

# Knowing Our Neighbors: Fundamental Properties of Nearby Stars

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# Solar Neighborhood

- ❖ Fundamental volume-limited sample
  - Eventually census stars within 25 pc
- ❖ Know 49 systems within 5 pc
  - Implies 392 systems within 10 pc
  - Only 249 systems known within 10 pc
  - 143 missing systems?
    - How do they fit into the sample?
    - What do they look like?
    - Do they host companions, esp. planets?

# CTIOPI Subsample

## ❖ Select candidates with

- Declination  $\leq 0^\circ$
- Photometric or spectroscopic distance  $\leq 15$  pc
- $V_J \leq 15$  mag or  $J \leq 13.1$  mag

## ❖ 31 possible nearby stars

- Estimated distances 6—15 pc
- Brightest  $V_J = 11.61$  mag
- Earliest spectral type M3, nearly half without

# CTIOPI Astrometric Results

❖ 28 probable members of the solar neighborhood

- 3 stars within 10 pc

LP 876-10            7.8     $\pm 0.1$  pc

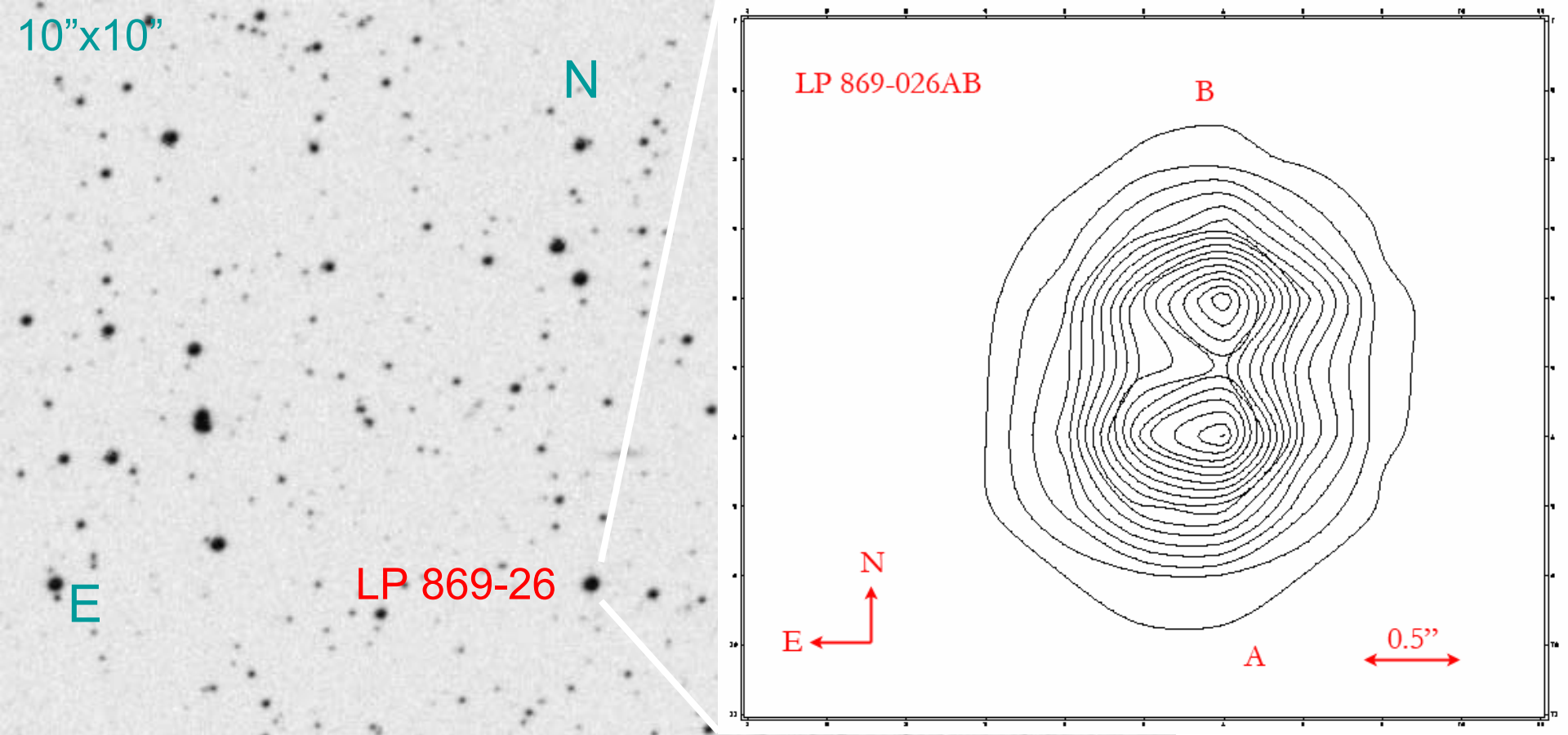
LP 991-84           8.4     $\pm 0.2$  pc

LHS 6167            9.6     $\pm 0.2$  pc

- LHS 2880  $9.8 \pm 0.7$  pc\*  $\rightarrow 29 \pm 1$  pc

❖ 5 high proper motion stars,  $\mu > 0.5''/\text{yr}$

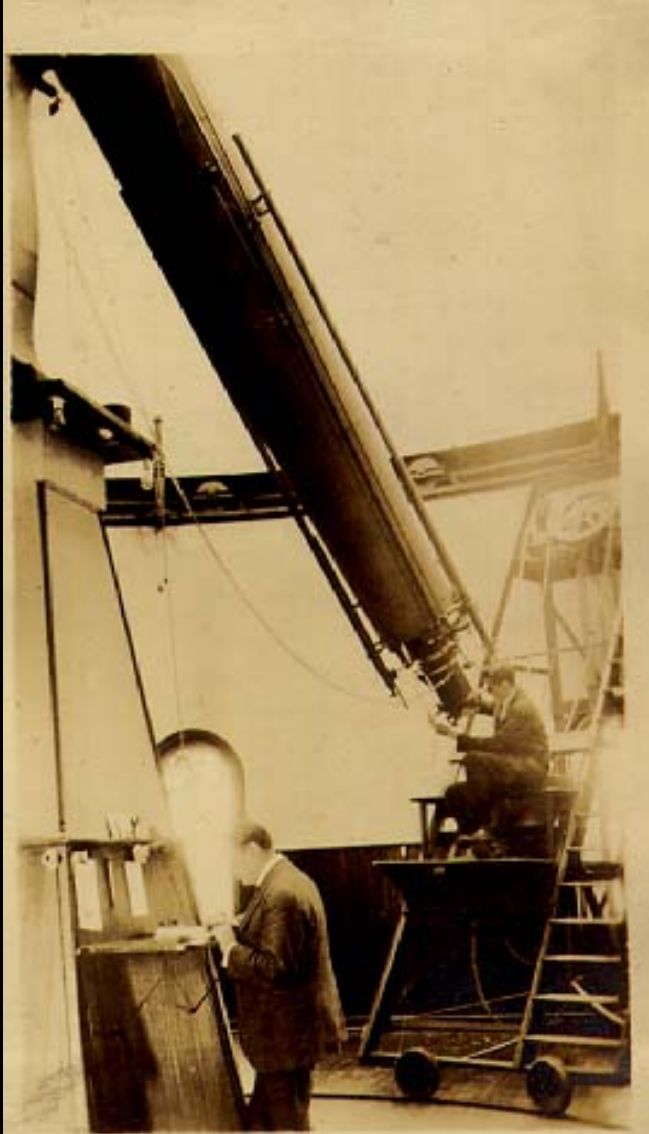
2MASS J02511490-0352459  $2.154 \pm 0.003''/\text{yr}$



## ~35% Multiples

- LP 869-26 newly resolved
- 5 parallactic distances > 2x previous estimates
- 5 previously identified pairs

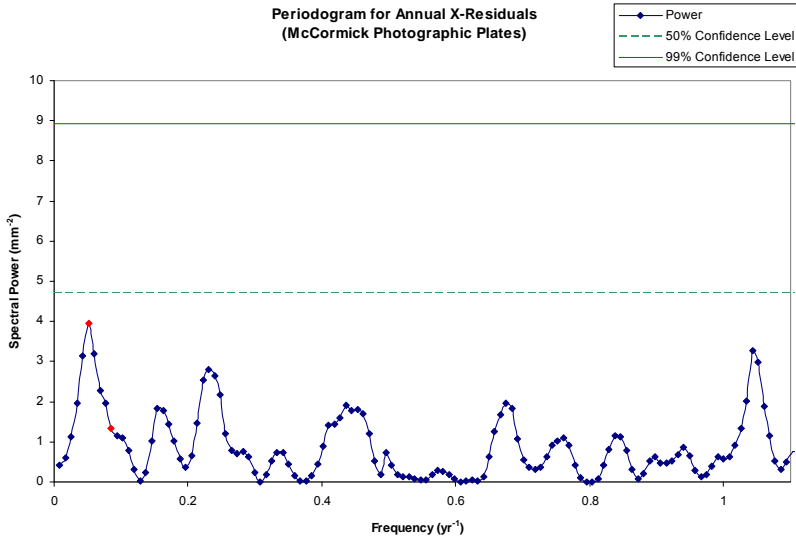
# Barnard's Star at LMO



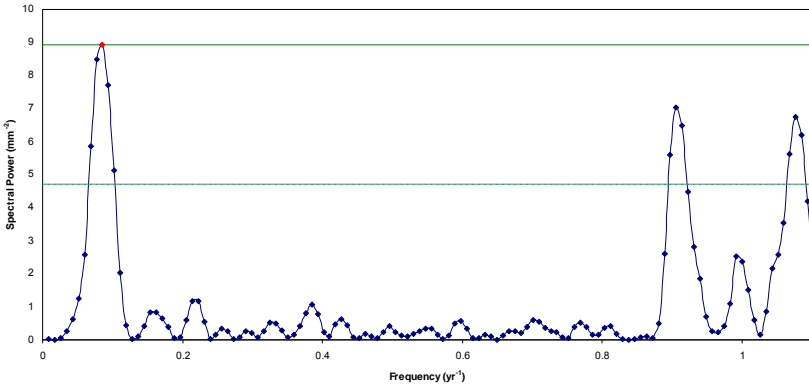
- ❖ 1963—1986, van de Kamp describes detection
  - 2 planets  $< 1 M_{24}$
  - $P_i = 12$  yrs,  $P_o = 20$  yrs
  - Unconfirmed
- ❖ Leander McCormick Obs
  - 26.25" Alvan Clark refractor
  - 2<sup>nd</sup> largest collection of Barnard's Star plates
    - ✓ 919 photographic plates
    - ✓ 1969 through 1998

# Barnard's Star

Periodogram for Annual X-Residuals  
(McCormick Photographic Plates)



Periodogram for Annual X Residuals  
(12-year orbit, 2-planet solution with no noise included)



❖ Relative Parallax  
 $0.547 \pm 0.001''$

❖ Proper Motion  
 $10.354 \pm 0.006''/\text{yr}$   
 $355.905 \pm 0.001^\circ$

❖ Secular acceleration  
 $0.00125 \pm 0.00004''/\text{yr}^2$

❖ Upper limit planet  
 $2.2 \pm 0.5 M_{21}$

# UVa Southern Parallax Program

## ❖ Siding Spring Observatory, Australia

- 40" telescope
- Observed 1987-2002

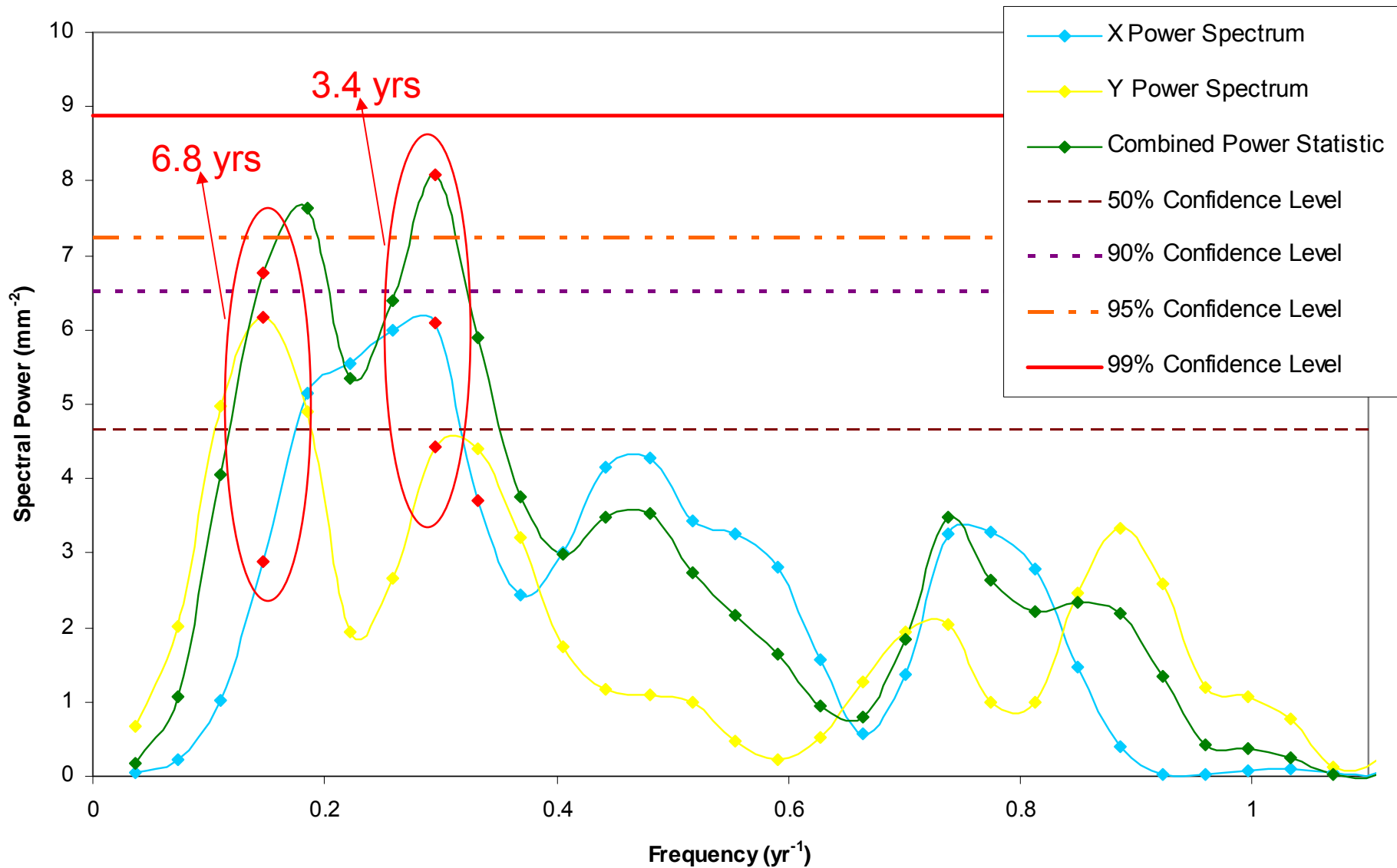
## ❖ 90 possible nearby stars

- 13 stars selected for further analysis
  - All with 25 pc, closest LHS 1565 at  $3.51 \pm 0.02$  pc
  - Spectral types M0.5V—M5.5V + LHS 34 (WD)
  - Brightness  $V_J$  11.4—14 mag
- 12 stars without significant perturbation
  - LHS 3242 nothing  $\geq 18 \pm 1 M_{21}$  (brown dwarf)
  - LHS 1565 nothing  $\geq 1.7 \pm 0.4 M_{21}$  (gas giant)



# LHS 288

Periodograms for LHS 288 Nightly Residuals



# Solar Neighborhood Updates

## ❖ Parallaxes

- ✓ 31 possible nearby stars under investigation
  - ✓ Preliminary parallaxes, proper motions
  - ✓ Preliminary photometry, spectroscopy
- ✓ 28 probable nearby stars, 3 within 10 pc
- ✓ 1 possible new binary resolved

## ❖ Planet Search Limits

- ✓ Barnard's Star nothing  $\geq 2.2 M_{\oplus}$
- ✓ 12 SPP nothing detected
- ✓ LHS 288, possible companion  $\geq 2.4 M_{\oplus}$

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- ❖ DSS2. This presentation made use of DSS2 images (McLean *et al.* 2000) that were obtained by AAO with UK Schmidt Telescope. STScI digitized and compressed images under US Govt. grant NAG W-2166. AAO Board retains copyright. UK Schmidt Telescope was operated by ROE with funding from UK SERC/PPARC, until 1988 June, and thereafter by AAO. In addition, I acknowledge using NASA's SkyView (McGlynn, Scollick, & White 1996) facility located at NASA Goddard Space Flight Center.
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# Abstract

Although the stars within 25 pc of the Sun constitute the one stellar sample that we can aspire to know thoroughly, we continue identifying objects closer than 10 pc. We know even less about local substellar populations, especially planets. The Cerro Tololo Inter-American Observatory Parallax Investigation (CTIOPI) is observing 31 late-type, red dwarfs selected for my thesis as part of a larger effort to complete the nearby star census. Preliminary parallaxes substantiate distances less than 25 pc for at least 28 stars. Of these, LP 991-84, LHS 6167, and LP 876-10 may lie within 10 pc. Preliminary proper motions for all but three stars exceed  $0.2'' \text{ yr}^{-1}$ . One recently established neighbor, LP 869-26, also appears to be a new binary. Associated *I*/VRI/ photometry and spectroscopy are in progress as well. Many of these stars are potential targets for astrometric planet searches, such as the Space Interferometry Mission (SIM).

In addition to confirming solar neighborhood membership, astrometry can discover brown dwarfs and planets. Time-series analyses of residuals to the UVa Southern Parallax Program (SPP) observations are contributing to frequency and distribution data for nearby substellar objects. In particular, LHS 288 displays an intriguing signal, which might be caused by a very low-mass companion. Twelve other SPP stars demonstrate no significant perturbations.

Finally, re-analyzing the Leander McCormick Observatory photographic plates of Barnard's Star failed to detect any planets orbiting it. This study of more than 900 exposures was sensitive to bodies of 2.2 Jupiter masses or more.

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Name	RA	Dec	Distance (pc)		PM (as/yr)		PA (deg)		T (yr)	
LP876-010	22 48 04.50	-24 22 07.8	7.8	± 0.1	0.377	± 0.002	117.0	± 0.7	3.0	
LP991-084	01 39 21.72	-39 36 09.1	8.4	± 0.2	0.259	± 0.002	145.1	± 0.8	3.9	
LHS6167	09 15 36.40	-10 35 47.2	9.6	± 0.2	0.437	± 0.001	244.3	± 0.3	3.2	
2MA1534-1418	15 34 56.93	-14 18 49.2	10.9	± 0.2	0.974	± 0.002	251.1	± 0.2	2.6	
2MA0921-2104	09 21 14.11	-21 04 44.8	11.5	± 0.4	0.941	± 0.003	164.1	± 0.3	2.1	R
LHS1363	02 14 12.56	-03 57 43.6	11.7	± 0.5	0.532	± 0.006	108	± 1	1.9	R
G075-035	02 41 15.14	-04 32 17.8	11.8	± 0.5	0.355	± 0.009	97	± 2	1.8	R
2MA0251-0352	02 51 14.99	-03 52 48.1	11.9	± 0.4	2.154	± 0.003	149.1	± 0.1	2.9	R
2MA2306-0502	23 06 29.21	-05 02 27.9	12.4	± 0.6	1.036	± 0.008	117.9	± 0.9	1.0	R
LP888-018	03 31 30.25	-30 42 38.8	13.4	± 0.7	0.408	± 0.006	172	± 1	1.9	R
LHS5094	04 26 32.65	-30 48 01.9	14	± 1	0.481	± 0.009	188	± 2	1.9	R
G161-071	09 44 54.18	-12 20 54.4	14.3	± 0.6	0.334	± 0.002	276.1	± 0.6	2.3	
LP731-076	10 58 27.99	-10 46 30.5	14.6	± 0.4	0.214	± 0.002	247	± 1	2.1	
LP776-025	04 52 24.39	-16 49 22.0	14.9	± 0.5	0.247	± 0.003	148	± 2	1.3	
2MA0429-3123	04 29 18.43	-31 23 56.7	15.2	± 0.9	0.133	± 0.006	40	± 5	1.9	
LP869-026	19 44 53.80	-23 37 59.4	15.4	± 0.4	0.352	± 0.001	116.8	± 0.4	3.0	
LP834-032	04 35 36.19	-25 27 34.9	17	± 1	0.20	± 0.01	162	± 5	1.0	R
LP889-037	04 08 55.58	-31 28 53.8	17	± 2	0.262	± 0.009	177	± 3	1.9	R
2MA0517-3349	05 17 37.70	-33 49 03.1	17	± 1	0.526	± 0.006	126	± 1	2.3	
LP756-003	20 46 43.64	-11 48 13.3	18	± 2	0.349	± 0.005	102	± 2	1.8	
LP869-019	19 42 00.66	-21 04 05.6	18.1	± 0.6	0.255	± 0.002	165.4	± 0.7	3.0	
LP739-002	13 58 16.18	-12 02 59.1	18.1	± 0.5	0.339	± 0.002	277.0	± 0.4	3.1	
LHS2783	13 42 09.97	-16 00 23.4	19.0	± 0.6	0.502	± 0.002	266.5	± 0.4	3.0	
LP984-092	22 45 00.07	-33 15 26.0	21	± 1	0.216	± 0.002	123	± 1	3.9	
LP870-065	20 04 30.79	-23 42 02.4	21	± 1	0.360	± 0.003	159.7	± 0.8	2.0	
LP717-036	05 25 41.67	-09 09 12.5	20.8	± 0.9	0.200	± 0.001	167.6	± 0.5	3.9	
LHS3056	15 19 11.74	-12 45 06.7	21	± 1	0.762	± 0.002	256.7	± 0.3	3.0	
2MA1507-2000	15 07 27.81	-20 00 43.3	24.3	± 0.4	0.129	± 0.001	121.8	± 0.7	3.1	
LP932-083	22 49 08.41	-28 51 20.1	26	± 5	0.303	± 0.008	221	± 3	1.7	R
LHS2880	14 13 04.86	-12 01 26.9	29	± 1	0.715	± 0.002	237.1	± 0.3	3.1	
LP822-101	23 31 25.04	-16 15 57.8	37	± 3	0.346	± 0.001	137.9	± 0.5	3.9	

Distances

# Preliminary Photometry

Name	V (mag)			R (mag)			I (mag)			Nights
LP876-010	12.60	±	0.01	11.32	±	0.01	9.63	±	0.01	3
LP991-084	14.48	±	0.01	12.969	±	0.007	11.069	±	0.009	3
LHS6167	13.81	±	0.01	12.326	±	0.007	10.42	±	0.01	2
2MA1534-1418	19.19	±	0.05	16.69	±	0.01	14.15	±	0.02	2
LHS1363	16.44	±	0.01	14.705	±	0.007	12.62	±	0.01	2
G075-035	13.79	±	0.01	12.477	±	0.008	10.769	±	0.008	2
2MA2306-0502	18.78	±	0.03	16.52	±	0.01	14.12	±	0.01	2
G161-071	13.76	±	0.01	12.26	±	0.01	10.36	±	0.01	2
LP731-076	14.43	±	0.01	13.055	±	0.007	11.254	±	0.009	2
LP776-025	11.634	±	0.009	10.538	±	0.008	9.117	±	0.008	3
LP869-026	14.10	±	0.01	12.647	±	0.008	10.850	±	0.008	3
LP889-037	14.55	±	0.02	13.21	±	0.01	11.49	±	0.01	1
2MA0517-3349	19.83	±	0.05	17.38	±	0.01	14.96	±	0.01	1
LP756-003	13.74	±	0.03	12.48	±	0.02	10.85	±	0.02	1
LP869-019	13.22	±	0.01	11.931	±	0.009	10.28	±	0.01	3
LP739-002	14.463	±	0.007	13.10	±	0.01	11.38	±	0.02	1
LHS2783	13.39	±	0.02	12.141	±	0.008	10.52	±	0.01	1
LP984-092	13.36	±	0.01	12.064	±	0.009	10.34	±	0.01	2
LP870-065	13.02	±	0.02	11.749	±	0.009	10.10	±	0.01	3
LP717-036	12.58	±	0.01	11.43	±	0.01	9.91	±	0.01	1
LHS3056	12.874	±	0.007	11.629	±	0.009	10.04	±	0.01	2
2MA1507-2000	18.77	±	0.07	16.72	±	0.01	14.30	±	0.01	2
LP932-083	13.88	±	0.03	12.62	±	0.02	10.95	±	0.02	1
LHS2880	13.87	±	0.01	12.540	±	0.007	10.799	±	0.008	3
LP822-101	13.13	±	0.01	11.96	±	0.01	10.41	±	0.01	1

Johnson V band centered on 547.5 nm  
Kron-Cousins R band centered on 642.5 nm  
Kron-Cousins I band centered on 807.5 nm

# Preliminary Spectroscopy

LP876-010	M4.0 V
LP991-084	M4.5 V
LHS6167	M8.0 V
LHS1363	M5.0 V
G075-035	M4.0 V
LP888-018	M8.0 V
LHS5094	M4.5 V
G161-071	M5.0 V
LP731-076	M4.5 V
LP776-025	M3.0 V
2MA0429-3123	M6.0 V
LP869-026	M4.5 V
LP834-032	M3.5 V
LP889-037	M4.5 V
2MA0517-3349	M8.0 V
LP756-003	M4.0 V
LP869-019	M4.0 V
LP739-002	M4.0 V
LP984-092	M4.5 V
LP870-065	M4.0 V
LP717-036	M3.5 V
LP932-083	M4.5 V
LP822-101	M3.5 V

Preliminary types  $\pm 1.0$  subtype  
Final types (expected)  $\pm 0.5$  subtype  
(T. Beaulieu, 2006, private communication)

# Southern Parallax Program

## Astrometric Results

Name	RA	Dec	Distance (pc)	PM (as/yr)	PA (deg)	T (yr)	Mass Limit( $M_{21}$ )	
LHS 1565	03 35 59.72	-44 30 45.5	3.51 ± 0.02	0.8308 ± 0.0004	117.40 ± 0.04	6.3	1.7 ± 0.4	R
LHS 288	10 44 21.24	-61 12 35.6	4.69 ± 0.04	1.6420 ± 0.0006	348.51 ± 0.03	6.8	2.4 ± 0.7	R
LHS 271	09 42 46.36	-68 53 06.1	6.5 ± 0.1	1.1185 ± 0.0006	356.16 ± 0.02	10.0	4.8 ± 0.8	R
LHS 337	12 38 49.10	-38 22 53.7	6.9 ± 0.1	1.4323 ± 0.0009	206.38 ± 0.03	3.3	6 ± 1	R
LHS 34	07 53 08.16	-67 47 31.5	8.5 ± 0.1	2.1026 ± 0.0007	135.80 ± 0.02	6.9	13.9 ± 0.8	R
LHS 1134	00 43 26.01	-41 17 34.0	10.1 ± 0.2	0.7645 ± 0.0007	221.00 ± 0.05	6.0	7 ± 1	R
LHS 532	22 56 24.66	-60 03 49.2	10.6 ± 0.2	1.0743 ± 0.0007	209.67 ± 0.04	7.1	6 ± 1	R
LHS 3064	15 22 12.98	-27 49 42.7	12.1 ± 0.1	0.7290 ± 0.0006	36.12 ± 0.04	8.2	6 ± 1	R
LHS 2310	10 47 38.69	-79 27 45.9	14.1 ± 0.6	0.484 ± 0.001	244.22 ± 0.09	6.7	16 ± 2	R
LHS 3242	16 48 24.49	-72 58 34.1	15.5 ± 0.3	0.7125 ± 0.0005	222.43 ± 0.04	7.1	18 ± 1	R
LHS 2813	13 51 21.75	-53 32 46.0	16.7 ± 0.5	0.5337 ± 0.0005	138.61 ± 0.06	8.2	17 ± 2	R
LHS 3418	18 52 00.17	-60 46 11.3	22.1 ± 0.4	0.7248 ± 0.0006	298.06 ± 0.06	6.4	17 ± 2	R
LHS 2739	13 27 19.59	-31 10 39.7	22.9 ± 0.5	0.5814 ± 0.0005	254.64 ± 0.05	7.1	17 ± 2	R