Letter to the Editor

A&A 374, L12–L15 (2001)
DOI: 10.1051/0004-6361:20010811

Astronomy & Astrophysics

Search for nearby stars among proper motion stars selected by optical-to-infrared photometry

I. Discovery of LHS 2090 at spectroscopic distance of $d \sim 6$ pc

R.-D. Scholz[1], H. Meusinger[2,⋆], and H. Jahreiß[3]

[1] Astrophysikalisches Institut Potsdam, An der Sternwarte 16, 14482 Potsdam, Germany
e-mail: rdscholz@aip.de
[2] Thüringer Landessternwarte Tautenburg, 07778 Tautenburg, Germany
e-mail: meus@obelix.tls-tautenburg.de
[3] Astronomisches Rechen-Institut, Mönchhofstraße 12-14, 69120 Heidelberg, Germany
e-mail: hartmut@ari.uni-heidelberg.de

Received 1 June 2001 / Accepted 11 June 2001

Abstract. We present the discovery of a previously unknown very nearby star – LHS 2090 at a distance of only $d = 6$ pc. In order to find nearby (i.e. $d < 25$ pc) red dwarfs, we re-identified high proper motion stars ($\mu > 0.18$ arcsec/yr) from the NLTT catalogue (Luyten 1979–1980) in optical Digitized Sky Survey data for two different epochs and in the 2MASS data base. Only proper motion stars with large $R - K_{\rm s}$ colour index and with relatively bright infrared magnitudes ($K_{\rm s} < 10$) were selected for follow-up spectroscopy. The low-resolution spectrum of LHS 2090 and its large proper motion (0.79 arcsec/yr) classify this star as an M6.5 dwarf. The resulting spectroscopic distance estimate from comparing the infrared $JHK_{\rm s}$ magnitudes of LHS 2090 with absolute magnitudes of M6.5 dwarfs is 6.0 ± 1.1 pc assuming an uncertainty in absolute magnitude of ± 0.4 mag.

Key words. astrometry and celestial mechanics: astrometry – astronomical data base: surveys – stars: late-type – stars: low mass, brown dwarfs

1. Introduction

Our knowledge on the stellar content of the solar neighbourhood is still very incomplete. From the statistics of the Catalogue of Nearby Stars one can infer that at 10 pc about 30% of all stars are so far undetected (Henry et al. 1997). But the detailed observation of the very nearby stars is one of the main starting points for investigations of the stellar luminosity function, the initial mass function as well as for the search for planetary systems. Future missions for the detection of extrasolar planets (SIM, TPF, DARWIN) will concentrate on very nearby stars ($d < 10$ pc) in order to be able to reveal not only Jupiter-class but also Earth-like planets.

High proper motion catalogues, e.g. the Luyten Half Second (LHS) catalogue (Luyten 1979) and the New Luyten Two Tenths (NLTT) catalogue (Luyten 1979–1980) contain most of the known nearby stars ($d <$ 25 pc). All 58 stars in the Catalogue of Nearby Stars (CNS3) of Gliese & Jahreiß (1991) with distances less than 5 pc have proper motions larger than 0.5 arcsec/yr. Among the 280 stars within 10 pc contained in the CNS3, there is only one M dwarf with a proper motion below the NLTT limit of 0.18 arcsec/yr. In the current CNS4 (not yet published) all stars within 10 pc do have proper motions above that limit.

The majority of the ∼60 000 NLTT stars have not yet been investigated further in order to determine their distances. Among the faint and red NLTT stars one can expect to find about 40% to lie within 25 pc (Jahreiß et al. 2001). The ∼3500 LHS stars received much more attention in spectroscopic and photometric follow-up observations. Nevertheless, the discovery of nearby stars among

Send offprint requests to: R.-D. Scholz,
e-mail: rdscholz@aip.de

⋆ Visiting astronomer, German-Spanish Astronomical Centre, Calar Alto, operated by the Max-Planck-Institute for Astronomy, Heidelberg, jointly with the Spanish National Comission for Astronomy.

the LHS stars is still going on (Henry et al 1997; Gizis & Reid 1997; Jahreiß et al. 2001).

One reason for the incompleteness of the catalogue of nearby stars is the lower limiting magnitude of the proper motion catalogues in the southern sky. The northern sky was covered by the Palomar Observatory Sky Survey (POSS) observations starting in the 50 s, and these Schmidt plates constitute the first epoch of Luyten's high proper motion star surveys (e.g. Luyten 1979). Nevertheless, few faint high proper motion stars can be found from second epoch POSS observations (Monet et al. 2000). South of $\delta = -30°$, which is the POSS survey limit in the southern sky, only recently deep high proper motion surveys have been started using Schmidt plates (Scholz et al. 2000; Ruiz et al. 2001). New high proper motion stars as bright as the active M 5 star APMPM J0237-5928 ($R = 13.4$, spectroscopic distance: 12 pc) discovered by Scholz et al. (1999) can be found in that region.

There are several attempts to detect nearby stars neglecting the proper motion information during the first steps of the search. One possibility is to search for extremely red faint objects, i.e. very late-type M dwarfs and the new class of L dwarfs obtained in the Two Micron All Sky Survey (2MASS) (Reid et al. 2000; Gizis et al. 2000) and in the DEep Near-Infrared Survey (DENIS) (Delfosse et al. 2001). Another way to detect missing nearby M dwarfs consists in the subsequent observation of X-ray sources in order to identify young M dwarfs with small space motions not present in proper motion catalogues (Fleming 1998). But all new nearby stars found in these surveys turned out to be high proper motion stars, at least in those cases when distances of less than about 15 pc were measured.

As a logical consequence, we have started a search for the missing stars in the solar neighbourhood by combining the proper motion catalogues with near-infrared and optical sky surveys. The 2MASS data base (2nd incremental release public data base) and the A2.0 catalogue (Monet et al. 1998) can well be used for that purpose. The proper motion stars, however, have to be re-identified in digitized sky survey (DSS) images at two different epochs.

2. Combining proper motion and photometry

Samples of very red (optical-to-infrared colour) point sources in the 2MASS or DENIS survey may contain compact extragalactic sources, distant red giants, nearby red dwarfs and very nearby asteroids. If the source is relatively faint in the optical ($R > 10$) and shows a proper motion of the order of 0.1 to 10 arcsec/yr (with Barnards's star still being the record holder in stellar proper motions), it must be a dwarf. For a red giant with that faint apparent magnitude, the proper motion would transform to a very large space velocity (>1000 $\mathrm{km\,s^{-1}}$), which is much larger than the Galactic escape speed (cf. Leonard & Tremaine 1990; Meillon et al. 1997).

In a previous paper (Jahreiß et al. 2001) we selected red NLTT stars (Luyten's spectral classes "m" and "m+") as candidates of nearby stars and obtained more accurate positions and photographic photometry from the APM sky catalogues (Irwin et al. 1994). However, the optical colours of these late-type star candidates show only a weak correlation with spectral subclass (Scholz et al. 2000). As already mentioned in Jahreiß et al. (2001), optical-to-infrared colours are a much better choice. The 2MASS data base allows an all-sky search with the input of target lists or by pre-defined search parameters.

We have cross-identified NLTT stars in a region covering about 50% of the northern sky ($07^{\mathrm{h}} < \alpha < 19^{\mathrm{h}}, \delta > 0°$) with the 2MASS data base. Only bright 2MASS sources ($K_{\mathrm{s}} < 10$) identified with faint (Luyten's $R > 14.5$) NLTT stars within a search radius of 60 arcsec were further investigated. All identifications were checked with two epochs of DSS images. In addition to the optical magnitude estimates given in the proper motion catalogue, we also extracted the R magnitudes from the A2.0 catalogue (Monet et al. 1998). The DSS1 images usually had the same epoch as the A2.0 catalogue, whereas the DSS2 images had an epoch close to that of the 2MASS data.

LHS 2090 turned out as a candidate nearby star in our first sample of about 50 stars selected for follow-up classification spectroscopy. With $K_{\mathrm{s}} = 8.4$ and $R - K_{\mathrm{s}} = 6.4$ (USNO-2MASS), LHS 2090 was one of the most promising objects in the list of candidates. The whole sample of about 35 objects which was successfully observed spectroscopically, will be subject of a forthcoming paper.

3. Former information on LHS 2090

LHS 2090 was detected by Willem Luyten within the scope of his proper motion survey with the 48-inch Schmidt telescope and got the detection designation LP 368-128. Its refined (LHS) proper motion is $0.785''$ in $216.3°$. Willem Luyten's estimates of its red and photographic magnitudes are $R = 15.5$ and $m_{\mathrm{pg}} = 17.4$, respectively. Luyten hoped that the mean error of the magnitudes are not larger than ± 0.6 mag *though errors of even 1.5 do occur* (Luyten 1964). Having this in mind Luyten's magnitudes are in good agreement with the USNO-A2.0 values $R = 14.8$ and $B = 17.7$, which are also measurements of the POSS-I O and E plates. A finding chart of LHS 2090 was published in the LHS Atlas (Luyten & Albers 1979). Luyten attributed a spectral class "m" to this object. Since Luyten's publication, no additional information on LHS 2090 became available unless the most recent astrometric and photometric measurements in USNO-A2.0 and 2MASS ($09^{\mathrm{h}}00^{\mathrm{m}}23\overset{\mathrm{s}}{.}59, +21°50'05\overset{''}{.}5$ (J2000 at 2MASS epoch 1998.44)). It was too faint to enter the photometric surveys of LHS stars carried out by Eggen or Weis.

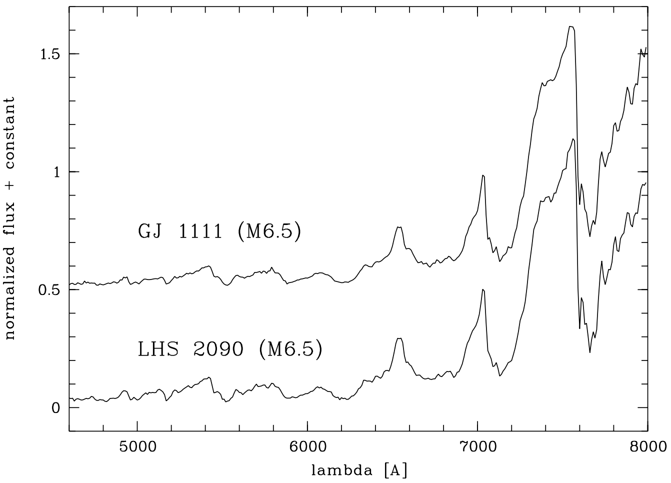

Fig. 1. Spectrum of LHS 2090 in comparison to that of the well known M6.5 star GJ 1111. Both spectra were taken with the 2.2 m telescope at Calar Alto. The spectra are nearly identical, and we adopted the spectral type of M6.5 for LHS 2090.

4. Spectroscopic distance estimate of LHS 2090

Spectroscopic follow-up observations were carried out with CAFOS, the focal reducer and faint objects spectrograph at the 2.2 m Calar Alto telescope. The grism B-400 was used yielding 9.6 Å per pixel on the SITe1d CCD and a wavelength coverage from 4000 Å to 8000 Å. A slit width of 1 arcsec was used, corresponding to a spectral resolution of 18 Å. The exposure time was 60 s for LHS 2090 and 120 s for the bright comparison star GJ 1111 (observed during twilight).

The spectra were calibrated by standard procedures within the MIDAS package for bias-subtraction, flat-fielding and wavelength calibration using Ne-Ar lamp spectra. For relative flux calibration we have used spectra of secondary spectrophotometric standard stars from Oke & Gunn (1983).

The low-resolution spectrum of LHS 2090 is nearly identical to that of the known M6.5 dwarf GJ 1111 (see Fig. 1). With that spectral type and taking the mean absolute magnitudes of M6.5 dwarfs $M_J = 10.51, M_H = 9.94, M_{K_s} = 9.60$ given in Kirkpatrick & McCarthy (1994), we obtained spectroscopic distance estimates $d_J = 6.06$ pc, $d_H = 6.07$ pc, $d_{K_s} = 5.83$ pc, respectively. A conservative assumtion of ± 0.4 mag accuracy in absolute magnitude yields 6.0 ± 1.1 pc.

5. Conclusions

1. After the recent discovery of DENIS-P J104817.7-395606.1 (Delfosse et al. 2001), an M 9 dwarf at only 4 pc spectroscopic distance from the Sun, we have found another very nearby star, LHS 2090, at 6 pc.
2. Despite its large proper motion ($\mu = 0.785$ arcsec/yr), LHS 2090 had not been further investigated up to now.
3. The low-dispersion spectrum of LHS 2090 closely resembles that of the M6.5 star GJ 1111. We conclude therefore that LHS 2090 is of spectral type M6.5 as well. Hence the distance estimate based on the 2MASS JHK_s magnitudes yields $d = 6$ pc. Trigonometric parallax determination and investigation of a possible binarity of LHS 2090 is needed for confirmation.
4. The combination of high proper motion star data with infrared sky surveys such as the 2MASS survey is a very effective tool for finding previously unknown nearby red dwarfs.

Acknowledgements. The spectroscopic confirmation of nearby star candidates is based on observations made with the 2.2 m telescope of the German-Spanish Astronomical Centre, Calar Alto, Spain, This research has made use of the SIMBAD database and the VizieR Catalogue Service, Strasbourg, of the STScI Digitized Sky Survey and of data products from the Two Micron All Sky Survey, which is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center, funded by the National Aeronautics and Space Administration and the National Science Foundation.

We would like to thank Darja Golikowa for her help with the re-identification of high proper motion stars in DSS images and their cross-correlation with USNO A2.0 and 2MASS data.

RDS gratefully acknowledges financial support from the Deutsches Zentrum für Luft- und Raumfahrt (DLR) (Förderkennzeichen 50 OI 0001).

We thank the referee, John Gizis, for his prompt report.

References

Delfosse, X., Forveille, T., Martin, E. L., et al. 2001, A&A, 366, L13

Fleming, T. A. 1998, ApJ, 504, 461

Gizis, J. E., & Reid, I. N. 1997, PASP, 109, 849

Gizis, J. E., Monet, D. G., Reid, I. N., et al. 2000, AJ, 120, 1085

Gliese, W., & Jahreiß, H. 1991, Preliminary Version of the Third Catalogue of Nearby Stars, computer-readable version on ADC Selected Astronomical Catalogs, vol. 1 – CD-ROM

Henry, T. J., Ianna, P. A., Kirkpatrick, J. D., & Jahreiß, H. 1997, AJ, 114, 388

Irwin, M. J., Maddox, S. J., & McMahon, R. G. 1994, Spectrum, No. 2, 14

Jahreiß, H., Scholz, R.-D., Meusinger, H., & Lehmann, I. 2001, A&A, 370, 967

Kirkpatrick, J. D., & McCarthy, D. W. 1994, AJ, 107, 333

Leonard, P. J. T., & Tremaine, S. 1990, ApJ, 353, 486

Luyten, W. J. 1964, Proper motion survey with the 48 inch Schmidt telescope, vol. II The North Pole, University of Minnesota, Minneapolis

Luyten, W. J. 1979, LHS Catalogue, Second Edition (University of Minnesota, Minneapolis)

Luyten, W. J. 1979–1980, New Luyten Catalogue of Stars with Proper Motions Larger than Two Tenths of an Arcsecond, University of Minnesota, Minneapolis, computer-readable version on ADC Selected Astronomical Catalogs, vol. 1, CD-ROM

Luyten, W. J., & Albers, H. 1979, LHS atlas, An atlas of identification charts for LHS stars (University of Minnesota, Minneapolis)
Meillon, L., Crifo, F., Gomez, A., Udry, S., & Mayor, M. 1997, in Hipparcos Venice'97, ed. B. Battrick, ESA-SP 402, 591
Monet, D., Bird, A., Canzian, B., et al. 1998, USNO-A V2.0, A Catalog of Astrometric Standards, U.S. Naval Observatory Flagstaff Station (USNOFS) and Universities Space Research Association (USRA) stationed at USNOFS
Monet, D. G., Fisher, M. D., Liebert, J., et al. 2000, AJ, 120, 1541
Oke, J. B., & Gunn, J. E. 1983, ApJ, 266, 713
Reid, I. N., Kirkpatrick, J. D., Gizis, J. E., et al. 2000, AJ, 119, 369
Ruiz, M. T., Wischnjewsky, M., Rojo, P. M., & Gonzalez, L. E. 2001, ApJS, 133, 119
Scholz, R.-D., Irwin, M., Schweitzer, A., & Ibata, R. 1999, A&A, 345, L55
Scholz, R.-D., Irwin, M., Ibata, R., Jahreiß, H., & Malkov, O. Yu. 2000, A&A, 353, 958