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Discovery of New Companions to High Proper Motion Stars from the VVV Survey. ⋆

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ABSTRACT

Context. The severe crowding in the direction of the inner Milky Way suggests that the census of stars within a few tens of parsecs in that direction may not be complete.

Aims. We search for new nearby objects companions of known high proper motion (HPM) stars located towards the densest regions of the Southern Milky Way where the background contamination presented a major problem to previous works.

Methods. The common proper motion (PM) method was used–we inspected the area around 167 known HPM ($\geq$200 mas yr^{-1}) stars: 67 in the disk and 100 in the bulge. Multi-epoch images were provided by the Two Micron All Sky Survey (2MASS) and the VISTA Variables in Via Lactea (VVV). The VVV is a new on-going $ZYJHK_S$ plus multi-epoch K_S survey of $\sim$562 deg^2 of Milky Way's bulge and inner Southern disk.

Results. Seven new co-moving companions were discovered around known HPM stars (L 149-77, LHS 2881, L 200-41, LHS 3188, LP 487-4, LHS 5333, and LP 922-16); six known co-moving pairs were recovered (LTT 5140 A + LTT 5140 B, L 412-3 + L 412−4, LP 920−25 + LP 920−26, LTT 6990 A + LTT 6990 B, M 124.22158.2900 + M 124.22158.2910, and GJ 2136 A + GJ 2136 B); a pair of stars that was thought to be co-moving was found to have different proper motions (LTT 7318, LTT 7319); published HPMs of eight stars were not confirmed (C* 1925, C* 1930, C* 1936, CD−60 4613, LP 866−17, OGLE BUL−SC20 625107, OGLE BUL−SC21 298351, and OGLE BUL−SC32 388121); last but not least, spectral types ranging from G8V to M5V were derived from new infrared spectroscopy for seventeen stars, members of the co-moving pairs.

Conclusions. The seven newly discovered stars constitute $\sim$4% of the nearby HPM star list but this is not a firm limit on the HPM star incompleteness because our starting point–the HPM list assembled from the literature–is incomplete itself, missing many nearby HPM M and L type objects, and it is contaminated with non-HPM stars. We have demonstrated, that the superior sub-arcsec spatial resolution, with respect to previous surveys, allows the VVV to examine further the binary nature nature of known HPM stars. The $\geq$5 yr span of VVV will provide sufficient baseline for finding new HPM stars from VVV data alone.

Key words. astrometry – proper motions – stars:general – stars:binaries:general – Galaxy:solar neighborhood

1. Introduction

The direction toward the inner Milky Way presents a formidable challenge for proper motions (PM) studies because of the crowding and confusion (for previous attempts see Lépine et al. 2002b; Lépine 2008). *VISTA Variables in the Via Lactea* (VVV) is a new ESO Public survey (Minniti et al. 2010; Saito et al. 2012a) that may help to alleviate these problems. The VVV is carried out with the *Visible and Infrared Survey Telescope for Astronomy* (VISTA; Dalton et al. 2006; Emerson et al. 2006) at Paranal

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⋆ The data for this work were obtained via observing programmes 179.B-2002, 087.D-0490, and 089.D-0462.

Observatory, and will obtain $ZYJHK_S$ coverage and multi-epoch (up to 100 for some pointings) K_S observations of ∼562 $\deg^2$ in the Milky Way's bulge and inner disk, at sub-arcsec seeing. After two years of operation, we already demonstrated, that VVV is producing new, interesting results: discovery of new star clusters (Minniti et al. 2011a; Borissova et al. 2011; Moni Bidin et al. 2011), investigation of the structure and stellar populations content of the Milky Way (Minniti et al. 2011b; Gonzalez et al. 2011a; Gonzalez et al. 2011b; Gonzalez et al. 2012; Saito et al. 2012c), study of variable stars and transients (Catelan et al. 2011; Saito et al. 2012b), and others. One of the main goals is to obtain 3-dimensional tomographic map of the Milky Way bulge based on Red Clump giants, RR Lyr and Cepheid variables. However, some corollary science objectives are also considered, including a PM study, taking advantage of the projected ≥5 yr survey duration. Early PM science with VVV is possible if it is used as a second epoch to a previous infrared survey, *e.g.* the Two Micron All Sky Survey (2MASS; Skrutskie et al. 2006). The 2MASS observations provide ≥10 yr baseline.

The VVV footprint on the sky is relatively small: ∼20 deg × 15 deg centered on the bulge, and ∼55 deg × 4.5 deg along the adjacent Southern disk, or just above 1% of the total sky, but it encompasses the regions with the highest stellar surface density in the Galaxy. This study is based on the available multi-filter imaging that was taken during the first VVV observing season, covering ∼500 $\deg^2$. The typical image quality is 0.8-1.0 arcsec, and the pixel scale is ∼0.34 arcsec pix^{-1}, which compare favorably to other Galactic surveys. The final VVV data products will be $ZYJHK_S$ atlas and a catalog of $\sim 10^9$ sources, $\sim 10^6$ of which are variables[1].

We embarked on a project to improve the Solar neighborhood census by searching for common PM companions to known nearby HPM stars. Our effort has the potential to improve the local stellar multiplicity fraction estimate–a key constraint to star formation theories, with implications for the stellar population modeling of unresolved stellar systems. We were driven by the argument that relatively bright new solar neighborhood stars could be found only in a survey covering the densest regions of the Milky Way, like VVV, because such stars far away from the Galactic plane were easy to discover with the previous generation of surveys. We build upon the success of the RECONS PM and parallax measurements project (Finch et al. 2007; Henry et al. 2004; Jao et al. 2009; Subasavage et al. 2009), the work of Léipne and collaborators (Lépine et al. 2002a; Lépine & Bongiorno 2007), Raghavan et al. (2010), Faherty et al. (2010), Allen et al. (2012), and others, with the advantage that VVV has better spatial resolution and higher sensitivity to low mass red objects, with respect to the previous surveys.

The paper is organized as follows: the next section describes the sample, Sec. 3 summarizes the search method, the follow up spectroscopy is reported in Sec. 4, and Sec. 5 gives the results.

2. Sample Selection

The sample was selected with SIMBAD, and it includes all stars with PM≥200 mas yr^{-1}, implying a total movement of ≥2 arcsec (≥6 VIRCAM pixels) over the ∼10-year interval separating 2MASS and VVV. Our previous experience shows that movements of this magnitude are easily detected. Some of the stars are saturated on the VVV images, but this still allows to search for fainter co-moving companions because the motions of the "doughnuts" with burned out cores are still discernible.

The VVV survey plan for the first year envisioned separate visits of each point of the survey area for ZY and JHK_S observations, and up to six visits in K_S, on separate nights, for variability studies. At the time we carried this study, 144 out of 152 disk tiles and 188 out of 196 bulge tiles were completed, covering ∼216 and ∼282 $\deg^2$, respectively.

We arrived at a target list of 167 objects: 67 in the disk and 100 in the bulge, for which the VVV can provide a new epoch of observations (Table 1). The stars come from the catalogs of LHS (Luyten 1979a), LTT (Luyten 1957; Luyten 1961; Luyten 1962), MACHO (Alcock et al. 2001), NLTT (Luyten 1979b; 1979c; Luyten 1980), OGLE (Sumi et al. 2004), and number of other works: Finch et al. (2007) Lépine (2005), Rattenbury & Mao (2008), Subasavage et al. (2005), Terzan et al. (1980).

The selection is dominated by nearby dwarfs (SIMBAD lists: 8 F, 19 G, 24 K, and 22 M-types). The distances to the few stars with parallaxes range from ∼1.3 to ∼136 pc, with a median of ∼44 pc.

The sample is heterogeneous, subjected to different biases, and the PMs from different catalogs have different error budgets, so our work cannot present a basis for strict statistical studies of the Solar neighborhood. This question will be addressed after the completion of VVV, when it will generate a long baseline coverage with self-consistent data.

3. Analysis

We visually searched around known HPM stars on false-3-color images, generated combining the reddest available POSSII band, and J-bands from 2MASS and VVV (Fig. 1). Three field sizes were used, to provide different levels of "zoom" into the vicinity of program stars: 0.9, 1.8, and 3.6 arcmin, centered on each candidate. Inspecting larger images was found impractical.

For each object in our sample we performed the following steps: first, we identified the known HPM star from its coordinates and the apparent change of position between the epochs of the surveys used to create the false-3-color images. The large PM made these identifications unambiguous. Second, we selected candidate companions looking by eye for other stars in the field with similar apparent motion as the known HPM star. Some candidates were discarded later, after we calculated their PMs (see below) and found them inconsistent with the PMs of the known HPM star. In a few cases the candidate companions were not fully resolved on the older images. Then, we used the non-circular PSF of older surveys as an argument supporting the companionship (Fig. 1, middle). Finally, we inspected the selected candidates on 3-color images built from VVV JHK_S data to minimize missidentification, *e.g.* rising from extreme colors or artifacts. The subjective nature of this procedure, together with the varying point spread function (PSF) are difficult to quantify, making our results unsuitable for a rigorous statistical constrain on the completeness of HPM stars.

The astrometric calibration of VVV data is based on hundreds of 2MASS stars that fall onto each tile (Irwin et al. 2004; Minniti et al. 2010). This procedure removes the systematic bulk motion of the "unmoving" background stars between the VVV and the 2MASS epochs. Therefore, we directly compared 2MASS and VVV coordinates, to measure PMs. This makes our PMs relative in nature, because the 2MASS reference stars that were used to derive the astrometric solution for the VVV have some average common motion than remains unaccounted for.

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[1] For further details see the VVV web page at: *http://vvvsurvey.org*

We measured PMs only for the new co-moving HPM candidates, for their hosts from the known HPM star list, and for the stars from the HPM list that appeared to move with much slower PM than the one given in the literature (Tables 2, and 3). We calculated the stellar positions as unweighted centroids. The cores of the bright stars ($K_S \leq 12$ mag) are saturated, and to investigate the effect of the saturation we set to zero the central pixels that are above 60% of the saturation limit, for 50 stars below the saturation limit. The result was much stronger than the typical saturation effect for the stars in our sample. The differences of the coordinates with and without "saturation" was 0.03±0.03 arcsec, *e.g.* the wings of the images are sufficient to measure the stellar positions accurately.

The final PMs are simple arithmetic averages of the PMs determined between 2MASS and various VVV observations, and the error are the r.m.s. of the measurements, if more than three are available (Tables 4 and 5). Adding older photographic epochs usually worsens the fit because of crowding and contamination. The 2MASS sets the faint magnitude limit of our new HPM candidates, and the minimum primary–companions separation: $J \leq 16$ mag and d≥1.5-1.7 arcsec, respectively (Skrutskie et al. 2006). The maximum separation was determined by the size of the cut outs.

After inspecting the 167 objects in our sample (67 in the disk and 100 in the bulge), we found:

(1) seven new co-moving companions to bright ($J \leq 16$ mag) HPM stars with PM≤200 mas yr^{-1}: L 149-77, LHS 2881, L 200-41, LHS 3188, LP 487-4, LHS 5333, and LP 922-16. Particularly notable is the discovery of a low-mass M5V companion to LHS 3188, at ~21 pc from the Sun;

(2) six known co-moving binaries were recovered: LTT 5140 A + LTT 5140 B, L 412−3 + L 412−4, LTT 6990 A + LTT 6990 B, GJ 2136 A + GJ 2136 B, LP 920−25 + LP 920−26, and MACHO 124.22158.2900 + MACHO 124.22158.2910;

(3) LTT 7318 and LTT 7319 that were considered co-moving stars, appeared not to be;

(4) we measured the PMs of all co-moving pairs of HPM stars in our sample (Table 4), and of the stars with previously overestimated PMs (Table 5);

(5) the spectral types of seventeen members of the co-moving pairs were determined from new near-infrared spectroscopy (Table 6). They range from G8V to M5V;

(6) HPMs of eight stars (C* 1925, C* 1930, C* 1936, CD−60 4613, LP 866−17, OGLE BUL−SC20 625107, OGLE BUL−SC21 298351, and OGLE BUL−SC32 388121) reported in at least some previous works appear to have been grossly overestimated.

4. Follow-up Spectroscopic Observations

Near-infrared spectra of co-moving pairs were obtained to determine their spectral types at the ESO NTT with SofI (Son of ISAAC; Moorwood et al. 1998) in two low-resolution modes, with blue (λ=0.95−1.64 μm) and red (λ=1.53−2.52 μm) grisms to cover the entire near-infrared spectral range. The slit was 1 arcsec wide during the Apr 2011 run, and 0.6 arcsec during the May 2012 run, delivering an average resolution of R~600 and ~1000, respectively. It was aligned along the axis connecting the two candidate companions, except if their apparent magnitudes were too different–in which case they were observed separately. Typically, four (six in the case of the relatively faint MACHO 124.22158.2900–MACHO 124.22158.2910 binary candidate) images were obtained, into a two-nodding ABBA or ABBAAB sequences, with nodding of 30-60 arcsec. Each image constituted 48–1050 sec of integration, averaged over 3–12 individual detector integrations to ensure the peak values are well below the non-linearity limit of the detector (Table 6). The atmospheric conditions varied during the observations but most often they were mediocre, with a seeing above 1.5 arcsec, thin to thick cirrus–because these targets were poor weather fillers which accounts for somewhat longer than usual integration times.

The data reduction steps were: sky/dark/bias removal by subtracting from each other the two complementary images in a nodding pair; flat fielding with dome flats; extraction of 1-dimensional (1-D) spectra from each star, on each individual image, by tracing the stellar continuum, with 6-8 pixel (1 pixel~0.29 arcsec) wide apertures, with the IRAF[2] task *apall*; wavelength calibration of each 1-D stellar spectrum with 1-D Xenon lamp spectrum, extracted from Xenon lamp images with the same trace as each target spectrum; combination of the four or six 1-D spectra of each star in wavelength space with the IRAF task *scombine*, with appropriate masking or rejection of remaining detector artifacts and cosmic ray affected regions; telluric correction with spectra of near-solar analogs (G1V-G3V), observed just before or after the science target, at similar airmass, and reduced the same way; recovery of the original spectral shape and removal of the artificial emission lines (Maiolino et al. 1996) by multiplying with spectra of corresponding spectral type star from the flux-calibrated IRTF library (Cushing et al. 2005; Rayner et al. 2009). The signal-to-noise of the final spectra varies significantly with the target's brightness and with wavelength, but the areas clear from telluric absorption have S/N~10–30. The final spectra are plotted in Fig. 2.

The spectral typing was performed comparing the overall shape of the SofI spectra with spectra from the IRTF library (Fig. 3) and the results are listed in Table 6. The typical uncertainty, estimated from a comparison with template stars of neighboring sub-types (Fig. 3), is one sub-type. It was determined by comparing our targets with IRTF spectra of stars with nearby subtypes, and comparing stars with multiple IRTF observations. Finally, we corrected for telluric absorption the telluric standard HIP 084636 with HIP 098813, and re-determined its spectral type obtaining a best match with G2V star, to be compared with G3V reported by Gray et al. (2006).

5. Discussion and Summary

Why have the new HPM stars not been detected before? Some of them appear on old photographic surveys but the contamination from nearby stars, aggravated by the poor spatial resolution of those surveys, makes the identification of the stars as HPM objects difficult. The extreme differences between optical and infrared brightness of stars that is often found in the Galactic plane often led to misidentifications and some spurious HPM detections while true HPM stars were missed. Even with the high-quality of the VVV data we cannot consider the position of the stars reliable because of the uneven background. Multiple measurements are needed, separated by some years, to let the stars move by at least 2-3 arcsec, so they lay on a completely different background, averaging out the contamination effects.

The PM errors in Table 4 are the r.m.s. for 3-4 measurements (Table 2), and they only include statistical uncertainties. A comparison with the measurements in the literature suggest that the real uncertainties are larger. Excluding the obvious errors which

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[2] IRAF is distributed by the NOAO, which is operated by the AURA under cooperative agreement with NSF.

yield differences exceeding 100 mas yr^{-1}, *e.g.* due to missidentification, we find an average difference of 2 mas yr^{-1}, with an r.m.s of 17 mas yr^{-1}, and suggest that the reader uses the latter number as the real error of our PMs that includes both internal and external uncertainties. The scatter gives an upper limit to the unaccounted bulk PM of the filed stars used for the astrometric calibration of the VVV data, and these are indeed small. More accurate measurements will become available in the future, as the VVV survey progresses. The planned survey duration of 5 yrs is likely to be extended to ∼7 yrs.

Some of the objects with overestimated PMs are very red. Interestingly, three of them were considered HPM objects despite being classified as Carbon stars, suggesting that they were giants. Probably, unaccounted astrometric color terms, combined with the extreme colors, have led to the erroneous classification.

Notes on some individual objects:

– LHS 2881 B is ∼8.1 arcsec away from a HPM object listed in Monet et al. (2003) with μ(RA)=198±38 and μ(Dec)=848±319 arcsec yr^{-1} which is absent on our data and it is likely a result of a missidentification or a spurious entry in the USNOB1.0. Interestingly, the LHS 2881 pair has similar PM to that of LHS 2871: μ(RA)=−461.01±1.67 and μ(Dec)=−645.32±1.31 arcsec yr^{-1} as reported by van Leeuwen (2007). The wide separation of ∼44 arcmin makes it unlikely that they are bound but may indicate a common origin.

– LP 487-4 is projected on the sky close to the open cluster NGC 6475 (M7) but it is not a physical member because the cluster has μ(RA)=2.58 and μ(Dec)=−4.54 arcsec yr^{-1} (Loktin & Beshenov 2003). Furthermore, the optical spectroscopy of James et al. (2000) yields a radial velocity $V_{\rm rad}$=78.6±0.2 km s^{-1}, inconsistent with $V_{\rm rad}$=−14.21±1.39 km s^{-1} of NGC 6475 (Kharchenko et al. 2005).

– LTT 5140 A parameters were derived from optical spectroscopy and Strömgren photometry by Nordström et al. (2004): $log\,T_{\rm eff}$=3.785, [Fe/H]=0.04, M_V=3.67 mag, Age=3.3 Gyr $V_{\rm rad}$=15.9±0.2 km/s. Later, Holmberg et al. (2009) updated them to $log\,T_{\rm eff}$=3.774, [Fe/H]=−0.06, and M_V=3.63 mag to reflect the revised HIPPARCOS parallaxes. Desidera et al. (2006) estimated from chromospheric activity *log* age=9.82 and 9.58 for the primary and the secondary, respectively.

– LTT 7318 and LTT 7319 were considered a binary by Dommanget (1983) but later measurement by Salim & Gould (2003), and van Leeuwen (2007) indicate that the two stars are not physically connected. Our data support this conclusion.

– Some objects were included in our sample just because one source, namely Monet et al. (2003) reported HPM for them, despite the fact that other works have estimated low PM. For example, C* 1925, C* 1930, C* 1936, which are known carbon stars, i.e. distant giants, as reported by Alksnis et al. (2001).

– CD−60 4613 was considered a HPM star by Turon et al. (1992) but it was probably misidentified with the nearby LTT 5126 because of the large error in the NLTT coordinates of the latter star, identified by Salim & Gould (2003). Indeed, van Leeuwen (2007) reported correct position and low PM for this star in the revised HIPPARCOS catalog under HIP 65056.

– the HPMs for OGLE BUL−SC20 625107, OGLE BUL−SC21 298351, OGLE BUL−SC32 388121 are subject to various sources of systematics: blending, contamination from variable sources, and seeing variations, aggravated by the crowded OGLE fields (see for details Sec. 7 in Sumi et al. 2004).

HPM stars are nearby objects, and finding seven of them implies an incompleteness of ∼4% (over 167 HPM stars) in the Solar neighborhood census. However, this is not a firm limit because: (i) it refers only to the bright stars considered here, (ii) the starting list of 167 stars is likely incomplete itself, and (iii) it is contaminated by non-moving stars, as we showed. Therefore, we refrain from making statements on the completeness of the Solar neighborhood census; we only demonstrated that the HPM census is lacking stars, and that high angular resolution surveys help for addressing this issue in the most crowded regions of the Galaxy.

The new generation of near-infrared surveys of the Milky Way will produce enormous amounts of data, allowing the possibility of many discoveries. This work allows us to refine the strategy for future surveys and HPM star searches in the densest regions of the Southern Milky Way disk and the Bulge. We expect that many more HPM stars and companions to them–including brown dwarfs and even planetary mass objects–will be discovered by these surveys when the baseline of observations reaches a few years, contributing to complete the census of faint nearby stars, and their multiplicity.

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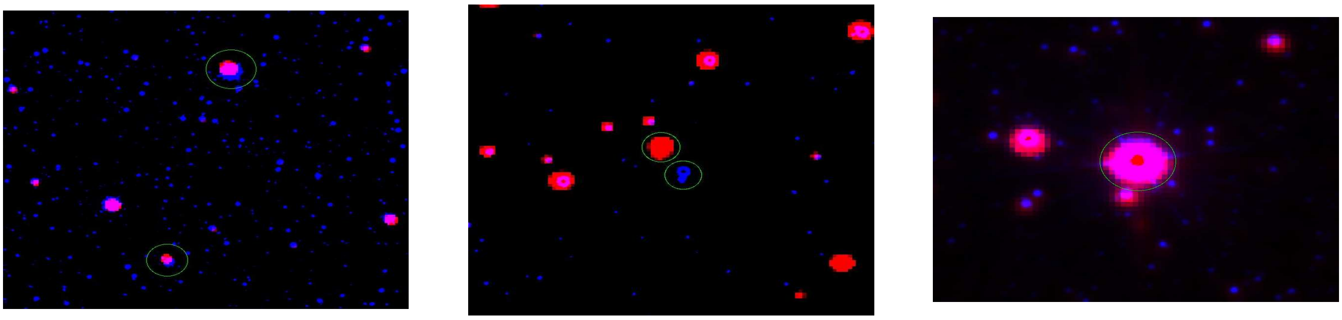

Fig. 1. Examples for the co-moving companion search. North is up and East is left. The red images are 2MASS K_S, and the blue images are VVV K_S. The objects of interest are circled. From left to right: LP 922-16 A and B (~2×2 arcmin), LHS 3188 A and B (~1.5×1.5 arcmin), and C* 1936 (~1×1 arcmin).

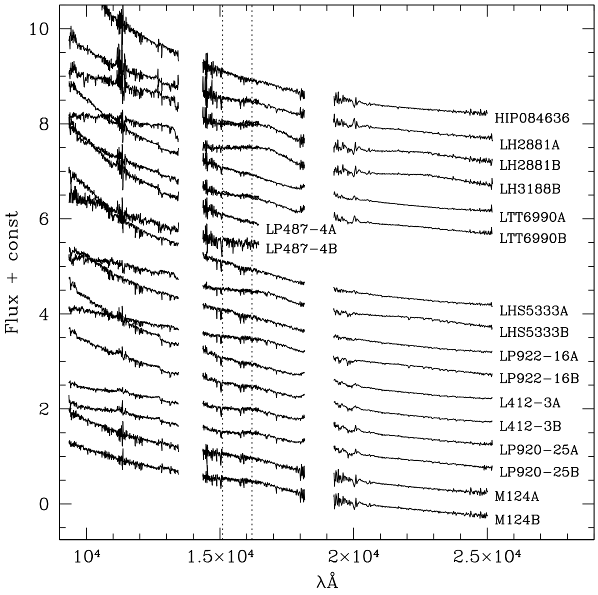

Fig. 2. Near-infrared spectra of our targets. The spectral areas with poor atmospheric transmission are omitted. The spectra were normalized to 0.5 in the overlapping region (bracketed with dotted lines) and shifted vertically by 0.5 for clarity. M124A and M124B indicate MACHO 124.22158.2900 and MACHO 124.22158.2910, respectively, L 412−3 B is an alternative notation of HD 322416 and LP 920−25 B is the same for LP 920−26. The spectrum of the telluric HIP 084636 shown here was corrected for the atmospheric absorption with HIP 098813.

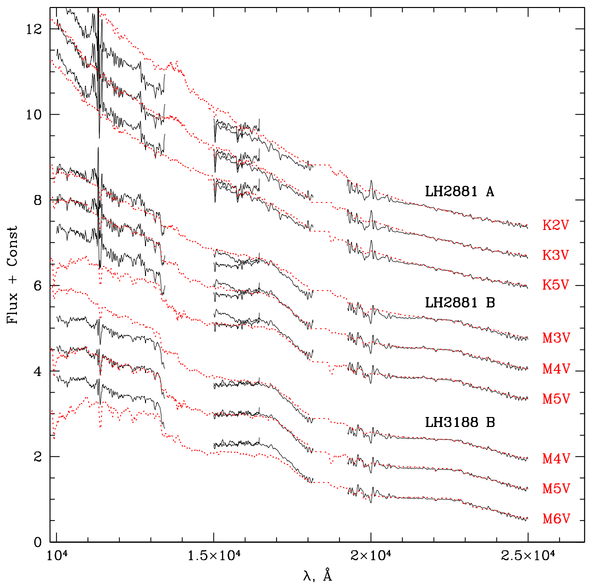

Fig. 3. Spectral classification example. Solid lines show our spectra, and dotted lines–the template spectra from the IRTF library (Cushing et al. 2005; Rayner et al. 2009).

Table 1. HPM stars in the VVV area.

Star ID	VVV Tiles	Star ID	VVV Tiles	Star ID	VVV Tiles	Star ID	VVV Tiles
			Disk area stars:				
LTT 18269	d007	NLTT 37871	d053	L 200−41	d095	SCR J1440−5745	d130
LTT 5140	d008	HR 5459	d053	LSR J15292−5620	d096	L 199−84	d131
L 149−77	d012	HR 5460	d053	L 263−307	d097	SCR J1448−5735	d131
V* V645 Cen	d014	LSR J14570−5943	d055	LHS 401	d098	L 263−307	d135
LSR J14382−6231	d014	LSR J14585−5916	d055	L 339−20	d101	L 264−83	d137
LTT 6019	d017	LTT 5981	d055	LTT 6467	d102	L 264−78	d138
L 200−104	d019	L 200−52	d059	LHS 3185	d104	LHS 3182	d142
GJ 9547	d025, d063	SCR J1637−4703	d068, d106	LHS 3233	d107	LHS 3188	d143
LHS 3223	d029	LTT 6763	d071	LTT 6714	d109	L 265−6	d140
LP 413−57	d036	LTT 6830	d073	LTT 6709	d109	LTT 6612	d144
C* 1925	d039	GJ 662A	d075	L 412−30	d111	LTT 6601	d144
C* 1936	d040, d078	GJ 662B	d075	LP 485−113	d113	L 339−20	d144
LHS 2530	d041	C* 1930	d078	LP 485−65	d114	LHS 3235	d146
TYC 8994−252−1	d047	LTT 4656	d080	LTT 4656	d118	L 412−3	d149
NLTT 35378	d049	SCR J1319−6200	d084	LTT 5126	d122	HD 322416	d149
LHS 2871	d050	L 148−26	d085	CD−60 4613	d122	L 412−30	d149
LHS 2881	d051	L 199−110	d093	LHS 2892	d128		
			Bulge area stars:				
LP 487−82	b203	MACHO 124.22028.40	b264	LTT 7207	b295	LHS 443	b342
V* eta Sgr	b205	MACHO 124.22158.2900	b264	OGLE BUL−SC42 133638	b295	[TBF80] 22	b344
NLTT 46160	b221	MACHO 124.22158.2910	b264	L 486−29	b300	LP 920−61	b345
LTT 7388	b227	MACHO 124.22801.395	b264	LP 486−36	b301	LP 920−25	b345
LTT 7182	b232	MACHO 116.24513.110	b265	LTT 7072	b304	LP 920−26	b345
LP 487−35	b232, b246	LP 922−14	b266	LTT 7073	b304	NLTT 45088	b346
LHS 3372	b235	LTT 7259	b266	LP 866−12	b309	LP 865−14	b348
NLTT 46160	b235	OGLE BUL−SC29 39202	b273	LP 866−13	b310	LTT 7150	b352
LTT 7233	b235	LP 559−192	b274, b288	LHS 5333	b311	G 154−40	b354
LP 922−20	b237	LP 487−4	b274	NLTT 45321	b318	NLTT 44877	b359
LTT 7318	b238	LHS 3335	b275	LP 921−21	b319	LP 920−55	b359
LTT 7319	b238	LP 559−120	b276	LP 921−20	b319	LHS 3310	b362
LHS 5337a	b239	LP 921−23	b277	LP 921−15	b320	NLTT 45440	b365
LP 922−17	b239	LP 921−26	b277	LP 921−16	b321	LP 864−17	b376
LHS 3337	b244	LTT 6990	b285	LTT 7183	b324	G 154−29	b381
LP 414−1	b243	LHS 3330	b289	LP 558−60	b330	LP 808−23	b382, b396
LP 487−37	b246	LP 921−28	b291	NLTT 45128	b331	NLTT 44500	b386
LP 922−18	b250	OGLE BUL−SC20 625107	b292	NLTT 45014	b331	[TBF80] 10b	b387
LP 866−17	b253	HD 316899	b292	NLTT 45163	b332	[TBF80] 10a	b387
LP 922−15	b253	OGLE BUL−SC21 298351	b292	LP 921−11	b333	NLTT 44488	b387
LP 922−16	b253	OGLE BUL−SC32 388121	b293	LP 921−13	b334	LTT 6900	b387
LP 866−19	b254	OGLE BUL−SC02 783242	b293	LP 865−20	b336	LTT 6890	b387
GJ 2136 A	b255	LTT 7186	b294, b308	LTT 6873	b341	LP 864−16	b389
GJ 2136 B	b255	LP 921−18	b294	LTT 6869	b341	LP 864−14	b390
LP 559−37	b264	NLTT 45948	b294	HD 156384	b342	LTT 7022	b392

Table 2. Multi-epoch observations of target stars. Typical positional uncertainties: ~0.1 arcsec for 2MASS, and ~0.05 arcsec for VVV.

Image Source	Primary RA Dec (J2000)	Secondary RA Dec (J2000)	Epoch, UT yyyy mm dd hh mm ss
LTT 5140 A – LTT 5140 B, separation ~5 arcsec			
2MASS	13 21 23.211 −64 02 59.08	13 21 23.965 −64 02 59.68	2000 04 27 02 57 44
VVV K_S	13 21 22.873 −64 02 59.51	13 21 23.657 −64 03 00.09	2010 02 19 08 02 07
VVV K_S	13 21 22.882 −64 02 59.58	13 21 23.651 −64 03 00.20	2010 03 17 06 27 32
VVV J	13 21 22.867 −64 02 59.56	13 21 23.636 −64 03 00.21	2010 03 17 06 36 38
L 149−77 A – L149−77 B, separation ~14 arcsec			
2MASS	14 12 28.089 −62 56 14.90	14 12 28.829 −62 56 27.86	2000 02 21 08 08 07
VVV K_S	14 12 28.351 −62 56 12.84	14 12 29.088 −62 56 25.93	2010 03 05 07 28 16
VVV K_S	14 12 28.313 −62 56 12.97	14 12 29.085 −62 56 25.94	2010 03 19 05 07 05
VVV J	14 12 28.329 −62 56 12.91	14 12 29.086 −62 56 25.91	2010 03 19 05 15 03
VVV K_S	14 12 28.323 −62 56 12.98	14 12 29.086 −62 56 25.91	2010 03 28 06 20 19
LHS 2881 A – LHS 2881 B, separation ~20 arcsec			
2MASS	14 13 32.369 −62 07 33.37	14 13 30.335 −62 07 45.70	2000 02 21 08 15 58
VVV J	14 13 31.584 −62 07 39.00	14 13 29.554 −62 07 51.21	2010 03 19 06 01 00
VVV K_S	14 13 31.581 −62 07 38.95	14 13 29.555 −62 07 51.20	2010 03 19 05 54 07
VVV K_S	14 13 31.479 −62 07 39.59	14 13 29.442 −62 07 51.94	2011 08 05 01 36 56
L 200−41 A – L 200−41 B, separation ~18 arcsec			
2MASS	15 18 40.449 −56 27 55.70	15 18 39.953 −56 28 12.94	1999 06 07 05 21 16
VVV J	15 18 40.240 −56 27 57.17	15 18 39.743 −56 28 14.43	2010 04 02 07 27 33
LHS 3188 A – LHS 3188 B, separation ~2.5 arcsec			
2MASS	16 24 21.178 −46 44 01.78	16 24 21.202 −46 44 05.78	1999 05 20 03 43 14
VVV J	16 24 20.651 −46 44 10.28	16 24 20.706 −46 44 12.87	2010 03 03 08 02 34
VVV K_S	16 24 20.656 −46 44 09.95	16 24 20.705 −46 44 12.84	2010 03 03 07 55 46
VVV K_S	16 24 20.598 −46 44 11.06	16 24 20.645 −46 44 13.75	2011 05 17 06 49 08
L412−3 – L412−4 (HD 322416), separation ~26 arcsec			
2MASS	16 58 45.218 −40 13 03.85	16 58 43.324 −40 13 18.64	1999 05 11 06 58 13
VVV K_S	16 58 45.087 −40 13 05.16	16 58 43.193 −40 13 19.96	2010 03 26 08 48 03
VVV J	16 58 45.091 −40 13 05.16	16 58 43.193 −40 13 19.97	2010 03 26 08 48 03
LP 920-25 – LP 920-26, separation ~8.5 arcsec			
2MASS	17 31 40.047 −30 40 56.51	17 31 40.510 −30 41 02.62	1998 08 10 03 19 18
VVV K_S	17 31 39.894 −30 40 58.87	17 31 40.360 −30 41 04.89	2010 04 15 08 56 31
VVV K_S	17 31 39.884 −30 40 59.05	17 31 40.348 −30 41 05.19	2010 08 03 04 18 06
VVV J	17 31 39.887 −30 40 58.97	17 31 40.353 −30 41 05.08	2010 08 03 04 23 02
LTT 6990 A – LTT 6990 B, separation ~3.5 arcsec			
2MASS	17 35 08.353 −38 37 27.94	17 35 08.644 −38 37 29.89	2000 07 05 00 38 29
VVV K_S	17 35 08.087 −38 37 30.51	17 35 08.374 −38 37 32.30	2010 08 31 02 58 30
VVV J	17 35 08.080 −38 37 30.49	17 35 08.372 −38 37 32.15	2010 08 31 03 03 35
VVV K_S	17 35 08.072 −38 37 30.70	17 35 08.351 −38 37 32.48	2011 07 27 04 43 36
LP 487-4 A – LP 487-4 B, separation ~36 arcsec			
2MASS	17 51 22.238 −35 05 58.39	17 51 23.322 −35 05 25.88	1998 08 14 23 35 01
VVV K_S	17 51 22.096 −35 05 59.79	17 51 23.180 −35 05 27.25	2010 04 21 09 24 05
VVV J	17 51 22.091 −35 05 59.81	17 51 23.175 −35 05 27.28	2010 04 21 09 27 24
VVV K_S	17 51 22.090 −35 05 59.84	17 51 23.173 −35 05 27.29	2010 06 27 07 58 12
MACHO 124.22158.2900 – MACHO 124.22158.2910, separation ~3 arcsec			
2MASS	18 07 57.462 −30 54 55.50	18 07 57.313 −30 54 58.14	1998 07 27 01 31 25
VVV K_S	18 07 57.323 −30 54 58.46	18 07 57.172 −30 55 01.13	2010 08 15 04 04 01
VVV J	18 07 57.324 −30 54 58.43	18 07 57.171 −30 55 01.07	2010 08 15 04 05 45
LHS 5333 A – LHS 5333 B, separation ~43 arcsec			
2MASS	18 09 17.677 −22 54 30.03	18 09 18.212 −22 55 12.06	1999 07 07 01 49 09
VVV K_S	18 09 17.713 −22 54 35.12	18 09 18.243 −22 55 16.95	2010 04 21 06 10 06
VVV J	18 09 17.708 −22 54 35.23	18 09 18.245 −22 55 16.95	2010 04 21 06 13 16
VVV K_S	18 09 17.713 −22 54 35.24	18 09 18.240 −22 55 17.13	2010 10 06 01 38 42
LP 922−16 A – LP922−16 B, separation ~95 arcsec			
2MASS	18 23 51.140 −27 46 18.21	18 23 52.896 −27 47 50.87	1998 07 19 02 56 37
VVV J	18 23 51.029 −27 46 20.65	18 23 52.785 −27 47 53.29	2010 04 08 07 35 20
VVV K_S	18 23 51.029 −27 46 20.72	18 23 52.784 −27 47 53.26	2010 04 08 07 32 05
VVV K_S	18 23 51.026 −27 46 20.81	18 23 52.776 −27 47 53.38	2010 10 26 23 57 33
LTT 7318 – LTT 7319, separation ~46 arcsec			
2MASS	18 24 26.943 −29 32 39.75	18 24 26.552 −29 31 54.45	1998 07 19 03 10 49
VVV K_S	18 24 27.119 −29 32 41.40	18 24 26.560 −29 31 56.99	2010 08 15 02 34 29
VVV J	18 24 27.124 −29 32 41.24	18 24 26.556 −29 31 56.94	2010 08 15 02 38 06
VVV K_S	18 24 27.135 −29 32 41.40	18 24 26.563 −29 31 56.94	2010 08 15 02 38 06
GJ 2136 A – GJ 2136 B, separation ~21 arcsec			
2MASS	18 27 18.623 −25 04 23.59	18 27 18.432 −25 04 02.55	1998 07 19 03 46 39
VVV K_S	18 27 18.543 −25 04 25.78	18 27 18.362 −25 04 04.78	2010 04 08 08 41 39
VVV J	18 27 18.543 −25 04 25.71	18 27 18.362 −25 04 04.73	2010 09 05 12 17 24
VVV K_S	18 27 18.535 −25 04 25.76	18 27 18.355 −25 04 04.80	2010 10 26 00 33 08

Table 3. Multi-epoch observations of stars with over-estimated PMs. Typical positional uncertainties: ~0.1 arcsec for 2MASS, and ~0.05 arcsec for VVV.

Image Source	Coordinates RA Dec (J2000)	Epoch, UT yyyy mm dd hh mm ss
	C* 1925	
2MASS	11 52 11.709 −62 15 00.18	2000 02 14 04 28 32
VVV K_S	11 52 11.700 −62 14 59.79	2010 03 15 03 35 33
VVV J	11 52 11.686 −62 14 59.91	2010 03 15 03 42 15
VVV K_S	11 52 11.721 −62 14 59.99	2011 07 24 23 25 52
	C* 1930	
2MASS	11 54 49.494 −61 30 54.03	2000 02 14 04 43 24
VVV K_S	11 54 49.495 −61 30 54.13	2010 03 14 03 29 49
VVV J	11 54 49.509 −61 30 54.09	2010 03 14 03 36 38
VVV K_S	11 54 49.518 −61 30 54.18	2011 06 12 02 44 58
	C* 1936	
2MASS	11 56 55.808 −62 15 30.93	2000 02 14 05 13 14
VVV K_S	11 56 55.798 −62 15 31.11	2010 03 15 03 56 04
VVV J	11 56 55.818 −62 15 30.87	2010 03 15 04 03 43
VVV K_S	11 56 55.808 −62 15 31.01	2011 05 20 23 45 27
	CD−60 4613	
2MASS	13 20 07.358 −61 29 34.65	2000 04 17 02 41 08
VVV K_S	13 20 07.367 −61 29 34.73	2010 03 07 09 01 48
VVV J	13 20 07.347 −61 29 34.66	2010 03 07 09 08 40
VVV K_S	13 20 07.331 −61 29 34.81	2011 06 14 03 38 57
	LP 866−17	
2MASS	18 20 55.854 −27 05 55.09	1998 07 19 02 14 03
VVV K_S	18 20 55.851 −27 05 55.13	2010 04 08 07 32 05
VVV J	18 20 55.851 −27 05 55.09	2010 04 08 07 35 20
VVV K_S	18 20 55.849 −27 05 55.17	2010 10 26 23 57 33
	OGLE BUL−SC20 625107	
2MASS	17 59 35.685 −29 11 57.34	1998 07 16 05 34 29
VVV K_S	17 59 35.526 −29 11 58.82	2011 05 09 05 22 40
VVV J	17 59 35.523 −29 11 58.84	2011 05 09 05 26 50
VVV K_S	17 59 35.521 −29 11 58.89	2011 05 18 07 44 05
	OGLE BUL−SC21 298351	
2MASS	18 00 12.122 −29 03 46.87	1999 07 05 03 48 58
VVV K_S	18 00 12.120 −29 03 46.98	2011 05 09 05 22 40
VVV J	18 00 12.118 −29 03 46.97	2011 05 09 05 26 50
VVV K_S	18 00 12.116 −29 03 47.01	2011 05 18 07 44 05
	OGLE BUL−SC32 388121	
2MASS	18 03 11.721 −28 13 22.08	1998 03 19 09 21 19
VVV K_S	18 03 11.733 −28 13 22.01	2011 05 09 05 51 15
VVV J	18 03 11.729 −28 13 22.04	2011 05 09 05 55 12

Table 4. Measured PMs for new, known, and rejected co-moving pairs of stars. The letter M in the star ID column stands for MACHO. PMs, parallaxes and spectral types from the literature are also listed.

Star ID	RA (2MASS)	Dec (2MASS)	PM (RA,Dec) [mas yr^{-1}], this work		PM (RA,Dec) [mas yr^{-1}], literature		Ref.	Parallax [mas]	Ref.	Sp. Type literature	Ref.
New co-moving companions around known HPM stars:											
L 149-77 A	14 12 28.089	−62 56 14.90	162.5±11.9	196.3±6.7	154.8±4.5	184.3±4.1	(4)	$25.6^{+12.8}_{-10.3}$	(17)	K7V	(17)/(18)
					158.1±3.1	183.5±2.9	(15)	20	(19)	K5V	(19)
					157.2±3.4	187.9±3.1	(16)	14.17±1.56	(20)		
					141.3±10.0	163.0±10.0	(20)				
L 149-77 B	14 12 28.829	−62 56 27.86	171.2±0.4	192.6±1.2	242.0±6.0	216.0±49.0	(15)				
					193.5±7.4	143.7±7.4	(16)				
LHS 2881 A	14 13 32.369	−62 07 33.37	−541.1±1.5	−551.7±7.9	−440±100	−607±100	(9)				
					−550.1±12.5	−548.7±12.5	(16)				
					−496±19	−588±33	(21)				
					548.3±8.0	−511.7±8.0	(22)				
LHS 2881 B	14 13 30.335	−62 07 45.70	−545.8±1.0	−545.3±1.1							
L 200-41 A	15 18 40.449	−56 27 55.70	−162.7±—-	−134.5±—-	−174.2±3.4	−142.8±3.2	(4)	24.47±11.91	(20)		
					−185.2±3.5	−143.9±1.3	(15)				
					−175.00±2.7	−141.47±2.7	(16)				
					−132.8±10.0	−108.5±10.0	(20)				
					−176	−144	(21)				
					−172.8±1.2	−139.7±1.2	(22)				
L 200-41 B	15 18 39.953	−56 28 12.94	−159.8±—-	−138.3±—-	−180±22	−126±36	(21)				
LHS 3188 A	16 24 21.178	−46 44 01.78	−491.3±1.4	−774.1±15.3	−511.6	−741.6	(12)	48±12	(10)	K5	(11)
					−458±76	−688±123	(21)				
					−462.3±12.2	−750.6±12.2	(23)				
					−520	−700	(24)				
LHS 3188 B	16 24 21.202	−46 44 05.78	−478.9±3.7	−658.5±5.1							
LP 487-4 A	17 51 22.238	−35 05 58.39	−165.8±3.9	−120.8±0.8	−157.9±4.4	−146.0±4.4	(1)				
					−158.35±2.7	−136.33±2.7	(16)				
LP 487-4 B	17 51 23.322	−35 05 25.88	−150.5±3.9	−117.7±1.2							
LHS 5333 A	18 09 17.677	−22 54 30.03	61.6±4.8	−473.3±9.5	40.08±0.91	−459.58±0.59	(2)	31.54±0.93	(2)	K1IV	(13)
					42.18±1.08	−459.56±0.70	(30)	31.27±1.12	(30)		
					42.1±6.4	−459.0±2.2	(1)				
					46.8	−477.7	(12)				
					42.1±1.0	−459.5±0.6	(15)				
					42.1±1.0	−459.5±0.7	(22)				
					37.7±6.4	−458.7±8.2	(23)				
					55.6	−489.7	(25)				
					45.9±3.1	−461.5±3.1	(26)				
					43±18	−486±18	(27)				
					52	−409	(28)				
					42±2.9	−462±2.9	(29)				
					44.64±2.48	−458.9±3.92	(31)				
LHS 5333 B	18 09 18.212	−22 55 12.06	52.5±6.5	−452.9±1.5							
LP 922-16 A	18 23 51.140	−27 46 18.21	−117.0±1.6	−212.1±3.3	−124.87±3.06	−205.72±1.89	(2)	10.93±2.29	(2)		
					−127.64±2.52	−207.02±1.68	(30)	12.30±2.22	(30)		
					−129.8±2.7	−217.2±2.5	(1)				
					−127.6±2.5	−207.0±1.6	(15)				
					−129.39±1.9	−210.12±1.4	(16)				
					−130	−218	(21)				
					−128.6±2.4	−209,8±2.2	(22)				
					−126.1±6.5	−217.0±6.0	(32)				
LP 922-16 B	18 23 52.896	−27 47 50.87	−130.7±3.4	−205.4±1.3	−122.3±9.0	−197.4±9.0	(15)				
					−160±48	−134±57	(21)				
					−154.8±9.5	−143.4±9.5	(23)				

Table 4. Continued.

Star ID	RA	Dec	PM (RA,Dec)		PM (RA,Dec)		Ref.	Parallax	Ref.	Sp. Type	Ref.
	(2MASS)		[mas yr^{-1}], this work		[mas yr^{-1}], literature			[mas]		literature	
Recovered known binaries:											
LTT 5140 A	13 21 23.965	−64 02 59.68	−223.4±6.3	−48.3±3.0	−233.7±0.6	−44.0±0.8	(2)	17.81±0.98	(2)	G0V	(6)
					−236.5±2.3	−47.6±2.3	(4)				
LTT 5140 B	13 21 23.211	−64 02 59.08	−207.1±8.1	−49.2±6.2	−223.0±3.1	−47.0±3.0	(4)			G0	(6)
L 412-3	16 58 45.218	−40 13 03.85	−135.1±—-	−121.2±—-	−147.4±5.4	−136.0±5.4	(1)			K2	(3)
L 412-4	16 58 43.324	−40 13 18.64	−150.4±—-	−121.8±—-	−145.1±4.5	−129.0±4.5	(1)			K2	(3)
(= HD 322416)					−144.3±2.2	−121.4±2.3	(4)				
LP 920-25	17 31 40.047	−30 40 56.51	−164.3±2.2	−206.5±5.0	−181.7±2.0	−197.0±2.0	(1)				
LP 920-26	17 31 40.510	−30 41 02.62	−169.7±3.9	−215.6±10.2	−181.7±2.0	−197.0±2.0	(1)				
LTT 6990 A	17 35 08.353	−38 37 28.15	−295.7±8.6	−250.9±1.8	−311.72±1.71	−228.28±1.08	(2)	30.40±1.36	(2)	K0V	(13)
LTT 6990 B	17 35 08.644	−38 37 29.89	−317.4±4.3	−230.6±7.8							
M 124.22158.2900	18 07 57.462	−30 54 55.50	−148.6±—-	−244.7±—-	−119.7±5.0	−249.8±5.0	(5)				
M 124.22158.2910	18 07 57.313	−30 54 58.14	−140.8±—-	−245.9±—-	−115.8±5.0	−242.8±5.0	(5)				
GJ 2136 A	18 27 18.623	−25 04 23.59	−79.8±8.2	−179.2±6.3	−84.4±3.2	−198.1±3.0	(1)	30.86±4.57	(7)	M0/M0.5	(14)/(7)
GJ 2136 B	18 27 18.432	−25 04 02.55	−77.1±3.7	−184.7±5.3	−88.0±25.0	−168.0±25.0	(8)				
Not co-moving:											
LTT 7318	18 24 26.943	−29 32 39.75	184.7±12.1	−132.1±7.6	194.4±2.0	−120.8±1.8	(1)	21.30±1.08	(2)	F8V	(6)
					192.4±1.3	−120.3±0.8	(2)				
LTT 7319	18 24 26.559	−29 31 54.53	0.0±7.9	−207.4±2.6	0.5±1.5	−197.8±2.0	(1)	21.38±0.92	(2)	K3/K4III+	(6)
					−1.1±1.1	−198.3±0.7	(2)				

References. (1) Salim & Gould (2003); (2) van Leeuwen (2007); (3) Nesterov et al. (1995); (4) Hog et al. (2000); (5) Alcock et al. (2001); (6) as given in SIMBAD, the original reference is unknown; (7) Reid et al. (2004); (8) Luyten (1963); (9) Bakos et al. (2002); (10) Jenkins (1963); (11) Bidelman (1985); (12) Luyten (1979a); (13) Gray et al. (2006); (14) Stephenson & Sanduleak (1975); (15) Zacharias et al. (2004); (16) Röser et al. (2008); (17) Ammons et al. (2006); (18) Schmidt-Kaler (1982); (19) Pickles & Depagne (2010); (20) Fresneau et al. (2007); (21) Monet et al. (2003); (22) Zacharias et al. (2013) – possibly, a wrong sign for the RA PM of LHS 2881 A; (23) Röser et al. (2010); (24) Stauffer et al. (2010); (25) Hog & von der Heide (1976); (26) Dunham (1986); (27) Smithsonian Astrophysical Observatory Star Catalog; (28) Schlesinger & Barney (1943); (29) Bastian & Röser (1993); (30) Perryman et al. (1997); (31) Urban et al. (1997); (32) Röser et al. (1994);

Table 5. List of stars with overestimated PMs. The first literature PM is the one listed in SIMBAD at the time of the sample preparation.

Star ID	PM(RA,Dec)		PM(RA,Dec)		Ref.	Sp. Type	Ref.
	[mas yr^{-1}], this work		[mas yr^{-1}], literature				
C* 1925	−1.3±12.0	25.6±10.6	256±110	342±40	(1)	Carbon star	(2)
C* 1930	10.6±7.1	−10.3±3.3	18±91	278±46	(1)	Carbon star	(2)
C* 1936	5.9±7.6	−6.5±11.6	146±44	226±7	(1)	Carbon star	(2)
CD−60 4613	−3.7±13.6	−8.2±6.7	−251±25	−23±25	(3)		
			−8.65±6.92	−8.27±6.40	(4)		
			−7.23±2.2	−0.35±2.2	(5)		
			−7.38±1.07	−1.76±1.04	(9)		
LP 866−17	−8.2±0.2	−3.4±3.4	−7.4±5.5	−216.9±5.5	(6)		
			−16.1±4.4	−19.1±4.3	(5)		
OGLE BUL−SC20 625107	−162.0±4.2	−117.5±2.6	−42.56±6.96	−330.93±32.81	(7)		
OGLE BUL−SC21 298351	8.1±1.5	−10.4±1.5	29.48±13.96	−262.32±28.43	(7)		
			0.2±4.4	−0.2±4.4	(5)		
			−5.9±12.3	−8.1±12.2	(8)		
OGLE BUL−SC32 388121	11.1±—-	5.0±—-	−78.63±6.88	−183.12±6.66	(7)		
			−116±2	−574±112	(1)		
			−114.6±9.5	−579.6±9.5	(5)		
			24.9±7.4	−18.7±11.6	(8)		

References. (1) Monet et al. (2003); (2) Westerlund (1971); (3) Turon et al. (1992); (4) Perryman (1997); (5) Röser et al. (2010); (6) Salim & Gould (2003); (7) Sumi et al. (2004); (8) Zacharias et al. (2013); (9) van Leeuwen (2007).

Table 6. Details of the IR spectroscopic observations and derived spectral types. Median airmasses are given. The target IDs are the same as in Fig. 2. A+B means that both the primary and the secondary were observed, B means that only the secondary was observed.

	Science Target					Date	Telluric Standard						“
Target	Blue grism		Red grism		Derived Sp. Types	mm-	Telluric	Blue grism		Red grism		Sp.	Ref.
ID	NDIT×DIT	sec z	NDIT×DIT	sec z	Primary+Secondary	yyyy	ID	NDIT×DIT	sec z	NDIT×DIT	sec z	Type	
L 412-3 A+B	4 × 30 s	1.42	6 × 30 s	1.36	K2V + K5V	05-2012	HIP 084636	4 × 1.2 s	1.46	6 × 1.2 s	1.44	G3V	(1)
LHS 2881 A+B	25 × 25 s	1.22	7 × 100 s	1.34	K3V + M4V	04-2011	HIP 064574	5 × 10 s	1.28	5 × 10 s	1.39	G1V	(1)
LHS 3188 B	7 × 150 s	1.10	7 × 150 s	1.05	n.a. + M5V	04-2011	HIP 090446	5 × 6 s	1.12	3 × 6 s	1.07	G0V	(2)
LHS 5333 A+B	12 × 2 s	1.14	12 × 4 s	1.16	K0V + M3V	05-2012	HIP 092515	6 × 10 s	1.12	6 × 15 s	1.14	G2V	(1)
LTT 6990 A+B	6 × 10 s	1.02	12 × 10 s	1.02	K0V + K4V	05-2012	HIP 084636	5 × 2 s	1.04	10 × 2 s	1.04	G3V	(1)
LP 487-4 A+B	2 × 120 s	1.01	3 × 120 s	1.01	G8V + K5V	05-2012	HIP 084636	5 × 2 s	1.04	10 × 2 s	1.04	G3V	(1)
LP 920-25 A+B	6 × 30 s	1.39	8 × 30 s	1.32	M1.5V + M1.5V	05-2012	HIP 084636	4 × 1.2 s	1.46	6 × 1.2 s	1.44	G3V	(1)
LP 922-16 A+B	3 × 20 s	1.21	4 × 30 s	1.23	K1IV + M1.5V	05-2012	HIP 092515	6 × 10 s	1.12	6 × 15 s	1.14	G2V	(1)
M 124... A+B	2 × 120 s	1.01	3 × 120 s	1.01	M0V + M1.5V	05-2012	HIP 098813	10 × 2 s	1.01	20 × 2 s	1.01	G1V	(3,4)

References. (1) Houk & Smith-Moore (1988); (2) Houk & Cowley (1975); (3) Houk (1982); (4) Gray et al. (2006).