 62. Fifteen have been recently published by Deacon & Hambly (2007). I thank N. Deacon for noting this mistake.

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