

A Search for Astrometric Companions to Southern Nearby Stars

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TABLE II. PARALLAXES AND PROPER MOTIONS

Star	Spectral Type	Position (epoch 2000)	Parallax (arcseconds)	Proper Motion & Position Angle	Observations
LHS 288	M5.5	$\alpha = 10:44:31.8$ $\delta = -61^{\circ}11'38''$	0.2154 ± 0.0016	$1.639''$ in 348.5°	101 plates on 18 nights May 1991 – March 1998
LHS 337	M4.5	$\alpha = 12:38:49$ $\delta = -38^{\circ}22'24''$	0.1448 ± 0.0016	$1.430''$ in 206.4°	104 plates on 14 nights Feb. 1994 – June 1997
LHS 532	M4.5	$\alpha = 22:56:28$ $\delta = -60^{\circ}03'00''$	0.0946 ± 0.0014	$1.072''$ in 209.6°	98 plates on 18 nights July 1994 – Oct. 1997
LHS 1134	M3	$\alpha = 00:43:26$ $\delta = -41^{\circ}17'36''$	0.1062 ± 0.0028	$0.761''$ in 221.0°	49 plates on 11 nights July 1996 – Nov. 2001
LHS 1565	M5.5	$\alpha = 03:36:00.0$ $\delta = -44^{\circ}30'46''$	0.2841 ± 0.0014	$0.830''$ in 117.4°	81 plates on 18 nights Oct. 1995 – Jan. 2002
LHS 2739	M3.5	$\alpha = 13:27:19$ $\delta = -31^{\circ}10'42''$	0.0446 ± 0.0009	$0.581''$ in 254.7°	137 plates on 22 nights May 1994 – June 1997
LHS 2813	M2	$\alpha = 13:51:20$ $\delta = -53^{\circ}32'18''$	0.0575 ± 0.0014	$0.532''$ in 138.7°	131 plates on 18 nights Feb. 1994 – June 1997
LHS 3064	M3	$\alpha = 15:22:12$ $\delta = -27^{\circ}50'12''$	0.0845 ± 0.0010	$0.724''$ in 36.2°	112 plates on 14 nights Feb. 1994 – March 1996

REFERENCES: Spectral type & position from SIMBAD for all, except LHS 288 & LHS 1565 taken from Henry 2002

What if a companion were present?

- Significant peaks in both x- and y-residual spectra at same frequency
- Similar peaks remain when nightly normal points used instead of individual observations
- Predicted perturbation of LHS 288 by various companions calculated, Table IV

TABLE IV. PREDICTED PERTURBATIONS OF LHS 288

Companion Mass (Jupiter Masses)	Companion Distance from Center of Mass (AU)	Period (years)	Perturbation (arcseconds)	Perturbation (millimeters)
40	0.5	1.49	0.0392	0.00154
	1.0	4.21	0.0783	0.00307
	5.0	47.1	0.391	0.0154
80	0.5	1.88	0.0783	0.00307
	1.0	5.33	0.157	0.00614
	5.0	59.6	0.783	0.0307

LHS 288 residuals are smaller than predictions.

NOTE: Assumes LHS 288 has mass of $0.105 M_{\odot}$ (Henry 2002) & telescope has a plate scale of $25.5''/mm$.

TABLE V. SPECTRAL FEATURES OF LHS 288

Axis	Frequency (1/years)	Period	Power	False Alarm Probability	Comments
x	0.147505	6.8 years	12.33890	< 5%	not in nightly normal points
y			12.67582		
x	0.184382	5.4 years	19.50216	< 5%	companion unlikely
y			12.68137		
x	0.295011	3.4 years	17.28494	< 5%	related to 3.9-year period in nightly normal points?
y			11.82144		
x	12.1323	30 days	23.7983	< 1%	highest peaks monthly observing cycle
y	12.2061		17.7172		

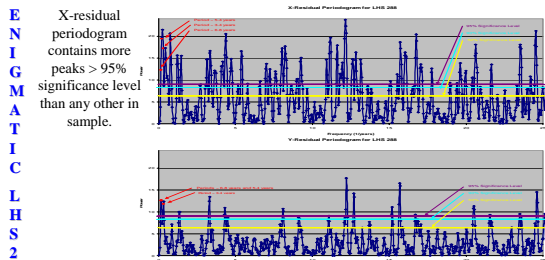


Figure 3. Periodograms for LHS 288 (individual observations).

What about LHS 288?

- Lack good explanation for differences between periodograms for LHS 288 and the rest of the sample, Figure 3 vs. Figures 2, 5, and 6
- Signals detected are probably spurious but require additional investigation to understand all of the features, Table V along with Figures 2 and 3
- Star lies in very crowded region near galactic plane

Most peaks smoothed away when observations combined as nightly normal points.

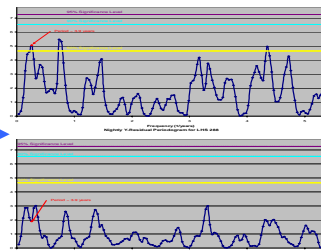


Figure 4. Periodograms for LHS 288 (nightly normal points).

Parallaxes and Proper Motions

- Preliminary results from the University of Virginia southern hemisphere parallax program
- Mean error of unit weight ranges from $0.0073''$ to $0.0118''$

Results

8 stars tested for possible astrometric perturbations due to low-mass companions

- Selection criteria
 - Spectral type – early to middle M
 - Large parallax – half within 10 pc
 - Not known to be binaries
- 6 Stars show no indication of companions LHS 337, LHS 532, LHS 1134, LHS 1565, LHS 2739, and LHS 3064
- 2 Stars show possible signals that merit further analysis
 - LHS 2813 may have a signal with period of 1.9 years
 - LHS 288 may have a signal with period of 3.4 or 3.9 years
 - Signals probably spurious

REFERENCES

Henry, Todd. "The One Hundred Nearest Star Systems." *RECONS: Research Consortium on Nearby Stars*. 7 March 2002. <<http://joy.chara.gsu.edu/RECONS/TOPI00.htm>> (27 May 2002).
 Press, W. H. et al. (1992). *Numerical Recipes in FORTRAN 77* (2nd ed; Cambridge University Press), 569-577.
 Seho, Kim. "The 40" telescope configured with the AAO's Low Dispersion Survey Spectrograph (LDSS)." *MSSSO Telescopes: 40-inch Telescope*. 24 April 2002. <<http://msowww.anu.edu.au/observing/>> (25 May 2002).
 SIMBAD. This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France.

TABLE III. SPECTRAL FEATURES OF LHS 2813

Axis	Frequency (1/years)	Period	Power	False Alarm Probability	Comments	
right ascension (α) \rightarrow x			9.208965	> 5%	Period ~ 1.9 years worth additional investigation	
	y	0.529258	1.9 years	6.208261		> 50%
declination (δ) \rightarrow y	x	56.5550	6 days	11.6855	4.4%	highest peaks different periods so companion unlikely
	y	36.5188	10 days	12.1798	2.7%	



Figure 1. Telescope at Siding Springs Observatory (image source: Research School of Astronomy and Astrophysics).

TABLE I. REFLECTOR CHARACTERISTICS

Parameter	Description
Objective	1 meter (40 inches), f/8
CCD	GEC P88500 chip with $0.57''/\text{pixel}$
Plate Scale	25.5 arcseconds per millimeter
Filters	V, R, & I according to Cousins

Method

University of Virginia southern hemisphere parallax program

- Uses 1-m reflector at Siding Springs Observatory, Figure 1 and Table I
- Reduces observations using standard plate constant, central overlap solution

Selected stars

- Parallaxes and proper motions measured, Table II
- Residuals to each observation analyzed
 - Residuals in x- and y- coordinates treated separately
 - Time-series analysis per Lomb periodogram method (Press et al. 1992)
 - Frequencies up to 4x Nyquist frequency searched
 - Periodograms prepared using
 - Individual observations, Figures 2, 3, 5, and 6
 - Nightly normal points, Figure 4

LHS 2813 - Possible signal for further investigation

- Peaks in x- and y-residual spectra with period of 1.9 years, Figure 2 and Table III
- Expect signal of similar strength in both coordinates but may not always occur
- In nightly normal points, peaks remain but with less than 50% significance level
- Probably spurious

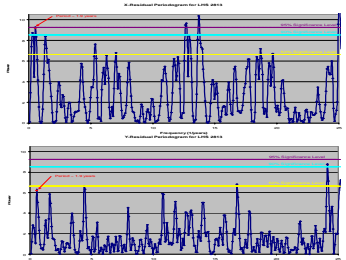


Figure 2. Periodograms for LHS 2813.

Significance Level vs. False Alarm Probability

- Higher power indicates stronger signal
- Significance level indicates likelihood that a peak identifies a real "signal"
- False Alarm Probability is likelihood that noise produces "signal"

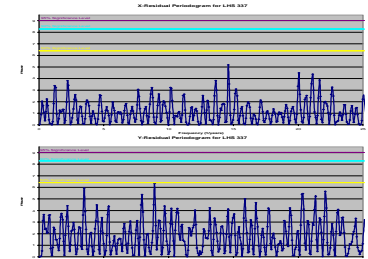


Figure 5. Periodograms for LHS 337.

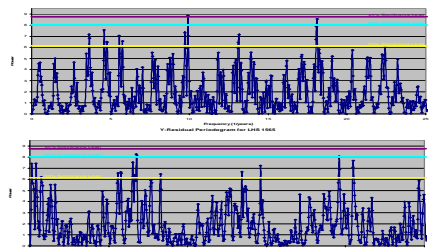


Figure 6. Periodograms for LHS 1565.

The other six

- Periodograms for LHS 337 and LHS 1565 are typical, Table VI along with Figures 5 and 6
- Either peaks have high false alarm probabilities or do not appear in both x- and y-residual spectra
- Periodograms for nightly normal points contain no peaks > 50% significance level
- No clear indication of any companions

TABLE VI. HIGHEST SPECTRAL PEAKS OF LHS 337 AND LHS 1565

Star	Axis	Frequency (1/years)	Period	Power	False Alarm Probability	Comments
LHS 337	x	57.2084	6 days	5.77007	73%	prob. due noise companion unlikely
	y	58.3435	6 days	6.53899	45%	
LHS 1565	x	9.91148	37 days	8.88060	4.4%	different periods companion unlikely
	y	6.75420	54 days	8.26741	8.0%	

No peak > 50% significance level when combined into nightly normal points

All the rest are similar—LHS 532, LHS 1134, LHS 2739, and LHS 3064—Nothing detected

ENIGMATIC LHS 288

LHS 2813 MAYBE