CCD PARALLAXES FOR SOUTHERN VERY LOW LUMINOSITY STARS

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ABSTRACT. Trigonometric parallaxes based on CCD observations are presented here for six southern very late-type M dwarf stars and three white dwarfs. The M dwarfs RG0050–2722, ESO207–61, MH2115–4518, MH2124–4228, and LHS3003 are among the very lowest luminosity stars known.

1. INTRODUCTION

There are only a very few stars known from their trigonometric parallaxes to have absolute visual magnitudes below 18th magnitude. This small sample limits our knowledge of the physical characteristics and evolution of the coolest, lowest mass stars and has implications for the faint end of the stellar luminosity function. One goal of our southern hemisphere program is to expand this sample of intrinsically faint stars. The use of CCD's in this application offers the advantage of exceptional geometrical stability and the sensitivity to be able to observe faint red stars with even moderately sized telescopes.

2. OBSERVATIONS

The parallaxes are reduced from CCD observations obtained with the Australian National University 1-meter reflector at the Siding Spring Observatory. The GEC 8603 CCD is 576 x 382 pixels in size, and at the f/8 focal plane scale of 25.4 arcsec/mm the field covers 5.36 x 3.54 arcmin at 0.56 arcsec/pixel. The data are obtained through either broad band R or I filters (Bessell 1986). The advantages of observing at these wavelengths include a better match to the chip sensitivity and to the stellar energy distributions for most of our stars, and minimal differential atmospheric refraction. For only a few fields in the vicinity of the south galactic pole have there been difficulties finding an adequate number of reference stars.

The CCD frames are bias subtracted using the two overscan regions of the chip and flat fielded usually by using a mean flat formed from three twilight flats through each filter obtained early in each observing run; additional flats are obtained if needed. Some cleaning of bad pixels is done interactively as necessary with FIGARO. The orientation of the CCD with the right ascension direction is checked on most runs by star trails.

Without a dedicated telescope, it is not practical always to constrain the observations as we would like to small hour angles and ideal nights. Consequently some frames with moderately high background levels and large hour angles have been used. We try to limit observing to seeing no worse than 3 arcsec. Poor frames are rejected early in the reduction procedure, before image centers have been calculated. Corrections for differential atmospheric refraction have not yet been applied, and we are currently determining the R,I magnitudes and colors for the reference stars. The refraction corrections are not expected to be large. The results described below also are preliminary in the sense that these stars remain on our active observing list.

The star positions are determined by fitting Gaussian profiles in x and y separately to background subtracted marginal distributions in 27 x 27 pixel subrasters extracted from the

I.I. Mueller and B. Kołaczek (eds.),
Developments in Astrometry and Their Impact on Astrophysics and Geodynamics, 75–78.

full frames. These software routines were adapted from those used in our photographic program and have been described elsewhere (Ianna 1984).

3. RESULTS

In Table 1 we present the astrometric results for the nine stars reduced up to the current time. The name and approximate position (just to illustrate where the objects are in the sky) for each star are given in columns 1 and 2; columns 3 and 4 have the relative parallaxes and proper motions; the last column lists for each the number of frames, number of nights, number of reference stars, and the time interval covered by the observations respectively.

TABLE 1. Preliminary Relative Parallaxes and Proper Motions

ID	α, δ	$\pi \pm \sigma$	μ, θ	n_f, n_n, n_{ref}; t
LHS 239	7 47,+07	$0''.0535 \pm 0''.0042$	$1''.788$, $187°.6$	41, 16, 12; 1988.18-1992.22
LHS 240	7 47,+07	$0''.0524 \pm 0''.0038$	$1''.793$, $187°.5$	41, 16, 12; 1988.18-1992.22
ER 8	13 10,-47	$0''.0617 \pm 0''.0040$	$2''.146$, $89°.0$	51, 15, 9; 1987.58-1992.53
RG0050	0 50,-27	$0''.0394 \pm 0''.0040$	$0''.098$, $26°.0$	48, 16, 6; 1988.50-1992.53
ESO 207-61	7 07,-49	$0''.0654 \pm 0''.0040$	$0''.405$, $5°.0$	87,21,11; 1991.30-1992.30
LHS 3003	14 54,-28	$0''.1524 \pm 0''.0035$	$0''.960$, $210°.0$	91,30, 9; 1987.58-1992.46
MH2115-45	21 24,-42	$0''.0410 \pm 0''.0036$	$0''.620$, $319°.0$	55,20, 8; 1987.57-1991.82
MH2124-42	21 15,-45	$0''.0324 \pm 0''.0057$	$0''.190$, $136°.0$	33,19,10; 1987.57-1989.90
LHS 527	22 39,-33	$0''.0354 \pm 0''.0025$	$1''.090$, $102°.5$	49,13,10; 1989.73-1992.51

The parallaxes have not yet been reduced to absolute. For the faint reference frames of these fields the amount of the correction can be expected to be on the order of 1 mas (e.g. Monet et al. 1992). This will not change the final results by any significant amount in most cases.

Parallaxes have been published for four of the stars in Table 1; these are displayed in Table 2. The agreement of the LHS 239/240 white dwarf pair with the Naval Observatory result (Monet et al. 1992) is excellent. For ER 8 and LHS 3003 (Ruiz et al. 1990), although the differences between the two results are larger and in the same sense, the disagreement is probably not significant. There are more stars on the Siding Spring program in common with the Naval Observatory, so further comparisons will be possible in the future.

TABLE 2. Comparison with Published Parallaxes

ID	SSO	other	Source
LHS 239	$0''.0535 \pm 0''.0042$	$0''.0530 \pm 0''.0012$	USNOFS
LHS 240	$0''.0524 \pm 0''.0038$	$0''.0539 \pm 0''.0011$	USNOFS
ER 8	$0''.0617 \pm 0''.0040$	$0''.068 \pm 0''.003$	Chile
LHS 3003	$0''.1524 \pm 0''.0035$	$0''.161 \pm 0''.006$	Chile

https://doi.org/10.1017/S0074180900172961 Published online by Cambridge University Press

4. DISCUSSION

Published photometry for the parallax stars of this paper is collected in Table 3; the data are taken from the original discovery papers for individual stars, Monet et al. (1992), or Bessell (1991). Data taken from Bessel (1991) for the last four stars in Table 3 are included for comparison; these are the four faintest stars with previously published parallaxes (Monet et al. 1992). The parallaxes of Table 1 are used to derive absolute magnitudes in V and/or K for the eight stars with photometry. There is no published photometry for LHS 527, except for the LHS catalog value of $m_R = 17.0$.

TABLE 3. Photometry for Parallax Stars

ID	V	I	K	V-I	I-K	R-I	M_V	M_K
LHS 239	17.01	15.76		1.25			15.66	
LHS 240	16.67	15.57		1.10			15.35	
ER 8	17.05	15.72	14.9	1.33	0.82	0.60	16.01	
LHS 3003	17.05	12.53	8.95	4.52	3.63	2.35	17.96	9.86
ESO207-61	20.39	16.23	12.21	4.16	4.02	2.40	19.47	11.29
RG0050		16.57	12.47		4.10			10.45
MH2115		16.34	12.36		3.98			10.42
MH2124		16.20	12.18		4.02			9.73
LHS 474	17.33	12.86	8.81	4.70	4.05	2.32	18.64	9.96
LHS 2397a	19.57	14.87	10.75	4.62	4.12	2.23	18.80	9.98
LHS 2065	18.74	14.54	9.96	4.36	4.58	2.20	19.15	10.30
LHS 2924	19.74	15.3	10.68	4.37	4.62		19.37	10.45

Parallaxes for four of the M stars in Tables 1 and 3 are published here for the first time. This doubles the number of stars with measured parallaxes at the extreme end of the main sequence. A few brief comments on these objects are in order.

The faintest star of this group is ESO 207-61. Ruiz et al. (1991) noted this very red object in a proper motion survey for faint members of the Hyades moving group. Based on similarities to LHS 2924 an absolute V magnitude of $M_V = 19.5$ was adopted, and its distance was estimated to be 15 pc. Our current parallax confirms these estimates very well, and makes ESO 207-61 slightly fainter than LHS 2924. The published K magnitude for the star gives an absolute K magnitude fainter than would be expected.

RG0050–2722 was found by Reid and Gilmore (1981) on UK Schmidt telescope plates in the course of an investigation of the stellar luminosity function towards the south galactic pole. They estimated the star's absolute V magnitude photometrically to be $M_V = 19 \pm 1$ and its distance to be about 25 pc. This agrees very well with our current parallax.

The two MH stars were identified as low luminosity star candidates by Hawkins and Bessell (1988) from deep R- and I-band Schmidt plates. From the photometric calibration of the red proper motion stars, distances of 27 and 33 pc were predicted for MH2115-4518 and MH2124-4228 respectively; the present parallax results for the two stars give distances of 24 and 31 pc. This result gives support to the validity of their photometric calibration and to the roughly constant space density of low mass stars found in their investigation. Additional M stars from their list are on our program.

https://doi.org/10.1017/S0074180900172961 Published online by Cambridge University Press

ER 8 is one of the coolest degenerate stars known. It was found by Ruiz et al. (1986) on wide field camera plates obtained in a supernova search program.

The discovery of such faint 'stellar' objects as these has come only slowly and in several cases from observations intended for other purposes. There are further recent examples of this (Irwin et al. 1991; Schneider et al. 1991), and it is tantalizing to anticipate finding more very low luminosity objects if future deep red surveys can probe a little fainter and additional faint star proper motion survey material becomes available.

5. ACKNOWLEDGEMENTS

Major contributors to the organization, observing, and data reduction for this program include M. C. Begam, M.S. Bessell, L.W. Fredrick, and R.J. Patterson. This work is partially funded by the National Science Foundation and the Estate of Leander J. McCormick. The continuing support of this program by the Mount Stromlo and Siding Spring Observatories is most gratefully acknowledged.

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