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*Research Note*

# The trigonometric parallax of DENIS–P J104814.7–395606.1

N. R. Deacon and N. C. Hambly

Institute for Astronomy, University of Edinburgh, Blackford Hill, Edinburgh EH9 3HJ, UK
e-mail: nd@roe.ac.uk

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**Abstract.** We present a measurement of the trigonometric parallax for a nearby very low mass star recently discovered by Delfosse et al. (2001). Using schmidt plates measured on the SuperCOSMOS plate scanning machine we find a parallax of $\pi = 192 \pm 37$ mas, giving a distance of $d = 5.2^{+1.2}_{-0.8}$ pc. Using this distance we find the absolute magnitude and kinematics for the object to be consistent with an intermediate–age disk object of mass 0.08 $M_{\odot}$. This star is clearly nearby and is on these measurements between the 30th and 86th closest known stellar system to the Sun; it could be the closest M 9 dwarf to the Sun.

**Key words.** astrometry – stars: low mass – stars: individual: DENIS 1048–39

## 1. Introduction

In recent years the DEep Near Infrared Survey (hereafter DENIS; Epchtein 1997) has been systematically surveying the southern sky. With high sensitivity in the infrared this survey, along with the 2MASS survey (Kleinman et al. 1994), is excellent for identifying very low mass (VLM) stars and brown dwarfs (BDs) in the immediate solar neighbourhood (e.g. Kirkpatrick et al. 2000). Without knowledge of the distances to these new discoveries, however, it is difficult to assign masses and hence measure the VLM/BD mass function into the brown dwarf régime. One particularly interesting object is DENIS–P J104814.7–395606.1, hereafter DENIS 1048–39, (Delfosse et al. 2001). The object distance was estimated from the available data (i.e. spectroscopy) as being $d = 4.1 \pm 0.6$ pc for a single star or up to 5.8 pc for a double star although they left this as an open question until a trigonometric parallax could be determined.

## 2. Observational data and reduction

Fortuitously, several survey and non–survey schmidt plates containing the target in question exist in the ROE plate library. These were scanned using the SuperCOSMOS microdensitometer. This measures the centroids of well–exposed stars (>∼3 mag above the plate limit) to an accuracy of as good as 0.5 $\mu$m or 33 mas at the schmidt plate scale of 67 arcsec mm$^{-1}$ giving exceptionally accurate relative postitional data (Hambly et al. 1998). The plates used are listed in Table 1 (note that southern sky survey plates are being systematically scanned and the data made available via the WWW – see Paper I of Hambly et al. 2001 and references therein).

The IIIaJ plate was not used for astrometry to avoid systematic errors in position due to differential colour refraction; it provided photometric data only. In the remaining plates a list of 63 reference stars was selected. All were within one magnitude of DENIS 1048−39, were good single images and were within 10 arcmin of the star. These were then used to correct the global astrometric solutions for plate to plate errors in position via a local linear plate model for each plate with respect to the array of mean positions from all four plates. This process reduced relative errors from over 100 milliarcsec to the values quoted in Table 1.

## 3. Results

Firstly a model with only proper motion and no parallax was fitted to the positional data of the target star using routines from the positional astronomy library SLALIB (Wallace 1998). The $\chi^2_\nu$ value, ie. normalised per degree of freedom, was calculated as 4.65 – significantly greater than one and therefore indicating a poor fit. The positional residuals are plotted in Fig. 1a showing a clear scatter from zero. This is evidence for a possible parallax. Once a model including parallax was introduced a better fit was found. The proper motions were found to be $\mu_\alpha = -1170 \pm 9$ mas/yr and $\mu_\delta = -984 \pm 8$ mas/yr.

*Send offprint requests to*: N. C. Hambly,
e-mail: n.hambly@roe.ac.uk

**Table 1.** Schmidt plates used in this study; relative astrometric quality is indicated (see text).

| Plate No. | Date (yymmdd) | LST | Emulsion | Filter | Exp. (min) | $\sigma_x$ (mas) | $\sigma_y$ (mas) | Notes |
|---|---|---|---|---|---|---|---|---|
| J1478 | 750513 | 10:38 | IIIaJ | GG395 | 90 | | | Survey original plate |
| R6366 | 860212 | 09:51 | IIIaF | RG630 | 200 | 43 | 38 | Copy of ESO survey original plate |
| OR13569 | 900126 | 10:13 | IIIaF | OG590 | 550 | 29 | 35 | Non-survey plate |
| OR15472 | 930415 | 09:58 | IIIaF | OG590 | 550 | 40 | 33 | Non-survey plate |
| OR15601 | 930619 | 12:15 | IIIaF | OG590 | 550 | 48 | 42 | Survey original plate |

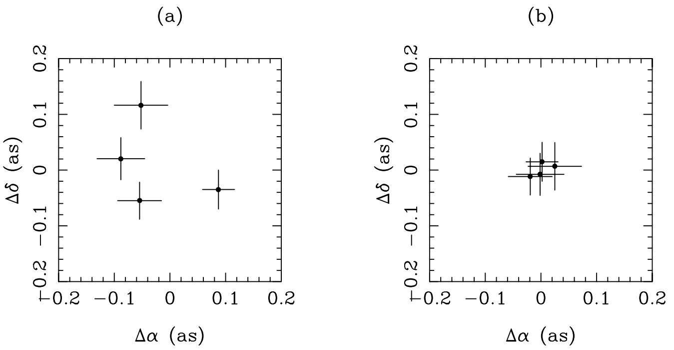


**Fig. 1.** Comparing the residuals of the non parallax model **a)** with the parallax model **b)**.

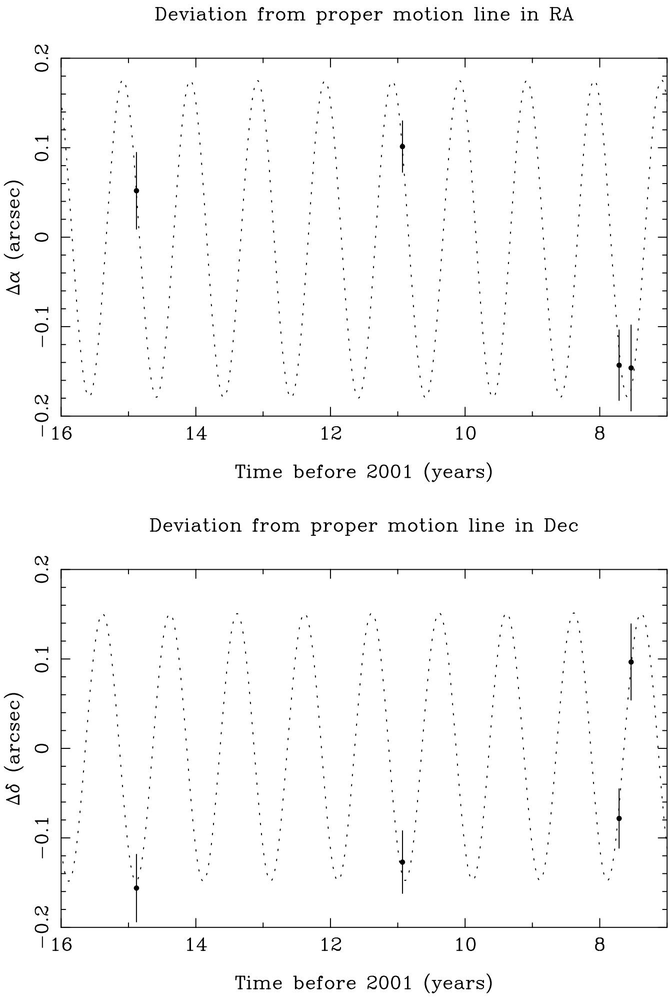


**Fig. 2.** Comparing the observed proper motion subtracted data (solid points with error bars) with the model parallax predicted displacement (dotted lines).

The parallax was $\pi = 192\pm37$ mas. The final $\chi^2_\nu$ value was 0.29. The residuals are plotted in Fig. 1b; no scatter larger than the estimated positional errors is present. Figure 2 shows the data points with proper motion subtracted plotted against the parallax model. To show the results are not an artefact of the method the reference stars were used as a control group. These results are plotted in Fig. 3 showing clearly that the proper motion, and in particular the parallax results for DENIS 1048−39 are statistically significant. The mean $\chi^2_\nu$ value of the reference stars was 1.35 indicating generally good fits. To ensure that the reference stars were not so close as to produce an error in our relative parallax measurement their mean colour was found. Assuming they are all main sequence stars the correction for their parallaxes (0.68 mas) is far less than the stated errors. We also investigated the effects of differential colour refraction for each plate. For the $R$ plates the effects were negligible (less than 10 mas on either axis) but for the blue plate the effect was substantial (9 mas in RA; 47 mas in Dec) vindicating the decision not to use the $B_J$ plate for astrometric measurements.

## 4. Discussion

With this distance, applying a 1 sigma error and referring to the RECONS list of the 100 nearest stellar systems (`http://www.chara.gsu.edu/RECONS`) makes DENIS 1048−39 the 30th to 86th nearest stellar system. With the distance measurement of 5.2 pc it would be the 50th nearest stellar system and at the lower limit of distance would be closer than LP 944−20 making it the nearest M 9 dwarf known. From the distance and proper motion measurements the space velocities of this object can be calculated. Taking Delfosse et al.'s radial velocity of +10.5 km s$^{-1}$, the galactocentric velocities are $U = -3$, $V = 210$, $W = -22$ km s$^{-1}$, consistent with membership of the disk population. Delfosse et al. measured the magnitudes of DENIS 1048−39 and with a trigonometric distance these can now be converted into absolute magnitudes. This gives $M_R = 17.1$, $M_I = 14.2$, $M_J = 11.0$ and $M_K = 10.0$ with an error of $\pm0.4$ mag from the parallax error alone. Delfosse et al.'s spectral analysis suggested that the object was older and more massive than the nearby brown dwarf LP 944−20 for which Tinney (1998) gave an age of 475

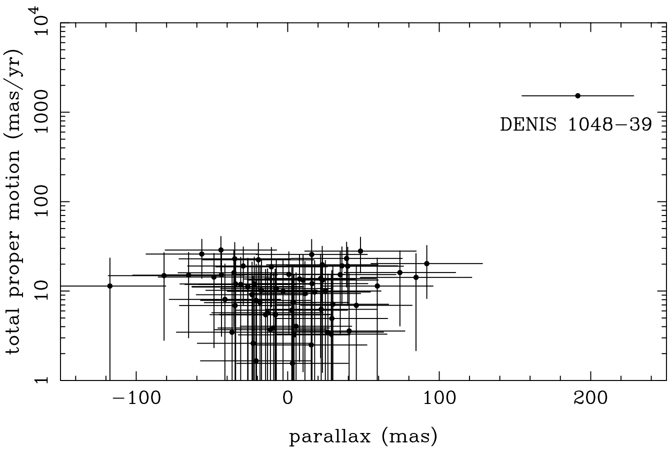


**Fig. 3.** Comparing the proper motion and parallax of the reference stars with those of DENIS 1048–39.

to 650 Myr and mass 0.056 to 0.064 $M_{\odot}$. There is no evidence DENIS 1048−39 is metal poor, so comparing the photometry with models for solar metallicity low mass stars (Baraffe et al. 1998) a reasonably good fit is found for a star of mass $0.08 \pm 0.01$ $M_{\odot}$ and an age of $1.0^{+0.8}_{-0.2}$ Gyr. The above estimates as to the nature of DENIS 1048−39 assume that it is a single star. Delfosse et al. also suggested that it could be an unresolved double with a distance of up to 5.8 pc and with our measurement this distance is possible. Further spectrosopic and astrometric measurements are required to find if this is the case. Of course, the motions of a binary system could affect the astrometric measurements made in this paper; however there is currently no evidence of such effects since the parallax model appears to be a good fit to the data (albeit with a small number of degrees of freedom).

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