Chapter 4 Solar Neighborhood Census: Identifying and Characterizing New Nearby Stars

4.1 INTRODUCTION

Distance provides the third dimension to the sky, converting the celestial sphere into a vast, three-dimensional array. It places objects within specific regions and creates the volume-limited samples that underlie the stellar luminosity function, the mass-luminosity relationship, local stellar velocity distribution, and the stellar multiplicity fraction. The resulting understanding of stellar populations, stellar evolution, and star formation history contributes to the larger picture of galactic structure. However, this fundamental parameter of distance is unknown, or at best only estimated, for many stars and most substellar objects. Trigonometric parallax is the only direct means of measuring distances to stars and brown dwarfs, but requires time and patience. It is the method that identifies nearby stars and establishes their membership in the solar neighborhood.

Table 1.2 provides a current listing of seventy-nine objects in forty-nine stellar systems known to lie within 5 parsecs (pc) of the Sun, which implies a density of 0.0936 ± 0.0057 systems pc^{-3}. Extending this density to larger volumes, between 368 and 416 stellar systems should exist within 10 pc of the Sun and between 5,750 and 6,500 systems within 25 pc. However, only 249 stellar systems within 10 pc have been identified (RECONS 2006[11]), leaving between 119 and 167 stellar systems yet to be found. The 25-pc volume appears to be missing about 4,100 systems (Backman *et al.*

2000; Henry *et al*. 2000; hereafter NStars Database[12]). The forty-three possible nearby stars studied herein will eventually account for some of these missing systems.

When a star is identified as belonging to the solar neighborhood, quantifying its fundamental properties increases in importance: spectral type, luminosity, motion, and metallicity. Determining whether it is truly a single star is also necessary. Its discovery may increase the census through the inclusion of stellar, brown dwarf, or planetary companions. Each new companion will also need its own fundamental properties measured. RECONS seeks to identify and thoroughly characterize all the stars within 10 pc. As part of these efforts, the Cerro Tololo Inter-American Observatory (CTIO) Parallax Investigation (CTIOPI) focuses on astrometric, photometric, and spectroscopic observations that identify nearby stars.

The parallax obtained from the astrometric observations will confirm whether these stars are truly part of the solar neighborhood and will clarify their three-dimensional position in space. In conjunction with the distance, the proper motion derived from the astrometric observations will provide the tangential component of the space velocity for each of these stars. CTIOPI stars are usually observed for 2–2.5 years (Jao *et al*. 2005), which is a short-baseline for determining proper motions. This information will help define stellar populations and the stellar velocity distribution, which together provide insight into the star formation history of the Galactic disk.

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[11]"The One Hundred Nearest Star Systems" is available at http://www.chara.gsu.edu/RECONS/TOP100.htm

[12]The NStars Database may be accessed at http://nstars.arc.nasa.gov/index.cfm

The relative parallax and proper motion of each star in this program is measured with respect to a reference frame of between five and fifteen stars, selected in accordance with the general rules adopted for CTIOPI and explained in Jao *et al*. (2005). Ideal reference stars are sufficiently distant to show neither parallax nor proper motion themselves and have apparent brightnesses similar to the possible nearby star. The actual stars selected will have small parallaxes and proper motions over the period of observation. Therefore, a correction to account for the mean distance and motion of the reference frame is necessary to convert the relative parallax and proper motion to an absolute one. Chapter 2 explores several methods of correcting relative values to absolute ones for Barnard's Star. As explained in Jao *et al*. (2005), CTIOPI adopted commonly used broadband photometric distance estimates for the reference stars to correct the relative parallax to absolute. No corrections are made to the proper motions at this time. In addition, the reference stars will not be uniform in color, which causes their apparent positions to change slightly as their light is refracted differently by the atmosphere as a function of hour angle and color. Jao *et al*. (2005) describes the model used by CTIOPI to correct this differential color refraction (DCR).

Photometry in the Johnson V band (V_J, centered on 547.5 nm) and the Kron-Cousins R and I bands (R_{KC} and I_{KC} centered on 642.5 nm and 807.5 nm) combined with an accurate distance will reveal the absolute magnitude of each star in these bands (Jao *et al*. 2005). In addition to providing a fundamental characteristic of each star, photometry is required to ensure the accuracy of the astrometric results. First, the photometry is used to make DCR corrections during the astrometric data reductions.

Then, the photometric distance to each reference star is used to convert a relative parallax to an absolute one.

4.2 SELECTION

Henry *et al*. (1997) describes the RECONS procedure by which the membership of a star in the solar neighborhood is established. Potential nearby stars are identified based on photometric or spectroscopic distances or based on high proper motion. Probable nearby stars have photometric distances based on both optical and near infrared observations plus spectroscopy to eliminate reddened giants. Henry *et al*. (1997) find that photometric distances generally provide better distance estimates than spectroscopy. Proven nearby stars have absolute parallaxes that place them in the solar neighborhood. This CTIOPI subsample seeks to advance possible nearby stars to proven nearby stars, but invested little effort on the intermediate step to establish them as probable nearby stars before proceeding to parallax measurements.

4.2.1 Possible Nearby Stars

The Two Micron All Sky Survey (Skrutskie *et al*. 2006, hereafter 2MASS), the Deep Near Infrared Survey of the Southern Sky (Epchtein *et al*. 1999, hereafter DENIS), and the Sloan Digital Sky Survey (York *et al*. 2000, hereafter SDSS) provide a wealth of new photometric data that can be used alone or in combination with other data sets to identify cool M and L dwarfs. The dim M dwarfs are currently about 70% of the stellar population of the solar neighborhood (Henry *et al*. 1997). The missing members of the solar neighborhood are likely to belong to this class and to the even fainter L class. Because of their inherent low luminosity, these very cool stars and brown dwarfs may have been missed by earlier optical surveys. Programs seeking to identify these stars in the large infrared surveys are an excellent potential source of new possible nearby stars as they frequently include photometric and spectroscopic distance estimates.

An initial list of possible, nearby very low mass stars was compiled from the literature available in 2003 October. The review of literature concentrated on the work of I. N. Reid and collaborators (Reid *et al*. 2003; Cruz *et al*. 2003; Gizis *et al*. 2003; Reid, Kilkenny, & Cruz 2002; Reid & Cruz 2002; Cruz & Reid 2002; Gizis *et al*. 2000) in the proceeding five years. The published details were extracted for any star that the literature indicated was within 25 pc and for which no trigonometric parallax was currently available. The 25-pc limit was selected to match that of the NStars Database and is also the limit of some earlier nearby star catalogs (Woolley *et al*. 1970; Gliese & Jahreiß 1991). No effort was made to include stars with measured distances greater than 25 pc but with associated errors that might bring them within that radius. These stars were supplemented with lists of unpublished brown dwarfs suggested by K. Cruz (2003, private communication).

CTIO is located in the southern hemisphere. CTIOPI can and does observe stars north of the celestial equator (Jao *et al*. 2005; Costa *et al*. 2005). However, 42% of the expected systems are known in the northern hemisphere while only 31% of those expected in the southern hemisphere are known (Henry *et al*. 2002). At the time of sample selection, the United States Naval Observatory was actively measuring parallaxes in the northern hemisphere. Therefore, all stars with declinations greater than

0 degrees (˚) were excluded from the proposed sample. Approximately 305 possible nearby stars were identified this way.

Initially, CTIOPI operated both the 0.9-meter and 1.5-meter CTIO telescopes. In 2002, CTIO canceled the 1.5-meter program. Therefore, the stars in the proposed subsample needed to be bright enough to be observed with the 0.9-meter telescope using integration times no greater than 1,200 seconds (20 minutes). In general, CTIOPI science stars have R_{KC} magnitudes between 9 and 16. Objects fainter than sixteenth magnitude in I band were removed. Because not all stars had published I-band photometry, stars with published V-band magnitudes greater than 15 or J-band magnitudes greater than 13.1 were also eliminated. However, these brightness limits only reduced the proposed sample slightly; about 243 possible nearby stars remained.

To avoid duplicating the University of Virginia Southern Parallax Program (SPP), which is discussed in Chapter 3 and described further in Begam, Ianna, and Patterson (2006, in preparation; hereinafter BIP), the proposed sample was compared with that observing list. All stars on that program with the exception of LP 993-116, LP 888-18, and LHS 2397a were removed. LP 993-116 was excluded subsequently as a wide companion to LP 993-115, which was already included in CTIOPI (Jao *et al.* 2003).

To restrict the proposed sample further and to reduce the possibility of including stars from outside the solar neighborhood, stars with photometric or spectroscopic distance estimates greater than 15 pc were eliminated from the sample. The proposed sample now contained a manageable forty-three possible nearby star systems, which are listed in Table 4.1, including three previously identified binary systems and four members of common proper motion pairs. Throughout this work, 2MASS designations are abbreviated 2MA hhmm-ddmm rather than 2MASS Jhhmmssss-ddmmsss.

4.2.2 Probable Nearby Stars

Ideally, the possible nearby stars would be promoted to probable nearby stars by the acquisition of photometry and spectroscopy to confirm and refine the published distance estimates. Then, the probable nearby stars would be candidates for CTIOPI or other future parallax programs.

Previous experience with spectroscopic and photometric distance estimates from literature has indicated that widely varying values maybe obtained depending on the quality of the relationships and observational data used. Table 4.2 provides a comparison among distances obtained by these methods for three stars, including a common proper motion pair. The distances for BD -44º836 and LP 993-116 (LP 993-15A and B) range from 6.0 to 611 pc and from 5.8 to 1,201 pc, respectively. To improve the photometric and spectroscopic distance estimates available from literature, a spectroscopic distance was calculated based on absolute I-magnitude relationships derived from RECONS stars. T. Henry (2003, private communication) initially provided the plots of absolute I-magnitude versus spectral type and (I-J) color shown in Figure 4.1 and Figure 4.2. Incomplete I and J photometry for the proposed sample of nearby stars made using the latter alone difficult. Rather than rely on values estimated from Figure 4.1, T. Henry (2003, private communication) later provided the data listed in Table 4.3.

TABLE 4.1

PROPOSED SAMPLE OF POSSIBLE NEARBY STARS FOR PARALLAX MEASUREMENT

Star	Alternate Name	Position (2000.0)[a] RA (hh mm ss.s)	Dec (dd mm ss.s)	Apparent Visual[b] Magnitude	Spectral Type	Estimated Distance (pc)	References	Notes[c]
LP 991-84		01 39 21.72	-39 36 09.1	14.517 ± 0.007	…	8 ± 1	1, 2, 2	
LHS 1363	LP 649-72	02 14 12.56	-03 57 43.6	…	M6.5V	10.1 ± 1.4	1, 3, 3	
G 75-35		02 41 15.14	-04 32 17.8	13.800 ± 0.002	M4.0V	11.2 ± 0.8	1, 2, 4, 4	
2MA 0251-0352		02 51 14.99	-03 52 48.1	…	L3	12.1 ± 1.1	1, 3, 3	
LP 888-18	2MA 0331-3042	03 31 30.26	-30 42 38.7	18.26 ± 0.25	M7.5V	12.1 ± 1.2	1, 5, 3, 3	
LP 889-37		04 08 55.58	-31 28 54.0	14.52 ± 0.02	…	13.4 ± 1.0	1, 6, 6	
LHS 5094	LP 890-27	04 26 32.64	-30 48 01.8	14.02 ± 0.02	…	11.0 ± 0.8	1, 6, 6	
2MA 0429-3123		04 29 18.43	-31 23 56.7	…	M7.5V	9.7 ± 0.9	1, 3, 3	binary
LP 834-32		04 35 36.19	-25 27 34.9	12.38 ± 0.02	…	12.0 ± 1.4	1, 6, 6	
LP 655-43		04 38 02.52	-05 56 13.4	14.44 ± 0.02	…	14.7 ± 1.2	7, 6, 6	
LP 716-10		04 52 03.98	-10 58 22.1	15.97[d] ± 0.25	M5.5V	14.3 ± 1.8	7, 5, 4, 4	
LP 776-25		04 52 24.42	-16 49 22.2	11.61 ± 0.02	…	12.4 ± 1.3	1, 6, 6	
2MA 0517-3349	LEHPM 2-0183	05 17 37.70	-33 49 03.1	…	M8V	14.7 ± 1.2	1, 3, 3	
LP 717-36		05 25 41.67	-09 09 12.6	12.56 ± 0.02	…	12.9 ± 1.5	1, 6, 6	
LHS 2024	LP 725-15	08 31 23.45	-10 29 53.8	15.0[e] ± 0.01[f]	M4V	13.9 ± 1.8	8, 9, 10, 11	
LHS 6167		09 15 36.40	-10 35 47.2	13.76 ± 0.02	M4-5	6.7 ± 0.5	1, 6, 12, 6	
2MA 0921-2104		09 21 14.10	-21 04 44.4	…	L2	12.4 …	1, 13, 13	
G 161-71		09 44 54.18	-12 20 54.4	13.73 ± 0.02	M5Ve	6.2 ± 0.5	1, 6, 14, 6	
LP 671-8	G 163-21	10 54 41.97	-07 18 33.1	13.24 ± 0.02	M3-4	13.3 ± 1.8	15, 6, 12, 6	
LP 731-76		10 58 27.99	-10 46 30.5	14.39 ± 0.02	M4-5	11.6 ± 0.8	1, 6, 12, 6	poss cpm pair
LHS 2397a	LP 732-94	11 21 49.19	-13 13 08.5	18.26[d] ± 0.25	M8.5V	12.0[g] ± 2.0	16, 5, 17, 17	binary

TABLE 4.1 (CONTINUED)
PROPOSED SAMPLE OF POSSIBLE NEARBY STARS FOR PARALLAX MEASUREMENT

Star	Alternate Name	Position (2000.0)[a] RA (hh mm ss.s)	Position (2000.0)[a] Dec (dd mm ss.s)	Apparent Visual[b] Magnitude	Spectral Type	Estimated Distance (pc)	References	Notes[c]
2MA 1155-3727		11 55 39.53	-37 27 35.7	…	L2e	12.6 …	18, 19, 13	
LP 734-34		12 10 28.37	-13 10 24.1	13.75 ± 0.02	…	12.9 ± 1.1	5, 6, 6	
LP 615-149		12 27 44.70	-03 15 00.6	12.82 ± 0.02	…	15.0 ± 1.7	15, 6, 6	
LHS 5226	LP 735-29	12 44 00.73	-11 10 30.3	14.18 ± 0.02	…	12.5 ± 0.9	8, 6, 6	
CE 303	2MA 1309-2330	13 09 21.85	-23 30 35.7	…	M8V	13.3 ± 1.1	20, 3, 3	
LHS 2783	LP 798-25	13 42 09.84	-16 00 23.4	13.39 ± 0.02	M4V	13.3 ± 1.8	1, 6, 10, 6	binary
LP 739-2		13 58 16.18	-12 02 59.1	14.41 ± 0.02	…	13.8 ± 1.0	1, 6, 6	
LHS 2880	GJ 540.2	14 13 04.86	-12 01 26.8	13.83 ± 0.02	M4.5V	9.8 ± 0.7	1, 6, 10, 6	
2MA 1507-2000		15 07 27.81	-20 00 43.3	…	M7.5V	14.2 ± 1.4	1, 3, 3	
LHS 3056	LP 742-61	15 19 11.72	-12 45 06.5	12.84 ± 0.02	M4V	11.6 ± 1.3	1, 6, 10, 6	
2MA 1534-1418		15 34 56.93	-14 18 49.2	…	M8V	13.5 …	1, 19, 13	
LP 869-19		19 42 00.66	-21 04 05.6	13.210 ± 0.020	…	10 ± 1	1, 2, 2	
LP 869-26		19 44 53.80	-23 37 59.4	14.078 ± 0.016	…	9 ± 1	1, 2, 2	poss new binary
LP 870-65		20 04 30.79	-23 42 02.4	13.0 ± 0.3	…	10 ± 2	1, 2, 2	
LP 756-3		20 46 43.64	-11 48 13.3	13.762 ± 0.024	M5-6	14 ± 2	1, 2, 21, 2	
LP 984-92		22 45 00.07	-33 15 26.0	13.381 ± 0.026	…	8 ± 1	1, 2, 2	poss cpm pair
LP 876-10		22 48 04.50	-24 22 07.8	12.618 ± 0.012	…	7.2 ± 0.8	1, 2, 2	
LP 932-83		22 49 08.41	-28 51 20.1	13.93 ± 0.02	…	14.1 ± 2.4	1, 22, 11	poss cpm pair
2MA 2306-0502[h]		23 06 29.36	-05 02 29.2	…	M7.5V	11.3 ± 2.0	1, 3, 17	
LP 822-101		23 31 25.04	-16 15 57.8	13.122 ± 0.000	…	15 ± 2	1, 2, 2	
2MA 2351-2537	LEHPM 1-6334	23 51 50.48	-25 37 36.5	…	L1	13.2 …	23, 13, 13	

TABLE 4.1 (CONTINUED)
PROPOSED SAMPLE OF POSSIBLE NEARBY STARS FOR PARALLAX MEASUREMENT

Star	Alternate Name	Position (2000.0)[a] RA (hh mm ss.s)	Dec (dd mm ss.s)	Apparent Visual[b] Magnitude	Spectral Type	Estimated Distance (pc)	References	Notes[c]
LP 704-15	G 273-186	23 57 20.59	-12 58 48.7	12.93 ± 0.02	M3V	13.2 ± 1.7	15, 24, 10, 11	poss cpm pair

NOTES.—[a]Coordinates from 2MASS updated with proper motion from the listed reference using addpm routine (25)

[b]Apparent visual magnitude (V_{JM}) on the Johnson-Morgan system (26, 27) with V=550 nm

[c]"poss cpm pair" identifies one member of a possible common proper motion pair; the other star is identified in 4.6.

[d](5) was not consulted during the initial compilation of possible nearby stars. If it had been, this star would have been excluded as too faint.

[e]V_{Eggen} is substantially the same as V_{JM} according to (28).

[f]Photometric error estimated from (29).

[g]Further investigation of the literature revealed an absolute trigonometric parallax for LHS 2397a of 70 ± 2 mas (30).

[h]CTIOPI also observed this star with the 1.5-meter telescope and measured an absolute parallax is 82.6 ± 2.6 mas (31).

REFERENCES.—(1) this work, see section 4.3 and Table 4.6; (2) Reid *et al*. 2003; (3) Cruz *et al*. 2003; (4) Cruz & Reid 2002; (5) Salim & Gould 2003; (6) Reid, Kilkenny, & Cruz 2002; (7) *NLTT*; (8) Bakos, Sahu, & Nemeth 2002; (9) Eggen 1987; (10) Reid, Hawley, & Gizis 1995; (11) Reid & Cruz 2002; (12) Gigoyan, Hambaryan, & Azzopardi 1998; (13) K. I. Cruz 2003, private communication; (14) Torres *et al*. 2000; (15) Giclas, Burnham, & Thomas 1978; (16) Tinney 1996; (17) Gizis *et al*. 2000; (18) Deacon, Hambly, & Cooke 2005; (19) Gizis 2002; (20) Lodieu *et al*. 2005; (21) Abrahamyan *et al*. 1997; (22) Ryan 1992; (23) Pokorny, Jones, & Hambly 2003; (24) Weis 1991; (25) Jao 2004; (26) Johnson & Morgan 1951; (27) Johnson & Morgan 1953; (28) Bessell & Weis 1987; (29) Ryan 1989; (30) Monet *et al*. 1992; (31) Costa *et al*. 2006

TABLE 4.2

COMPARISON OF DISTANCE ESTIMATES

		Photometric Distances (pc)			Other Distances (pc)			
Star	Alternate Name	RECONS 1998	Non-RECONS	RECONS 2003	RECONS Spectroscopic	Relative or Absolute Parallax[a]		References
BD -44º836	LP 993-115A	611	10.5 ± 1.2	9.8	6.0 ± 2.1	10.7 ± 0.4	pr	1,2,3,4,3
LP 993-116	LP 993-115B	1201	7 ± 0.6	9.8	5.8 ± 2.0	10.7 ± 0.3	pr	1,2,3,4,3
LHS 2397a		…	12.0 ± 2.0	…	12.2 ± 3.5	14.3 ± 0.4	a	5,4,6

NOTE.—[a] A "pr" indicates a preliminary, relative parallax was used. An "a" indicates a final absolute parallax was used.

REFERENCES.—(1) Patterson, Ianna, & Begam 1998; (2) Reid, Kilkenny, & Cruz 2002; (3) T. Henry 2003, private communication (4) method discussed in 4.2.2; (5) Gizis *et al*. 2000; (6) Monet *et al*. 1992

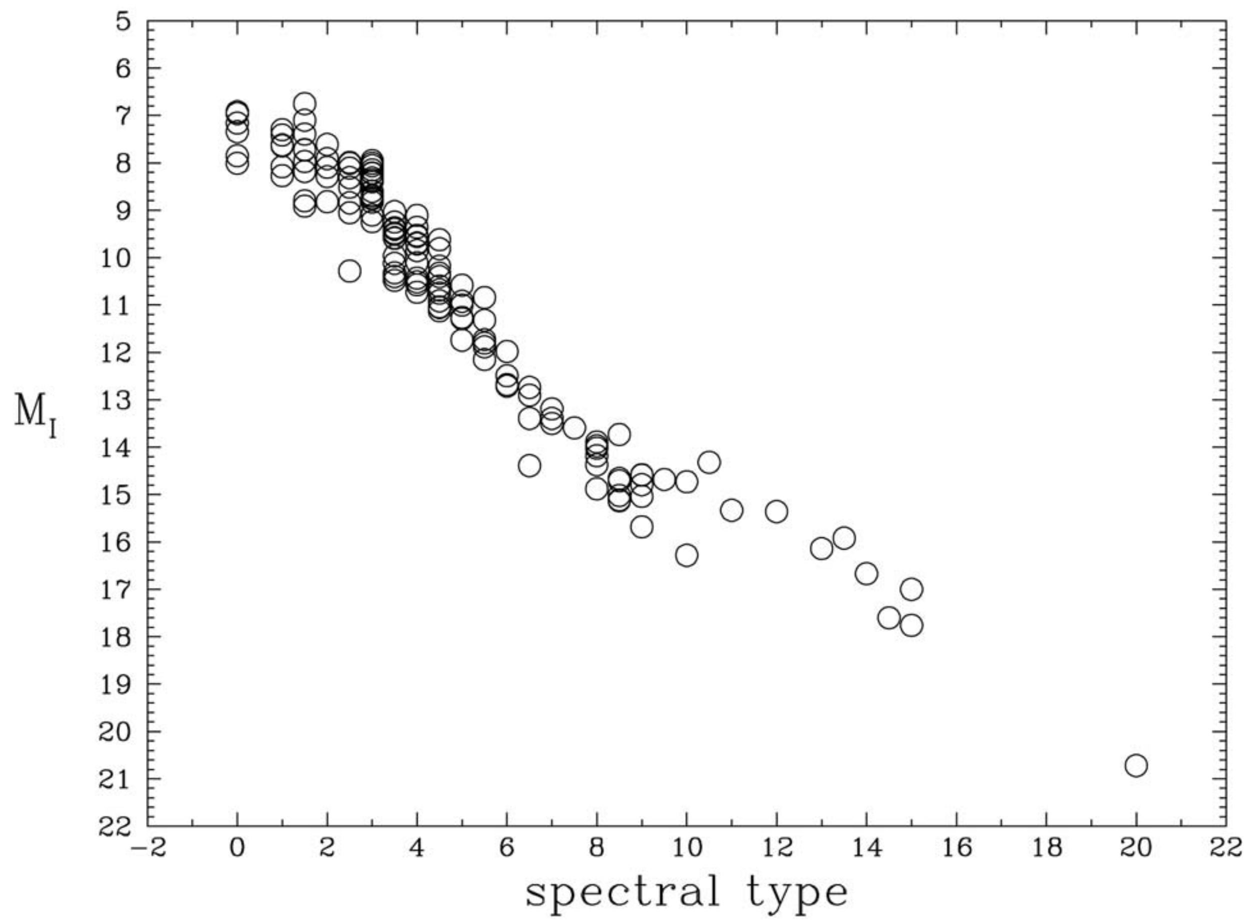

FIG. 4.1.— Absolute I-Magnitude versus Spectral Type (T. Henry 2003, private communication).

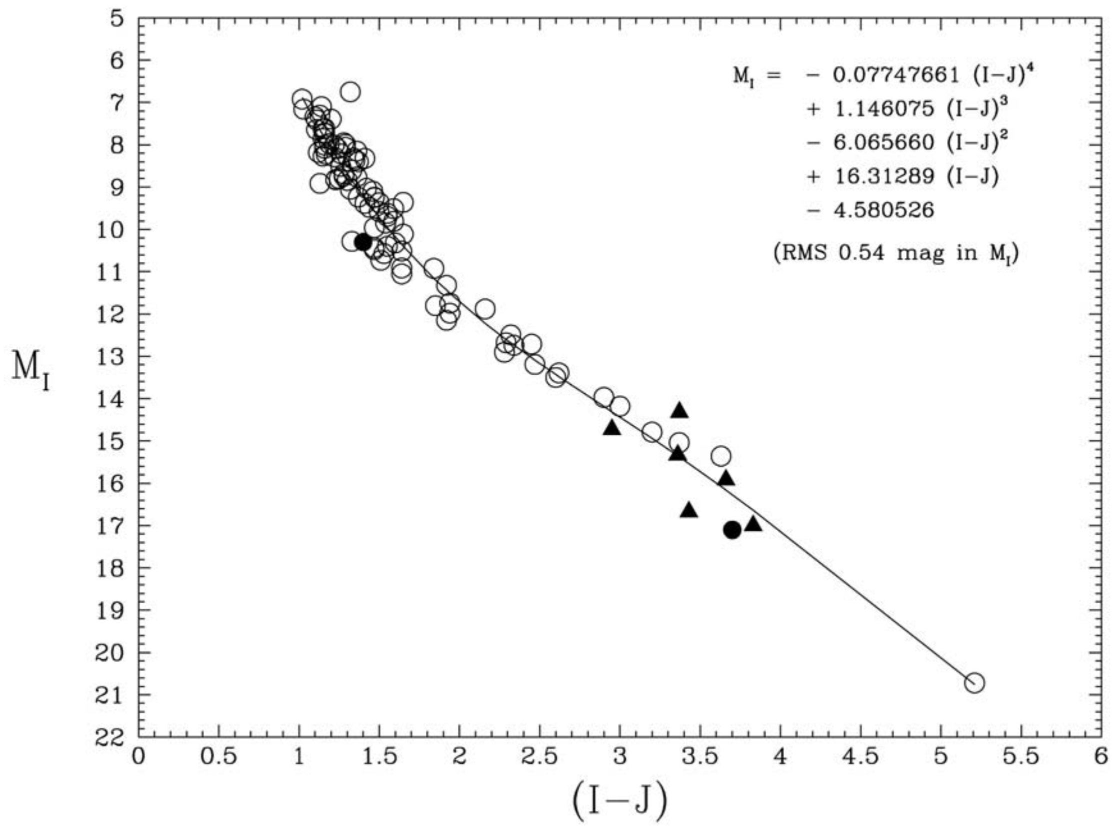

FIG. 4.2.— Absolute I-Magnitude versus (I-J) Color for Known Nearby Stars. Open circles are main sequence stars; filled circles are possibly subdwarfs; and filled triangles are possibly brown dwarfs (T. Henry 2003 & 2006, private communication).

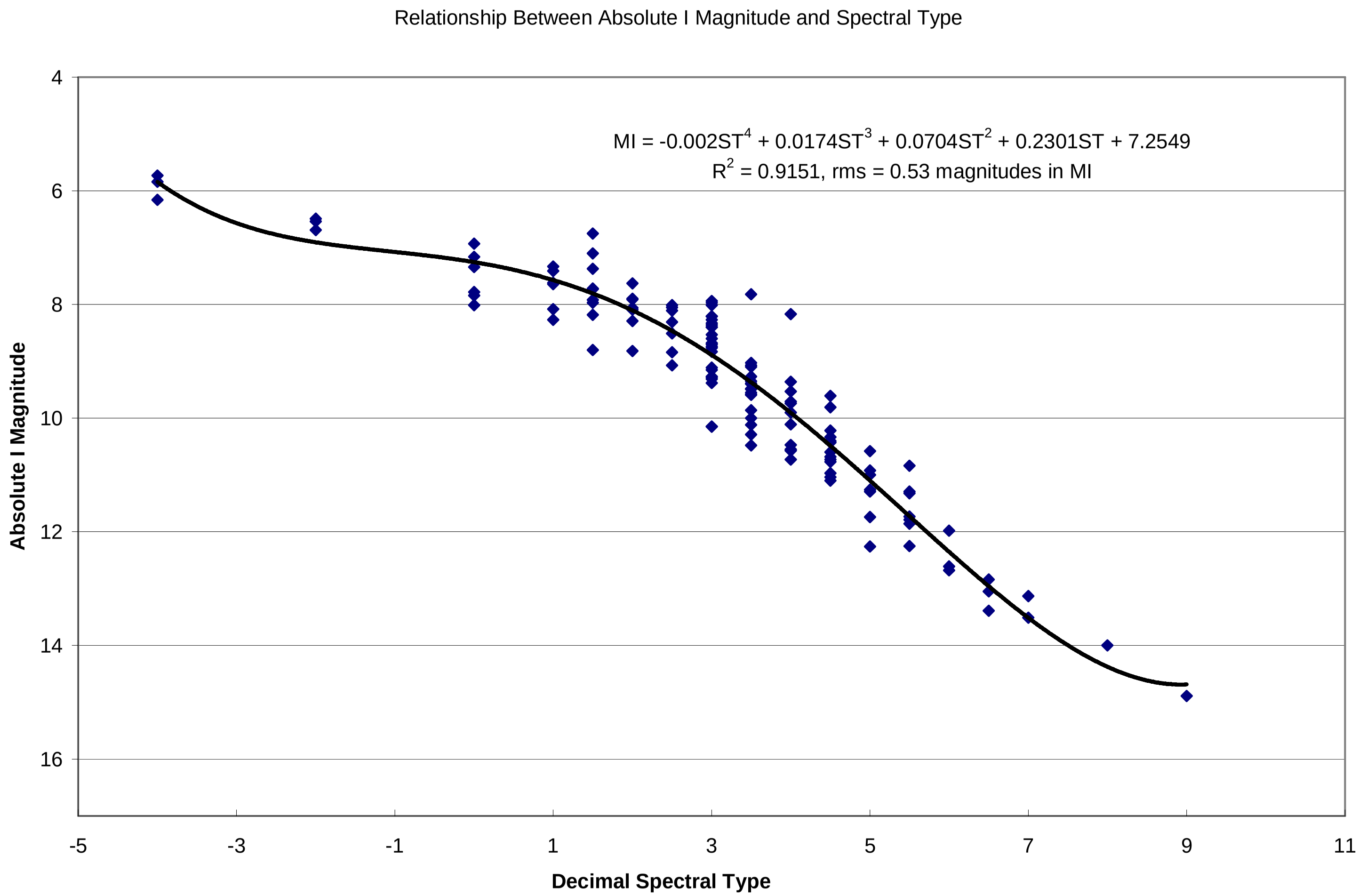

FIG. 4.3.— Absolute I-Magnitude versus Spectral Type for Known Nearby Files. Plot is based on data in Table 4.3, which was provided by T. Henry (2003, private communication).

TABLE 4.3

NEARBY STAR DATA FOR SPECTROSCOPIC AND PHOTOMETRIC DISTANCE ESTIMATES (1)

Star (GJ)	Alternate Name	Spectral Type		M_I (mag)	I-J (mag)	I-H (mag)	I-K (mag)	J-H (mag)	J-K (mag)	H-K (mag)	Comments
1		M3.0	V	8.21	1.08	…	1.89	…	0.81	…	
15 A		M1.5	V	8.18	…	…	1.92	…	…	…	
15 B		M3.5	V	10.48	1.45	2.05	2.29	0.6	0.84	0.24	41” visible orbit (2)
17		F9	V	3.9	…	…	…	…	…	…	
33		K2	V	5.4	…	…	…	…	…	…	
48		M2.5	V	8.01	1.27	1.87	2.12	0.6	0.85	0.25	
54.1		M4.5	V	11.1	1.69	2.2	2.53	0.51	0.84	0.33	
71		G8	Vp	4.86	…	…	…	…	…	…	
83.1		M4.5	V	10.97	1.7	2.24	2.56	0.54	0.87	0.32	
84		M3.0	V	7.97	1.3	1.94	2.18	0.64	0.88	0.24	
102		M4.0	V	10.11	1.59	2.15	2.43	0.56	0.85	0.29	
105 B		M3.5	V	9.58	1.55	2.09	2.31	0.54	0.76	0.22	165” visible orbit (3)
109		M3.0	V	8.7	1.36	1.91	2.15	0.55	0.79	0.24	
137		G5	Ve	4.29	…	…	…	…	…	…	
139		G5	V	4.56	…	…	…	…	…	…	
144	ε Eridani	K2	V	5.25	…	…	…	…	…	…	cold dust
166 A		K1	Ve	5.03	…	…	…	…	…	…	
166 C		M4.5	V	9.81	1.57	2.04	2.36	0.47	0.79	0.32	7” visible orbit (3)
169.1 A		M4.0	V	9.53	…	…	…	…	…	…	possibly corrupted by B in 2MASS
176		M2.0	V	7.91	1.27	1.91	2.12	0.64	0.86	0.22	
178		F6	V	3.13	…	…	…	…	…	…	
183		K3	V	5.4	…	…	…	…	…	…	

TABLE 4.3 (CONTINUED)

NEARBY STAR DATA FOR SPECTROSCOPIC AND PHOTOMETRIC DISTANCE ESTIMATES (1)

Star (GJ)	Alternate Name	Spectral Type	M_I (mag)	I-J (mag)	I-H (mag)	I-K (mag)	J-H (mag)	J-K (mag)	H-K (mag)	Comments
190		M3.5 V	7.82	1.49	2.08	2.36	0.58	0.86	0.28	
203		M3.5 V	9.86	1.49	1.96	2.26	0.47	0.77	0.3	
205		M1.5 V	7.1	…	…	…	…	…	…	
213		M4.0 V	9.9	1.62	2.11	2.35	0.5	0.74	0.24	
216 A		F6 V	3.26	…	…	…	…	…	…	19’ possible cpm companion (3)
216 B		K2 V	5.4	…	…	…	…	…	…	96” visible orbit (3)
226		M2.5 V	8.31	1.31	1.89	2.12	0.57	0.81	0.23	
229 A		M1.0 V	7.33	1.04	…	…	…	…	…	
232		M4.0 V	10.57	1.52	…	2.27	…	0.75	…	
239		M0.0 V	7.78	1.08	1.72	1.89	0.64	0.81	0.17	
244 A	Sirius	A1 V	1.49	…	…	…	…	…	…	
250 A		K3 V	5.74	…	…	1.34	…	…	…	
250 B		M2.5 V	8.11	1.24	…	2.1	…	0.86	…	58” visible orbit (3)
251		M3.0 V	8.76	1.39	1.96	2.21	0.58	0.83	0.25	
273		M3.5 V	9.27	1.45	…	2.3	…	0.86	…	
283 B		M6.0 V	12.68	2.28	2.8	3.14	0.53	0.86	0.34	21” visible orbit (3)
285		M4.0 V	9.36	1.66	2.23	2.54	0.58	0.88	0.31	
299		M4.0 V	10.73	1.48	1.97	2.24	0.5	0.76	0.27	
358		M3.0 V	8.4	1.39	1.97	2.23	0.58	0.85	0.26	
380		K7.0 V	6.54	…	…	…	…	…	…	
382		M2.0 V	7.63	1.22	1.85	2.1	0.63	0.87	0.24	

TABLE 4.3 (CONTINUED)

NEARBY STAR DATA FOR SPECTROSCOPIC AND PHOTOMETRIC DISTANCE ESTIMATES (1)

Star (GJ)	Alternate Name	Spectral Type	M_I (mag)	I-J (mag)	I-H (mag)	I-K (mag)	J-H (mag)	J-K (mag)	H-K (mag)	Comments
388		M3.0 V	8.36	1.36	1.97	2.22	0.61	0.86	0.25	
393		M2.0 V	8.09	1.22	1.8	2.09	0.57	0.87	0.29	
406		M6.0 V	12.61	2.41	3.02	3.42	0.6	1	0.4	
408		M2.5 V	8.51	1.32	1.87	…	0.55	…	…	
411		M2.0 V	8.29	…	…	…	…	…	…	
412 A		M1.0 V	8.27	1.16	1.7	1.93	0.54	0.77	0.23	
412 B		M5.5 V	12.25	1.94	2.5	2.84	0.56	0.9	0.34	28” visible orbit (3)
424		M1.0 V	7.64	1.12	1.7	1.9	0.58	0.77	0.2	
432 A		K0 V	5.19	…	…	1.07	…	…	…	
433		M2.0 V	7.9	1.22	1.83	2.07	0.62	0.85	0.23	possible brown dwarf companion (4)
442 A		G5 V	4.33	…	…	…	…	…	…	
445		M3.5 V	9.48	1.41	1.91	2.18	0.51	0.77	0.26	
447		M4.0 V	10.55	1.66	2.22	2.52	0.56	0.85	0.29	
450		M1.5 V	7.97	1.22	1.81	2.03	0.59	0.81	0.22	
465		M3.0 V	9.27	1.28	1.76	2.06	0.49	0.78	0.3	
479		M3.0 V	8.33	1.38	1.95	2.22	0.58	0.84	0.26	
480.1		M3.0 V	10.15	1.4	1.92	2.21	0.51	0.8	0.29	
486		M3.0 V	9.11	1.49	2.01	2.32	0.53	0.83	0.3	
493.1		M4.5 V	10.73	1.73	2.31	2.62	0.59	0.89	0.31	
506		G6 V	4.31	…	…	…	…	…	…	
514		M1.0 V	7.62	1.11	1.71	1.97	0.6	0.87	0.26	

TABLE 4.3 (CONTINUED)

NEARBY STAR DATA FOR SPECTROSCOPIC AND PHOTOMETRIC DISTANCE ESTIMATES (1)

Star (GJ)	Alternate Name	Spectral Type	M_I (mag)	I-J (mag)	I-H (mag)	I-K (mag)	J-H (mag)	J-K (mag)	H-K (mag)	Comments
526		M1.5 V	7.72	1.21	…	1.97	…	0.77	…	
551	Proxima Centauri	M5.5 V	11.86	2.07	…	3.05	…	0.97	…	7,849" visible orbit (3)
555		M3.5 V	9.55	1.65	2.23	2.55	0.58	0.9	0.32	
559 A	α Centauri A	G2 V	3.69	…	…	…	…	…	…	
559 B	α Centauri B	K0 V	4.83	…	…	…	…	…	…	18" visible orbit (5)
581		M2.5 V	9.07	1.35	1.97	2.22	0.61	0.87	0.26	
588		M2.5 V	8.05	1.27	1.89	2.16	0.62	0.89	0.27	
595		M3.0 V	9.38	1.42	1.92	2.17	0.5	0.75	0.25	
609		M4.0 V	9.74	1.6	2.08	2.36	0.48	0.76	0.28	
618 A		M3.0 V	8.53	1.37	1.94	2.21	0.57	0.84	0.27	
618 B		M5.5 V	11.29	…	…	…	…	…	…	9" visible orbit (3)
625		M1.5 V	8.8	1.28	1.83	2.06	0.54	0.77	0.23	
628		M3.0 V	9.28	1.47	2.05	2.35	0.58	0.88	0.3	
631		K0 Ve	4.94	…	…	…	…	…	…	
643		M3.5 V	10	1.5	…	2.33	…	0.83	…	72" visible orbit (3)
644 C	VB 8	M7.0 V	13.13	2.4	2.98	3.36	0.57	0.96	0.39	221" visible orbit (3)
664		K5 Ve	6.16	…	…	…	…	…	…	732" visible orbit, poss. RV variable (3)
667 C		M2.5 V	8.84	1.29	1.82	2.1	0.53	0.81	0.29	31" visible orbit (3)
673		K7.0 V	6.49	1	1.59	…	0.59	…	…	
674		M3.0 V	8.68	1.26	1.82	2.11	0.56	0.86	0.3	
678.1		M1.0 V	7.41	1.16	1.75	1.98	0.59	0.82	0.23	

TABLE 4.3 (CONTINUED)

NEARBY STAR DATA FOR SPECTROSCOPIC AND PHOTOMETRIC DISTANCE ESTIMATES (1)

Star (GJ)	Alternate Name	Spectral Type	M_I (mag)	I-J (mag)	I-H (mag)	I-K (mag)	J-H (mag)	J-K (mag)	H-K (mag)	Comments
680		M1.5 V	7.92	1.21	1.8	2.05	0.59	0.84	0.25	
682		M4.5 V	9.61	1.57	2.19	2.5	0.63	0.94	0.31	
686		M0.0 V	8.01	1.19	1.76	1.98	0.57	0.79	0.22	
687		M3.0 V	8.4	1.34	1.91	2.13	0.57	0.79	0.22	
693		M3.5 V	9.35	1.33	1.88	2.16	0.56	0.84	0.28	
694		M3.0 V	8.21	1.29	1.88	2.14	0.59	0.85	0.26	
699		M4.0 V	10.47	1.55	1.96	2.27	0.41	0.72	0.31	
701		M0.0 V	7.84	1.14	1.73	1.99	0.59	0.85	0.26	
721	Vega	A0 V	0.59	…	…	…	…	…	…	cold dust
725 A		M3.0 V	8.74	1.29	1.74	2.05	0.45	0.76	0.31	
725 B		M3.5 V	9.39	1.41	1.93	2.13	0.52	0.72	0.2	16” visible orbit, poss. RV variable (3)
729		M3.5 V	10.29	1.43	1.99	2.28	0.57	0.85	0.29	
745 A		M3.0 V	8.83	1.24	…	2.02	…	0.77	…	
745 B		M2.0 V	8.82	1.25	…	2.01	…	0.76	…	115” visible orbit (3)
752 A		M3.0 V	7.94	…	1.85	2.11	…	…	0.26	
752 B	VB 10	M8.0 V	14	2.93	3.61	4.07	0.68	1.14	0.46	74” visible orbit (3)
780		G8 V	3.86	…	…	…	…	…	…	
784		M0.0 V	7.16	1	…	1.84	…	0.84	…	
785		K0 V	5.07	…	…	…	…	…	…	
793		M3.0 V	8.6	1.37	1.97	2.18	0.6	0.8	0.2	
803		M1.5 V	6.75	1.28	1.89	2.19	0.61	0.91	0.3	

TABLE 4.3 (CONTINUED)
NEARBY STAR DATA FOR SPECTROSCOPIC AND PHOTOMETRIC DISTANCE ESTIMATES (1)

Star (GJ)	Alternate Name	Spectral Type	M_I (mag)	I-J (mag)	I-H (mag)	I-K (mag)	J-H (mag)	J-K (mag)	H-K (mag)	Comments
809		M0.0 V	7.34	1.15	…	1.96	…	0.81	…	
820 B		K7.0 V	6.69	…	…	…	…	…	…	29” visible orbit (6)
825		M0.0 V	6.93	…	…	…	…	…	…	
827		F8 V	3.79	…	…	…	…	…	…	
832		M3.0 V	8.01	1.12	…	1.97	…	0.85	…	
845	ε Indi	K5 Ve	5.73	…	…	…	…	…	…	
849		M4.0 V	8.17	1.37	1.98	2.29	0.61	0.92	0.31	
867 B		M3.5 V	9.1	1.44	…	2.29	…	0.85	…	24” visible orbit (3)
873		M3.5 V	9.03	1.44	2	2.25	0.55	0.81	0.26	
876 A		M3.5 V J	9.07	1.5	2.08	2.42	0.59	0.92	0.34	
877		M3.0 V	8.27	1.33	1.87	2.14	0.53	0.81	0.27	
879		K5 Ve	5.84	0.73	…	…	…	…	…	7,060” visible orbit (3)
880		M1.5 V	7.37	1.19	1.75	2.03	0.56	0.84	0.28	
881	Fomalhaut	A3 V	1.65	…	…	…	…	…	…	cold dust
884		<K5.0 V	6.68	0.88	…	1.75	…	0.87	…	
887		M1.5 V	7.73	…	…	…	…	…	…	
905		M5.5 V	11.32	1.94	2.57	2.89	0.64	0.95	0.32	
908		M1.0 V	8.08	1.12	1.67	1.91	0.55	0.78	0.24	
1002		M5.5 V	11.79	1.83	2.36	2.71	0.53	0.88	0.35	
1057		M5.0 V	10.92	1.81	2.37	2.75	0.57	0.94	0.38	
1065		M3.0 V	10.15	1.47	…	2.29	…	0.82	…	

TABLE 4.3 (CONTINUED)

NEARBY STAR DATA FOR SPECTROSCOPIC AND PHOTOMETRIC DISTANCE ESTIMATES (1)

Star (GJ)	Alternate Name	Spectral Type	M_I (mag)	I-J (mag)	I-H (mag)	I-K (mag)	J-H (mag)	J-K (mag)	H-K (mag)	Comments
1093		M5.0 V	11.74	2.03	2.64	2.96	0.61	0.93	0.32	
1105		M4.0 V	9.71	1.51	2.11	2.36	0.6	0.86	0.26	
1111		M6.5 V	12.84	2.41	3.02	3.38	0.62	0.97	0.36	
1125		M3.0 V	9.15	1.43	1.95	2.26	0.51	0.83	0.31	
1138		M4.5 V	10.22	1.62	2.12	2.42	0.49	0.79	0.3	
1151		M4.5 V	10.6	1.68	2.22	2.53	0.54	0.85	0.32	
1154		M5.5 V	10.84	1.99	2.59	2.91	0.6	0.92	0.32	
1156		M5.0 V	11.26	1.82	2.46	2.77	0.64	0.95	0.31	
1224		M4.5 V	11.04	1.79	2.35	2.6	0.55	0.81	0.26	
1227		M4.5 V	10.77	1.71	2.3	2.61	0.59	0.9	0.3	
1235		M4.5 V	10.43	1.63	2.21	2.5	0.58	0.86	0.28	
1245 B		M6.0 V	11.98	2	2.54	2.88	0.55	0.89	0.34	8" visible orbit (7)
1253		M5.0 V	11	1.81	…	2.74	…	0.93	…	
1256		M4.5 V	10.4	1.72	2.28	2.61	0.57	0.89	0.33	
1286		M5.5 V	11.73	1.88	2.52	2.85	0.64	0.97	0.32	
1289		M3.5 V	10.12	1.55	2.21	2.43	0.66	0.88	0.22	
2066		M2.0 V	8.06	1.24	1.82	2.09	0.59	0.86	0.27	
3325	LHS 1731	M3.0 V	9.31	1.33	1.91	2.21	0.58	0.88	0.31	
3378	LHS 1805	M3.5 V	9.59	1.52	2.04	2.35	0.52	0.83	0.31	
3380	LHS 1809	M5.0 V	11.29	1.78	2.36	2.69	0.58	0.91	0.33	
3421	LHS 224	M4.5 V	10.33	1.61	2.06	2.37	0.44	0.76	0.32	

TABLE 4.3 (CONTINUED)

NEARBY STAR DATA FOR SPECTROSCOPIC AND PHOTOMETRIC DISTANCE ESTIMATES (1)

Star (GJ)	Alternate Name	Spectral Type	M_I (mag)	I-J (mag)	I-H (mag)	I-K (mag)	J-H (mag)	J-K (mag)	H-K (mag)	Comments
3517	LHS 2065	M9.0 V	14.89	3.33	4.07	4.6	0.74	1.27	0.53	
3622	LHS 292	M6.5 V	13.05	2.47	3.07	3.4	0.59	0.93	0.34	
3801	LHS 2784	M3.5 V	9.49	1.48	2.06	2.29	0.58	0.81	0.23	
3855	LHS 2930	M6.5 V	13.39	2.52	3.17	3.52	0.65	1	0.35	
3877	LHS 3003	M7.0 V	13.51	2.56	3.22	3.6	0.65	1.04	0.39	
3959	G 180-060	M5.0 V	12.26	1.83	2.42	2.78	0.59	0.96	0.36	
3988	LHS 3262	M5.0 V	10.58	1.7	2.28	2.55	0.57	0.85	0.27	
4247	G 188-038	M3.5 V	9.4	1.52	2.12	2.38	0.6	0.86	0.26	
4274	LHS 3799	M4.5 V	10.68	1.8	2.4	2.72	0.6	0.92	0.32	

NOTE.—"cpm" is "common proper motion" and "poss. RV variable" is "possible radial velocity variable."

REFERENCES.—(1) T. Henry 2003, private communication; (2) Lippincott 1972; (3) Gliese 1969; (4) Bernstein 1997; (5) Heintz 1982; (6) Josties & Harrington 1984; (7) Gliese 1979

From Table 4.3, the 132 stars later than K4V were used to plot absolute I-magnitude (M_I) against spectral type (Sp), as shown in Figure 4.3. A fourth-order polynomial in spectral type was fitted to the data as follows

$$M_I = -0.002\,ST^4 + 0.0174\,ST^3 + 0.0704\,ST^2 + 0.2301\,ST + 7.2549 \qquad (4.1)$$

where spectral type is expressed as a decimal value. The Pearson product moment correlation coefficient (r^2) associated with this fit is 0.9151; a value of 1.0 would indicate complete correlation. The error associated with this fit is 0.53 magnitudes.

First, the absolute I-magnitude was calculated for each possible nearby star in the proposed sample for which a spectral type was available using Equation 4.1. Then, the (I-J) color was estimated from Figure 4.2 and

$$M_I = -0.07747661(I-J)^4 + 1.146075(I-J)^3 - 6.065660(I-J)^2 + 16.31289(I-J) - 4.580526 \qquad (4.2)$$

(T. Henry 2003, private communication) using the absolute I-magnitude obtained earlier. The error associated with this fit is 0.54 magnitudes. Adding 2MASS J (1.235 μm; Cohen, Wheaton, & Megeath 2003) to the (I-J) color provided an estimate of the apparent I-magnitude (m_I). At the time of selection, only the second incremental data release of the 2MASS point source catalog was available (Skrutskie *et al.* 1997). For the nearest stars, reddening should not play a significant factor. Therefore, the distance modulus formula

$$m_I - M_I = 5\ \log(d_{sp}) - 5 \qquad (4.3)$$

can be used to estimate a spectroscopic distance (d_{sp}). Table 4.4 lists the distance estimates obtained in this manner. The formal errors indicate that these distances

TABLE 4.4

COMPARISON OF DISTANCE ESTIMATES FOR POSSIBLE NEARBY STARS

Star	Spectral Type	Distance Estimates (pc) Literature[b]	Distance Estimates (pc) Spectroscopic[c]	Parallactic Distances (pc)[d]	Type[e]	Ratios[a] L	Ratios[a] S	References	Comment
LP 991-84	…	8 ± 1	…	8.64 ± 0.24	r	1.1	…	1	
LHS 1363	M6.5V	10.1 ± 1.4	9.8 ± 3.1	12.42 ± 0.60	r	1.2	1.3	2	
G 75-35	M4.0V	11.2 ± 0.8	14.6 ± 5.1	11.83 ± 0.54	r	1.1	0.8	3	
2MA 0251-0352	L3	12.1 ± 1.1	1200 ± 1800	12.7 ± 1.2	r	1.0	…	2	poor spectroscopic estimate
LP 888-18	M7.5V	12.1 ± 1.2	11.1 ± 3.3	13.44 ± 0.70	r	1.1	1.2	2	
LP 889-37	…	13.4 ± 1.0	…	16.9 ± 1.6	r	1.3	…	4	
LHS 5094	…	11.0 ± 0.8	…	14.0 ± 1.0	r	1.3	…	4	
2MA 0429-3123	M7.5V	9.7 ± 0.9	8.9 ± 2.7	15.14 ± 0.89	a	1.6	1.7	2	binary, see also Table 4.16
LP 834-32	…	12.0 ± 1.4	…	16.5 ± 1.4	r	1.4	…	4	
LP 655-10	M4.5V	18.7 ± 3.7	15.3 ± 5.4	…	…	…		5, 6	see also Table 4.14
LP 716-10	M5.5V	14.3 ± 1.8	14.3 ± 4.9	…	…	…		3	see also Table 4.14
LP 776-25	…	12.4 ± 1.3	…	14.1 ± 2.2	r	1.1	…	4	
2MA 0517-3349	M8V	14.7 ± 1.2	13.4 ± 3.9	17.1 ± 1.3	a	1.2	1.3	2	
LP 717-36	…	12.9 ± 1.5	…	18.4 ± 1.2	r	1.4	…	4	
LHS 2024	M4V	13.9 ± 1.8	21.9 ± 7.7	…	…	…		7, 8	see also Table 4.14
LHS 6167	M4.5	6.7 ± 0.5	9.1 ± 4.2	9.73 ± 0.28	a	1.5	1.1	9, 4	M4-5 in source
2MA 0921-2104	L2	12.4 …	120 ± 110	11.48 ± 0.35	r	0.9	…	10	poor spectroscopic estimate
G 161-71	M5Ve	6.2 ± 0.5	7.0 ± 2.4	14.16 ± 0.56	a	2.3	2.0	11, 4	
LP 671-8	M3.5	13.3 ± 1.8	15.3 ± 6.6	…	…	…		9, 4	M3-4 in source
LP 731-76	M4.5	11.6 ± 0.8	13.9 ± 6.4	14.42 ± 0.53	a	1.2	1.0	9, 4	M4-5 in source
BD -10°3166[f]	K0V	< 200	> 9000	50 ± 29	a	…		12	poor spectroscopic estimate
LHS 2397a	M8.5V	12 ± 2	12.2 ± 3.5	14.29 ± 0.42	a	1.2	1.2	13, 13, 14	binary

TABLE 4.4 (CONTINUED)
COMPARISON OF DISTANCE ESTIMATES FOR POSSIBLE NEARBY STARS

Star	Spectral Type	Distance Estimates (pc) Literature[b]	Distance Estimates (pc) Spectroscopic[c]	Parallactic Distances (pc)[d]	Type[e]	Ratios[a] L	Ratios[a] S	References	Comment
2MA 1155-3727	L2	12.6 …	120 ± 210	…	…	…		15, 10	poor spectroscopic estimate
LP 734-34	M4.0V	15.4 ± 3.1	15.3 ± 5.4	…	…	…		5, 6	see also Table 4.14
CE 303	M8V	13.3 ± 1.1	12.0 ± 3.5	…	…	…		2	
LHS 2783	M4V	13.3 ± 1.8	13.4 ± 4.7	19.6 ± 1.2	r	1.5	1.5	8, 4	binary
LP 739-2	…	13.8 ± 1.0	…	17.3 ± 1.1	r	1.3	…	4	
LHS 2880	M4.5V	9.8 ± 0.7	11.2 ± 4.0	25.8 ± 2.2	a	2.6	2.3	7, 4	
2MA 1507-2000	M7.5V	14.2 ± 1.4	13.0 ± 3.9	22.8 ± 1.7	a	1.6	1.8	2	
LHS 3056	M4V	11.6 ± 1.3	10.5 ± 3.7	19.10 ± 0.71	a	1.6	1.8	7, 4	
2MA 1534-1418	M8V	13.5 …	10.1 ± 3.1	11.09 ± 0.28	a	0.8	1.1	15, 10	
LP 869-19	…	10 ± 1	…	18.4 ± 1.1	a	1.8	…	1	
LP 869-26	…	9 ± 1	…	13.97 ± 0.68	a	1.6	…	1	possible new binary
LP 870-65	…	10 ± 2	…	17.9 ± 1.5	a	1.8	…	1	
LP 756-3	M5.5	15 ± 2	8.4 ± 3.8	17.4 ± 1.4	a	1.2	2.1	16, 1	M5-6 in source
LP 984-92	…	8 ± 1	…	18.9 ± 2.0	a	2.4	…	1	
LP 876-10	…	7.2 ± 0.8	…	7.41 ± 0.19	a	1.0	…	1	
LP 932-83	…	14.1 ± 2.4	…	25.9 ± 4.6	r	1.8	…	8	
2MA 2306-0502	M7.5V	11.3 ± 2.0	11.1 ± 3.3	12.41 ± 0.62	r	1.1	1.1	2, 13	
LP 822-101	…	15 ± 2	…	22.7 ± 4.5	r	1.5	…	1	
2MA 2351-2537	L1	13.2 …	31 ± 16	…	…	…		10	see also Table 4.14
LP 704-15	M3V	13.2 ± 1.7	16.7 ± 5.7	…	…	…		7, 8	see also Table 4.14

TABLE 4.4 (CONTINUED)

COMPARISON OF DISTANCE ESTIMATES FOR POSSIBLE NEARBY STARS

NOTES.—[a]Ratios are the distance from the trigonometric parallax divided by either the literature distance in the "L" column or by the spectroscopic distance in the "S" column.

[b]Distance estimates from literature include photometric and spectroscopic techniques.

[c]Spectroscopic distance estimates are from this work as discussed in section 4.2.2.

[d]Trigonometric parallaxes are from this work as discussed in section 4.3 with the exception of LHS 2397a.

[e]An "a" in the Type column indicates that the distance is from a preliminary absolute parallax while an "r" indicates that the distance is calculated from a preliminary relative parallax.

[f]BD -10˚3166 was not part of the sample of possible nearby stars but is included as a possible common proper motion companion to LP 731-76.

REFERENCES.—(1) Reid *et al*. 2003; (2) Cruz *et al*. 2003; (3) Cruz & Reid 2002; (4) Reid, Kilkenny, & Cruz 2002; (5) T. D. Beaulieu 2006, private communication; (6) Scholz, Meusinger, & Jahreiß 2005; (7) Reid, Hawley, & Gizis 1995; (8) Reid & Cruz 2002; (9) Gigoyan, Hambaryan, & Azzopardi 1998; (10) Cruz, K. I. 2003, private communication; (11) Torres *et al*. 2000; (12) Butler *et al*. 2000; (13) Gizis *et al*. 2000; (14) Monet *et al*. 1992; (15) Gizis 2002; (16) Abrahamyan *et al*. 1997

are good to about 30%; using more consistent photometry would eliminate the need for Equation 4.2, which makes a large contribution to the error. Spectroscopic distances could not be estimated for the eighteen stars either with no spectral type or inadequate spectral type information. In addition, the revised distances obtained for the early L dwarfs are unreasonably large in most cases; Table 4.3 provides no examples of such cool objects so the absolute I-magnitudes were extrapolated. Although L dwarf parallaxes could have been located in the literature to improve the derived relationship between absolute I-magnitude and spectra type, an alternative color relationship was explored instead.

2MASS provides a comprehensive source of consistant infrared photometry. Therefore, J and K_S (2.16 μm) should be available for all the possible nearby stars in the proposed sample (Cohen, Wheaton, & Megeath 2003). The 117 stars in Table 4.3 with a (J-K) color were plotted against absolute I-magnitude as shown in Figure 4.4 from which no meaningful relationship was apparent.

Rather than spending additional time reviewing the literature for additional photometry or obtaining further supporting observations, T. Henry, CTIOPI program director, tentatively accepted the potential sample of forty-three stars for inclusion in CTIOPI.

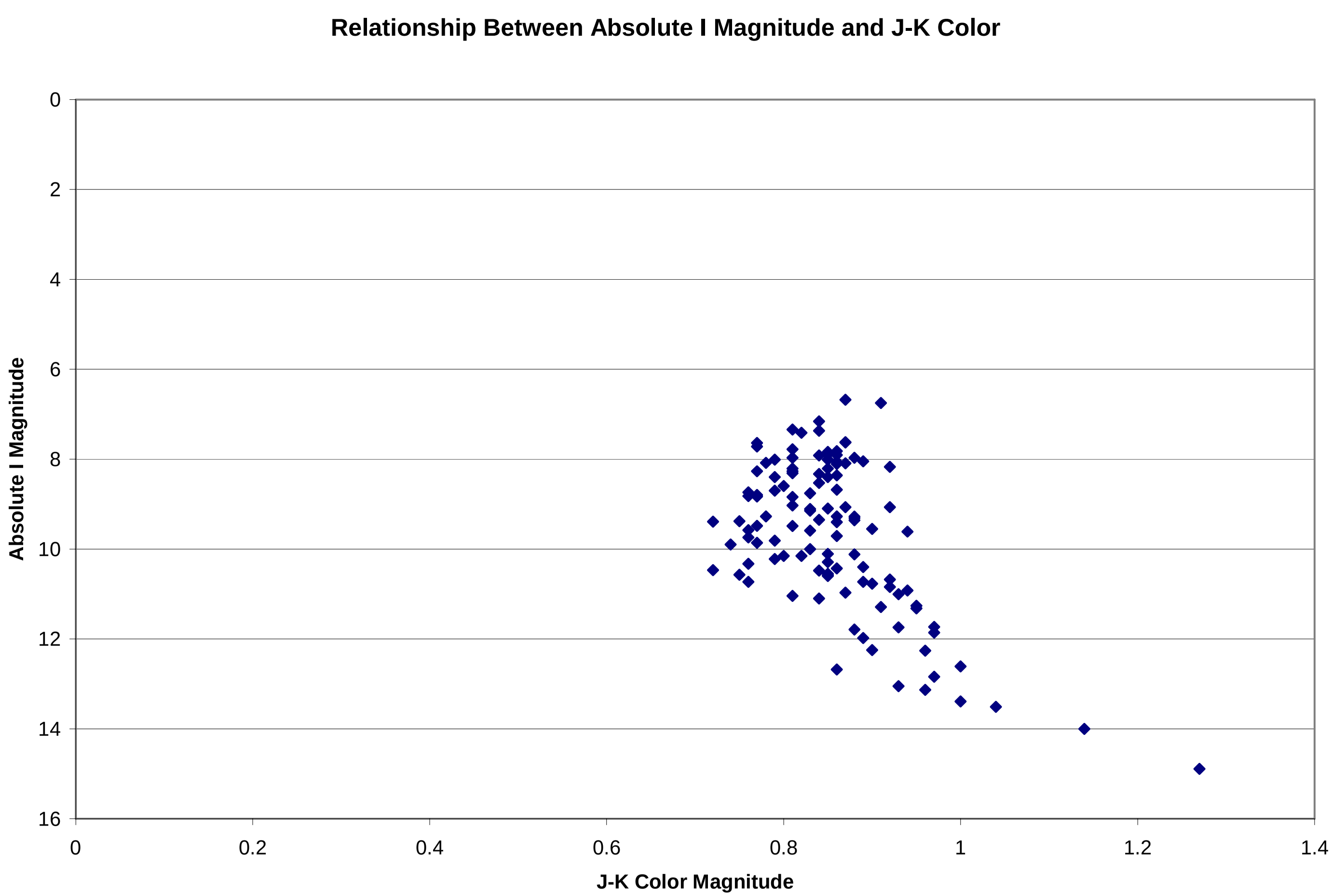

FIG. 4.4.— Absolute I-Magnitude and (J-K) Color for Known Nearby Stars. Plot is based on data in Table 4.3, which was provided by T. Henry (2003, private communication).

4.3 ASTROMETRY

Set-up and observation of the accepted CTIOPI subsample of forty-three stars began in 2003 December. Finding charts for all of the stars were prepared for use at CTIO; copies of most of them are in Appendix A. Since then, programmatic concerns have reduced the subsample to thirty-two stars that continue to be observed as of 2006 November. The number of possible nearby stars observed by CTIOPI with right ascensions between three and four hours and twelve and thirteen hours was becoming congested. To complete parallax and proper motions observations quickly, the observing list should contain no more than fourteen stars per hour of right ascension on a telescope that is available for an average of a week each month (T. Henry 2006, private communication).

CTIOPI stars are observed for a minimum of two years and, then, until the following conditions are met

- Error in relative parallax is no greater than 3 milliseconds of arc (mas)
- At least forty useable images have been processed
- Astrometric observations include at least four seasons, with each season including two or three months of observations at positive or negative parallax factor
- Photometric observations are available in V_C, R_{KC}, and I_{KC} bands.

Meeting these conditions usually requires less than 2.5 years (Jao *et al*. 2005). Although no specific requirements for coverage of the parallactic ellipse are set, the individual reducing the astrometric data should consider the range of parallax factors represented. Because the conditions above are not yet met for any of the stars in the subsample, final parallaxes and proper motions are not yet possible. However, I undertook preliminary reductions for thirty stars in the subsample at Georgia State University in 2006 May to estimate the eventual parallaxes and proper motions. The observations utilized are summarized in Table 4.5.

The stars in this subsample were observed using the 2048x2048 Tectronix CCD camera on the 0.9-meter telescope, which has a plate scale of 401.2 ± 0.3 mas pixel^{-1} (Jao *et al.* 2003). The central quarter of the chip is used for a 6.8 minutes of arc^{-2} field of view (Jao *et al*. 2005). The CTIOPI observing procedures are based on those established for the SPP. The observations of a possible nearby star are made with a filter selected to balance the brightness of the star of interest with potential reference stars in the field of view (Jao 2004). Bias and dome flat frames are taken each night for use in the preliminary reduction of the observations. The exposure time for each field is selected to maximize the counts in the images of the science star and the potential reference stars without saturating any stellar images. Generally, three to ten observations are made within thirty minutes of the meridian to minimize the effects of DCR (Jao *et al*. 2005).

TABLE 4.5

SUMMARY OF OBSERVATIONS USED TO MEASURE PRELIMINARY PARALLAXES AND PROPER MOTIONS

Star	Filter	Seasons[a]	# Observations[b] Evening	Morning	Useable Frames[c]	Baseline (yr)	Reference Stars	Suggested Improvements
LP 991-84	V	2c+	14	22	30	1.95	7	
LHS 1363	I	2c+	8	19	22	1.87	6	
G 75-35	R	1c+	11	15	22	1.76	9	
2MA 0251-0352	I	2c+	12	7	16	1.94	9	
LP 888-18	I	2c+	6	21	25	1.86	7	better trail plate
LP 889-37	R	2s+	6	10	15	1.85	10	
LHS 5094	V	2c+	6	11	13	1.93	10	
2MA 0429-3123	R	2c+	6	16	22	1.94	11	better photometry and trail plate
LP 834-32	V	1s+	6	5	11	1.04	8	
LP 776-25	V	1c+	6	11	13	1.31	12	
2MA 0517-3349	I	2c+	12	11	22	2.26	10	
LP 717-36	V	3c	21	15	34	1.95	12	
LHS 6167	V	3c	18	22	40	2.27	9	
2MA 0921-2104	I	3c	20	8	28	2.12	9	
G 161-71	V	3c	15	9	24	2.28	9	
LP 731-76	I	2c	30	10	35	1.28	6	better photometry
BD -10°3166[d]	I	1c+	17	5	15	1.94	5	better photometry
LHS 2783	R	3c	17	21	32	1.28	9	
LP 739-2	I	3c	9	23	29	1.92	6	
LHS 2880	R	3c	11	14	25	1.92	8	
2MA 1507-2000	I	3c	27	16	43	1.92	10	
LHS 3056	V	3s	20	20	36	1.93	6	better photometry
2MA 1534-1418	I	3s	17	21	37	1.93	11	better trail plate

TABLE 4.5 (CONTINUED)

SUMMARY OF OBSERVATIONS USED TO MEASURE PRELIMINARY PARALLAXES AND PROPER MOTIONS

Star	Filter	Seasons[a]	# Observations[b] Evening	Morning	Useable Frames[c]	Baseline (yr)	Reference Stars	Suggested Improvements
LP 869-19	R	3c	26	20	40	1.81	10	better trail plate
LP 869-26	I	3c	37	13	37	1.79	11	
LP 870-65	R	3c	22	5	24	1.80	9	get morning observations
LP 756-3	R	3c	14	11	25	1.79	10	
LP 984-92	R	2c+	6	18	22	1.96	6	
LP 876-10	V	3c+	11	21	31	2.43	7	
LP 932-83	V	2c+	6	17	22	1.68	7	
2MA 2306-0502[e]	I	2c	6	11	17	0.98	11	better trail plate
LP 822-101	V	2c+	16	19	29	1.68	9	

NOTES.—[a]Seasons indicates the number of observing seasons during which the star was observed; each season may contain 2–3 months. A "c" indicates that the observations were continuous during most seasons while an "s" indicates that only scattered observations were available. A plus sign (+) indicates that images were used from "seasons" during which fewer than four observations were available; "seasons" with so few exposures are not included in the count.

[b]Number of Observations indicates the number of morning and evening frames taken for astrometric purposes, some of which may not have been excluded from the reduction due to poor quality.

[c]Useable Frames is the total number of frames used in this analysis, including all astrometric observations of adequate quality possibly supplemented by frames taken for other purposes.

[d]BD -10°3166 was not part of the sample of possible nearby stars but is included as a possible common proper motion companion to LP 731-76.

[e]The CTIOPI 1.5-meter program recently finalized a parallax for this star using 45 frames over 3.3 years with 18 reference stars (Costa *et al*. 2006)

The preliminary reductions followed the methodology outlined in Jao *et al*. (2005) and described in greater detail in Jao (2004). Five to fifteen reference stars surrounding the star for which the parallax and proper motion are to be measured were selected based on their photometry, shape (ellipticity less than 0.2), and brightness. A small ellipticity throughout the frame indicates that the guiding was adequate during the exposure; a small ellipticity for individual stars helps eliminate close double stars and background galaxies. Source-Extractor (Bertin & Arnouts 1996; hereafter SExtractor) determined the centroids for each star of interest in every frame; this software was designed to produce a list of detected objects from an astronomical image.

The coordinates for the possible nearby star were obtained from 2MASS and adjusted to epoch 2000.0 using published proper motions (Jao 2004), as shown in Table 4.6. When no proper motions were available from literature, 2MASS coordinates were used directly until a preliminary proper motion was calculated based on CTIOPI observations. Then, the preliminary proper motion was used to update the coordinates that were used in turn to re-reduce the region. The coordinates in Table 4.1 are updated in this manner for those stars with preliminary relative parallaxes and proper motions. The coordinates and observation times were used to calculate parallax factors and hour angles.

TABLE 4.6

PROPER MOTIONS FOR POSSIBLE NEARBY STARS

Star	From Literature: Proper Motion[a] (mas yr^{-1})	From Literature: Position Angle (deg.)	Preliminary Results: Proper Motion (mas yr^{-1})	Preliminary Results: Position Angle (deg.)	Reference	Comment
LP 991-84	279 ± 25[a]	150 …	258.7 ± 5.8	151.2 ± 2.5	1	
LHS 1363	540 ± 25[b]	106.4 …	531.8 ± 5.5	107.5 ± 1.1	2	
G 75-35	377 ± 27[c]	106.0 ± 4.5[c]	355.0 ± 8.8	96.5 ± 2.2	3	
2MA 0251-0352	2,185 ± 57.0	149.300 …	2,153.7 ± 8.6	149.40 ± 0.44	4	initial reduction updated position
LP 888-18	425 ± 25[a]	175 …	407.5 ± 5.6	171.9 ± 1.2	1	
LP 889-37	26 ± 25[a]	195 …	261.6 ± 8.9	176.7 ± 2.9	1	
LHS 5094	560 ± 100	176.8 ± 5	480.5 ± 9.4	188.2 ± 1.8	2	
2MA 0429-3123	…	…	132.7 ± 5.9	40.0 ± 5.1		initial reduction updated position
LP 834-32	205 ± 25[a]	158 …	203 ± 11	161.9 ± 5.4	1	
LP 655-43	198 ± 25[a]	204 …	…	…	1	dropped from CTIOPI
LP 716-10	386 ± 25[a]	238 …	…	…	1	dropped from CTIOPI
LP 776-25	256 ± 25[a]	254 …	243 ± 15	149.1 ± 6.4	1	
2MA 0517-3349	545.6 ± 13.2	125.09 …	526.1 ± 6.1	125.5 ± 1.3	5	
LP 717-36	186 ± 25[a]	167 …	194.5 ± 4.3	168.0 ± 2.1	1	
LHS 2024	660 ± 25[b]	241.4 …	…	…	2	dropped from CTIOPI
LHS 6167	459 ± 25[b]	244.3 …	446.1 ± 2.6	244.20 ± 0.62	2	
2MA 0921-2104	965 ± 16.0	162.600 …	940.5 ± 2.8	164.1 ± 0.30	4	
G 161-71	347 ± 27[c]	270.7 ± 4.5[c]	334.1 ± 2.2	276.10 ± 0.64	3	
LP 671-8	451 ± 27[c]	199.2 ± 4.5[c]	…	…	3	dropped from CTIOPI

TABLE 4.6 (CONTINUED)

PROPER MOTIONS FOR POSSIBLE NEARBY STARS

Star	From Literature: Proper Motion[a] (mas yr^{-1})	From Literature: Position Angle (deg.)	Preliminary Results: Proper Motion (mas yr^{-1})	Preliminary Results: Position Angle (deg.)	Reference	Comment
LP 991-84	279 ± 25[a]	150 …	258.7 ± 5.8	151.2 ± 2.5	1	
LP 731-76	203 ± 25[a]	250 …	218.1 ± 4.5	244.5 ± 2.2	1	initial reduction updated position
BD -10°3166[d]	203 ± 25[a]	250	184 ± 19	272 ± 8.6		
LHS 2397a	513.4 ± 7.8	263.8 ± 0.9	…	…	6	dropped and then reinstated
2MA 1155-3727	868 ± 39.0	172.500 …	…	…	4	dropped from CTIOPI
LP 734-34	420.0 ± 5.5	144.68 ± 0.75	…	…	7	dropped from CTIOPI
LP 615-149	308 ± 27[c]	271.1 ± 4.5[c]	…	…	3	dropped from CTIOPI
LHS 5226	500 ± 25[b]	253.3 …	…	…	2	dropped from CTIOPI
CE 303	376 ± 2	179 ± 1	…	…	8	dropped from CTIOPI
LHS 2783	510 ± 25[b]	91.5 …	518.5 ± 5.4	267.20 ± 0.90	2	
LP 739-2	350 ± 25[a]	278 …	339.3 ± 4.2	276.7 ± 1.1	1	
LHS 2880	758 ± 25[b]	237.1 …	718.1 ± 4.8	236.90 ± 0.75	2	
2MA 1507-2000	…	…	125.8 ± 4.0	124.2 ± 3.5		initial reduction updated position
LHS 3056	680 ± 100	245.7 ± 5	771.5 ± 2.7	258.50 ± 0.32	2	
2MA 1534-1418	…	…	966.5 ± 2.9	251.20 ± 0.32		initial reduction updated position
LP 869-19	260 ± 25[a]	163 …	254.4 ± 4.9	163.1 ± 1.9	1	
LP 869-26	347 ± 25[a]	118 …	347.2 ± 5.1	117.1 ± 1.6	1	
LP 870-65	333 ± 25[a]	165 …	360.5 ± 5.4	161.8 ± 1.6	1	
LP 756-3	353 ± 25[a]	99 …	348.9 ± 5.1	102.0 ± 1.6	1	

TABLE 4.6 (CONTINUED)

PROPER MOTIONS FOR POSSIBLE NEARBY STARS

Star	From Literature Proper Motion[a] (mas yr^{-1})	From Literature Position Angle (deg.)		Preliminary Results Proper Motion (mas yr^{-1})	Preliminary Results Position Angle (deg.)	Reference	Comment
LP 991-84	279 ± 25[a]	150	…	258.7 ± 5.8	151.2 ± 2.5	1	
LP 984-92	206 ± 25[a]	120	…	221.0 ± 6.3	123.0 ± 3.2	1	
LP 876-10	355 ± 25[a]	120	…	369.5 ± 4.7	117.3 ± 1.4	1	
LP 932-83	289 ± 25[a]	216	…	303.2 ± 7.9	220.9 ± 3.0	1	
2MA 2306-0502	1,042 ± 25.0	119.700	…	1,035.6 ± 8.1	117.90 ± 0.87	4	
LP 822-101	344 ± 25[a]	139	…	349.7 ± 1.3	142.5 ± 4.1	1	
2MA 2351-2537	4,203.0 ± 20.9	60.44	…	…	…	5	dropped from CTIOPI
LP 704-15	203 ± 27[c]	85.5	4.5[c]	…	…	3	dropped from CTIOPI

NOTES.—[a]Proper motion errors for (1) are estimated from (9).

[b]Proper motion in (2) is based on (1) and so the error is estimated from (9).

[c]Proper motion errors for (3) are estimated from (10).

[d]BD -10°3166 was not part of the sample of possible nearby stars but is included as a possible common proper motion companion to LP 731-76.

REFERENCES.—(1) *NLTT*; (2) Bakos, Sahu, & Nemeth 2002; (3) Giclas, Burnham, & Thomas 1978; (4) Deacon, Hambly & Cooke 2005; (5) Pokorny *et al*. 2004; (6) Tinney 1996; (7) Salim & Gould 2003; (8) Lodieu *et al*. 2005; (9) Gould & Salim 2003; (10) Giclas 1966

A high-quality frame taken close to the meridian was selected based on the shape and brightness of the stellar images to serve as the "trail plate" (Jao *et al*. 2005). First, the trail plate was rotated to align with *The Guide Star Catalog, Version 2.2* (STScI & OAT 2001). Then, all the other frames were reduced with respect to the rotated trail plate; consequently, careful selection of an appropriate trail plate is essential. If photometry was available for the reference frames during the astrometric reduction, then DCR corrections were made for the parallax star and its reference stars (Jao *et al*. 2005). For those stars without photometry, DCR corrections could not be included in the preliminary reduction. However, photometry will be obtained so that DCR corrections will be included in the calculations of final parallaxes and proper motions.

GaussFit[13] (Jefferys *et al*. 1987; hereafter GaussFit), a program for astrometric modeling using both least-squares and robust estimation approaches, calculated the preliminary relative parallax and proper motion of each possible nearby star. It used a standard three plate-constant model, with scale, orientation, and origin terms. The small parallactic shifts and proper motions of the reference stars can affect the calculation of the plate constants. GaussFit assumed that both of these motions summed to zero over the reference frame (Jao *et al*. 2005).

After GaussFit calculated the preliminary parallax and proper motion, the quality of the solution was assessed. For many fields, only a few observations at a limited number of epochs were available so large errors in parallax and proper motion

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[13]GaussFit is available at ftp://clyde.as.utexas.edu/pub/gaussfit

were expected. The errors in these values along with the mean errors of unit weight are reviewed along with a number of factors that can contribute to the quality of the results. The distribution of hour angles and range of seeing at which individual observations were made was considered. Keeping the hour angles as small as possible reduces the DCR effects. However, to obtain sufficient frames for preliminary parallaxes, some set-up and photometry images taken at large hour angles were used. The parallax reduction pipeline rejects frames with seeing worse than 2.5 seconds of arc ("). Although the seeing at CTIO is generally good, it is rarely so good that a lower limit must be specified. The range of parallax factors sampled by the observations is considered. The difference between calculated and measured positions, or residuals, is reviewed in each coordinate for individual observations of the possible nearby star and its reference stars. Figure 4.5 summarizes this information for LP 876-10, the star with the largest preliminary parallax in this subsample. If individual frames or reference stars appear to have a significant negative effect on the overall result, they can be removed and a new preliminary parallax and proper motion calculated. Because of the preliminary nature of the astrometric reductions reported herein, most frames and reference stars were retained. Once all of these factors appear reasonable, the preliminary relative parallax is complete.

If photometry was available for a region, then the correction to absolute was also calculated. Before any parallax is finalized, photometry is obtained. Therefore, the final relative parallaxes will all be corrected to absolute values.

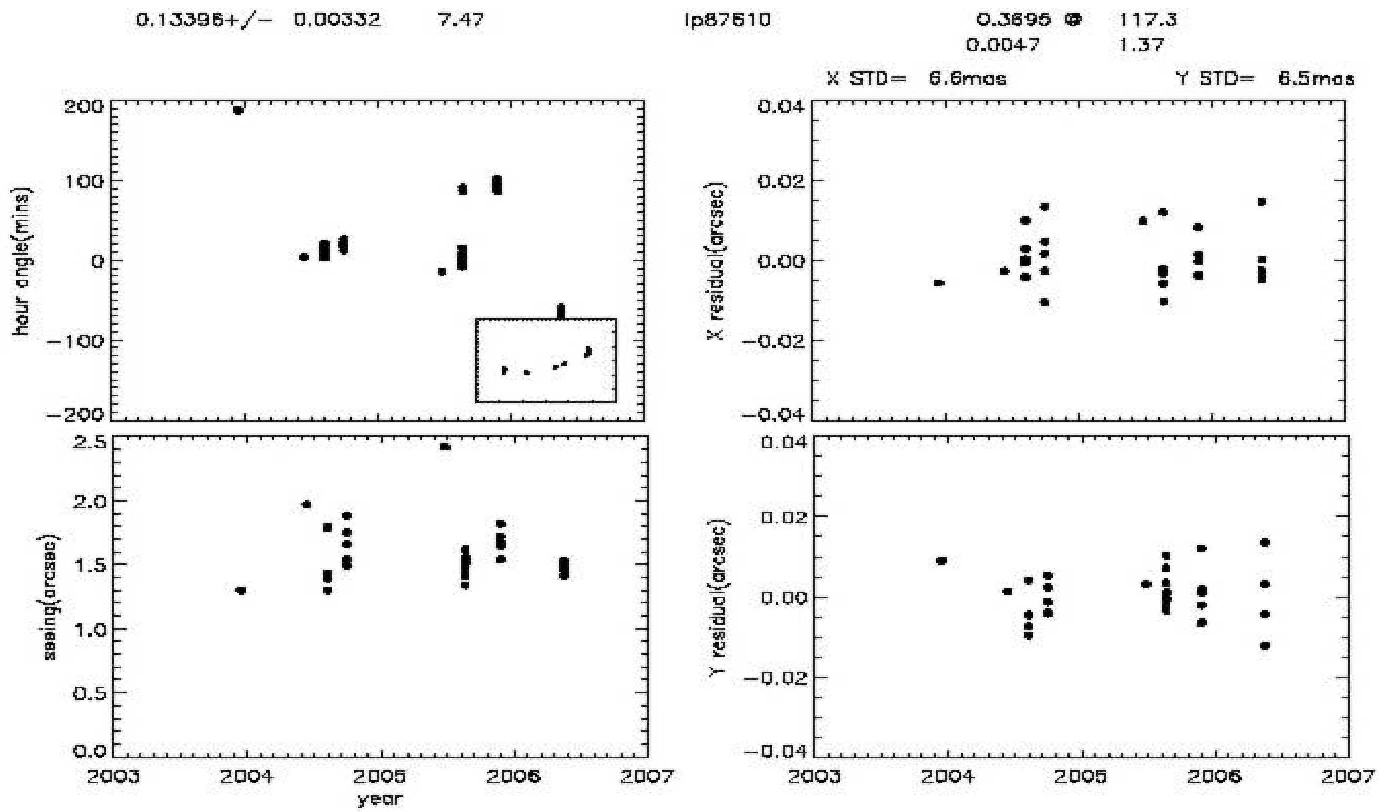

FIG. 4.5.— Preliminary Relative Parallax Reduction for LP 876-010. The upper-left values are parallax with associated error in seconds of arc and corresponding distance in parsecs. The upper-right values are proper motions in seconds of arc per year, followed by the position angle in degrees. The associated errors appear directly below the corresponding value. The upper-left plot shows the hour angle for each observation. The insert box shows the range of parallax factors sampled. The lower-left plot shows the seeing conditions for each observation. The upper and lower plots on the right show the range of residuals in the x- (right ascension) and y- (declination) coordinates respectively. The standard deviations appear above the x-residual plot.

Table 4.7 summarizes the preliminary parallax results for thirty-one stars in the subsample plus BD -10˚3166. Additional notes on selected individual stars follow in sections 4.3.1 and 4.3.2 *infra*. For stars with parallaxes (π in seconds of arc), the tangential velocity (v_t) in kilometers second^{-1} (km s^{-1}) can be calculated using

$$v_t = \frac{4.74\mu}{\pi} \tag{4.4}$$

where μ is the total proper motion in seconds of arc year^{-1}. Table 4.8 lists the tangential velocities calculated for stars in this subsample, including BD -10˚3166.

4.3.1 Stars with Preliminary Absolute Parallaxes

Preliminary absolute parallaxes have been measured for fifteen stars in this subsample, plus BD -10˚3166, as shown in Table 4.7. Of these sixteen stars, all but two (BD -10˚3166 and LHS 2880) have formal distances that place them within the solar neighborhood. Two stars (LHS 6167 and LP 876-10) appear to be within 10 pc. Another six had photometric or spectroscopic distance estimates that placed them within 10 pc of the Sun but the preliminary absolute parallaxes place them at greater distances; all of these are discussed in 4.6.9.

High proper motions are frequently associated with nearby stars. As shown in Table 4.6, all but three of these stars have a preliminary proper motion greater than 200 mas year^{-1} (yr^{-1}), including four with proper motions greater than 500 mas yr^{-1}. The tangential velocities range from 9.53 to 88.0 km s^{-1}, including three faster than 50 km s^{-1}..

TABLE 4.7

PRELIMINARY PARALLAXES FOR POSSIBLE NEARBY STARS

Star	Baseline (yr)	Relative Parallax (mas)	Correction (mas)	Absolute Parallax (mas)	Standard Error Unit Weight X (mas)	Y (mas)	Comment
LP 991-84	1.95	115.7 ± 3.1	…	…	9.8	8.8	
LHS 1363	1.87	80.5 ± 3.7	…	…	8.1	5.3	
G 75-35	1.76	84.5 ± 3.7	…	…	6.7	5.0	
2MA 0251-0352	1.94	79.0 ± 6.8	…	…	15.1	17.4	
LP 888-18	1.86	74.4 ± 3.7	…	…	6.5	6.3	
LP 889-37	1.85	59.2 ± 5.2	…	…	7.7	5.8	
LHS 5094	1.93	71.2 ± 4.9	…	…	2.7	5.6	
2MA 0429-3123	1.94	65.8 ± 3.7	0.230 ± 0.050	66.0 ± 3.7	7.4	6.7	
LP 834-32	1.04	60.5 ± 4.7	…	…	3.3	3.6	
LP 776-25	1.31	71.0 ± 9.7	…	…	4.0	10.2	
2MA 0517-3349	2.26	57.2 ± 4.0	1.340 ± 0.050	58.6 ± 4.0	9.6	8.1	
LP 717-36	1.95	54.5 ± 3.3	…	…	5.2	5.6	
LHS 6167	2.27	101.7 ± 2.8	1.09 ± 0.16	102.8 ± 2.8	5.9	5.8	
2MA 0921-2104	2.12	87.1 ± 2.6	…	…	9.5	8.8	
G 161-71	2.28	69.7 ± 2.7	0.880 ± 0.060	70.6 ± 2.7	3.5	4.1	
LP 731-76	1.28	66.8 ± 2.4	2.54 ± 0.55	69.4 ± 2.5	4.4	6.2	
BD -10°3166[a]	1.94	17.3 ± 7.3	2.63 ± 0.66	19.9 ± 7.3	7.6	10.9	
LHS 2783	1.28	51.1 ± 2.9	…	…	6.6	6.8	
LP 739-2	1.92	57.9 ± 3.5	…	…	4.4	4.2	

TABLE 4.7 (CONTINUED)
PRELIMINARY PARALLAXES FOR POSSIBLE NEARBY STARS

Star	Baseline (yr)	Relative Parallax (mas)	Correction (mas)	Absolute Parallax (mas)	Standard Error Unit Weight X (mas)	Standard Error Unit Weight Y (mas)	Comment
LHS 2880	1.92	37.7 ± 3.0	0.960 ± 0.080	38.7 ± 3.0	7.2	12.8	
2MA 1507-2000	1.92	43.1 ± 3.1	0.740 ± 0.090	43.8 ± 3.1	7.9	8.8	
LHS 3056	1.93	51.0 ± 1.9	1.36 ± 0.11	52.4 ± 1.9	3.3	6.2	
2MA 1534-1418	1.93	88.4 ± 2.2	1.75 ± 0.19	90.2 ± 2.2	6.6	5.1	
LP 869-19	1.81	51.9 ± 3.0	2.57 ± 0.16	54.4 ± 3.0	7.9	9.6	
LP 869-26	1.79	69.9 ± 3.3	1.630 ± 0.070	71.6 ± 3.3	6.8	5.0	
LP 870-65	1.80	53.6 ± 4.3	2.36 ± 0.30	55.9 ± 4.3	10.9	5.9	
LP 756-3	1.79	56.1 ± 4.4	1.43 ± 0.12	57.5 ± 4.4	4.3	6.8	
LP 984-92	1.96	51.6 ± 5.1	1.20 ± 0.12	52.8 ± 5.1	4.6	7.1	faint reference stars
LP 876-10	2.43	134.0 ± 3.3	0.96 ± 0.19	134.9 ± 3.3	6.6	6.5	
LP 932-83	1.68	38.6 ± 5.8	…	…	9.1	6.6	
2MA 2306-0502[b]	0.98	80.6 ± 3.9	…	…	4.1	5.6	
LP 822-101	1.68	44.1 ± 7.3	…	…	12.8	10.7	

NOTES.—[a]BD -10˚3166 was not part of the sample of possible nearby stars but is included as a possible common proper motion companion to LP 731-76.

[b]The CTIOPI 1.5-meter program measured an absolute parallax of 82.6 ± 2.6 mas (12.11 ± 0.39 pc) over 3.3 years (Costa *et al.* 2006).

TABLE 4.8

PRELIMINARY TANGENTIAL VELOCITIES FOR POSSIBLE NEARBY STARS

Star	Parallax (mas)			Type[a]	Proper Motion (mas yr^{-1})			Position Angle (deg)			Tangential Velocity (km s^{-1})		
LP 991-084	115.7	±	3.1	r	258.7	±	5.8	151.2	±	2.5	10.60	±	11
LHS 1363	80.5	±	3.7	r	531.8	±	5.5	107.5	±	1.1	31.3	±	1.3
G 75-35	84.5	±	3.7	r	355.0	±	8.8	96.5	±	2.2	19.91	±	2.0
2MA 0251-0352	79.0	±	6.8	r	2153.7	±	8.6	149.40	±	0.44	129	±	2.3
LP 888-18	74.4	±	3.7	r	407.5	±	5.6	171.9	±	1.2	26.0	±	0.68
LP 889-37	59.2	±	5.2	r	261.6	±	8.9	176.7	±	2.9	20.9	±	1.5
LHS 5094	71.2	±	4.9	r	480.5	±	9.4	188.2	±	1.8	32.0	±	2.4
2MA 0429-3123	66.0	±	3.7	a	132.7	±	5.9	40.0	±	5.1	9.53	±	3.0
LP 834-32	60.5	±	4.7	r	203	±	11	161.9	±	5.4	15.9	±	1.1
LP 776-25	71.0	±	9.7	r	243	±	15	149.1	±	6.4	16.2	±	0.58
2MA 0517-3349	58.6	±	4.0	a	526.1	±	6.1	125.5	±	1.3	42.6	±	1.5
LP 717-36	54.5	±	3.3	r	194.5	±	4.3	168.0	±	2.1	16.9	±	0.87
LHS 6167	102.8	±	2.8	a	446.1	±	2.6	244.20	±	0.62	20.57	±	0.61
2MA 0921-2104	87.1	±	2.6	r	940.5	±	2.8	164.10	±	0.30	51.2	±	17
G 161-71	70.6	±	2.7	a	334.1	±	2.2	276.10	±	0.64	22.43	±	2.8
LP 731-76	69.4	±	2.5	a	218.1	±	4.5	244.5	±	2.2	14.91	±	1.7
BD -10°3166[b]	19.9	±	7.3	a	184	±	19	272.5	±	8.6	44	±	6.8
LHS 2783	51.1	±	2.9	r	518.5	±	5.4	267.20	±	0.90	48.1	±	1.0
LP 739-002	57.9	±	3.5	r	339.3	±	4.2	276.7	±	1.1	27.8	±	2.5
LHS 2880	38.7	±	3.0	a	718.1	±	4.8	236.90	±	0.75	88.0	±	1.3

TABLE 4.8 (CONTINUED)

PRELIMINARY TANGENTIAL VELOCITIES FOR POSSIBLE NEARBY STARS

Star	Parallax (mas)	Type[a]	Proper Motion (mas yr^{-1})	Position Angle (deg)	Tangential Velocity (km s^{-1})
2MA 1507-2000	43.8 ± 3.1	a	125.8 ± 4.0	124.2 ± 3.5	13.6 ± 1.3
LHS 3056	52.4 ± 1.9	a	771.5 ± 2.7	258.50 ± 0.32	69.8 ± 1.1
2MA 1534-1418	90.2 ± 2.2	a	966.5 ± 2.9	251.20 ± 0.32	50.8 ± 2.4
LP 869-19	54.4 ± 3.0	a	254.4 ± 4.9	163.1 ± 1.9	22.2 ± 2.2
LP 869-26	71.6 ± 3.3	a	347.2 ± 5.1	117.1 ± 1.6	23.0 ± 2.0
LP 870-65	55.9 ± 4.3	a	360.5 ± 5.4	161.8 ± 1.6	30.5 ± 0.36
LP 756-3	57.5 ± 4.4	a	348.9 ± 5.1	102.0 ± 1.6	28.8 ± 5.7
LP 984-92	52.8 ± 5.1	a	221.0 ± 6.3	123.0 ± 3.2	19.8 ± 3.0
LP 876-10	134.9 ± 3.3	a	369.5 ± 4.7	117.3 ± 1.4	12.98 ± 6.4
LP 932-83	38.6 ± 5.8	r	303.2 ± 7.9	220.9 ± 3.0	37.2 ± 11
2MA 2306-0502[c]	80.6 ± 3.9	r	1035.6 ± 8.1	117.90 ± 0.87	60.9 ± 1.3
LP 822-101	44.1 ± 7.3	r	350 ± 13	142.5 ± 4.1	37.6 ± 2.0

NOTE.—[a]An “a” in the Type column indicates that the distance is from a preliminary absolute parallax while an “r” indicates that the distance is calculated from a preliminary relative parallax.

[b]BD -10°3166 was not part of the sample of possible nearby stars but is included as a possible common proper motion companion to LP 731-76.

Additional comments on six stars, for which absolute parallaxes have been measured, that display interesting characteristics or for which further questions remain follow. Section 4.3.2 discusses six additional stars with relative parallax of that also merit further comment.

4.3.1.1 2MA 0517-3349

2MA 0517-3349 is a high proper motion star. The CTIOPI preliminary proper motion of 526.1 ± 6.1 mas yr^{-1} in 125.5 ± 1.3º is a little slower than an earlier measurement of 576 mas yr^{-1} in 126.39º with a possible proper motion error of 7–29 mas yr^{-1} (Phan-Bao *et al*. 2003). At a distance of 17.1 ± 1.3 pc, it has a tangential velocity of 42.6 ± 3.0 km s^{-1}. Two more seasons will probably be needed finalize the parallax and proper motion.

4.3.1.2 LHS 6167

The second nearest star for which an absolute parallax was obtained, LHS 6167, has a preliminary absolute parallax of 102.8 ± 2.8 mas, which corresponds to a distance of 9.73 ± 0.28 pc; it is confirmed as a nearby star and is a possible new member of the 10-pc sample. The photometric distance estimate by Reid, Kilkenny, and Cruz (2002) placed it even closer, 6.7 ± 0.5 pc. Because the ratio of the parallactic to photometric distance is 1.5, this star may be a close binary and is discussed further in 4.6.9. Another season of observations should be sufficient to finalize this parallax.

4.3.1.3 BD -10˚3166

BD -10˚3166 was not initially a member of the subsample, but a preliminary parallax was calculated because the *New Lutyen Two-Tenths Catalogue* (Luyten 1980, *NLTT)* identified it as a common proper motion pair with a member of this subsample, LP 731-76. The preliminary absolute parallax 19.9 ± 7.3 mas indicates that this star lies well outside the solar neighborhood at a distance of 50 ± 29 pc. The parallax is based on fifteen observations primarily within one season. Consequently, the error is large enough that it may still be a nearby star. Several more seasons of observations and improved photometry are required before a final parallax will be achieved for this star. It is discussed further in 4.6.2.

4.3.1.4 LHS 2880

LHS 2880 has the smallest preliminary parallax, relative or absolute, of any possible nearby star in this subsample. Its preliminary absolute parallax of 38.7 ± 3.0 mas corresponds to a distance of 25.8 ± 2.2 pc, which places it outside the solar neighborhood. However, the associated error is large enough that it may still be a nearby star. The photometric distance estimate by Reid, Kilkenny, and Cruz (2002) places it within 10 pc, 9.8 ± 0.7 pc, while the spectroscopic distance estimate described in 4.2.2 places it at 11.2 ± 4.0 pc. Because of the large discrepancy between the current parallactic and the other distance estimates, the possibility that it is a close binary is discussed in 4.6.9. Two more seasons of observations may be required to finalize this parallax.

4.3.1.5 2MA 1534-1418

2MA 1534-1418 is a new high proper motion star with a preliminary proper motion of 966.5 ± 2.9 mas yr^{-1} in 251.2 ± 0.32º. At a distance of 11.09 ± 0.28 pc, it has a tangential velocity of 50.8 ± 1.3 km s^{-1}. One more season should be sufficient to finalize the parallax and proper motion.

4.3.1.6 LP 876-10

LP 876-10 appears to be the nearest star in the subsample. It displays the largest preliminary parallax, relative or absolute, of any star in this subsample. Its preliminary absolute parallax of 134.9 ± 3.3 mas corresponds to a distance of 7.41 ± 0.19 pc. Thus, it is confirmed as a nearby star and a new member of the 10-pc sample. Another season of observations should be sufficient to finalize this parallax.

4.3.2 Stars with Preliminary Relative Parallaxes

Preliminary relative parallaxes are available for another sixteen stars in this subsample, as shown in Table 4.7. Of these, all but LP 932-83 have formal distances that place them within the solar neighborhood. LP 991-84 appears to be within 10 pc. Another, LHS 1363, had a spectroscopic distance estimate that placed it within 10 pc of the Sun but its preliminary relative parallax places it at a greater distance.

All but one of the possible nearby stars with only preliminary relative parallaxes also could be considered high proper motion stars because their proper motions are greater than 200 mas yr^{-1}. As shown in Table 4.6, five of these stars also have a preliminary proper motion greater than 500 mas yr^{-1}, including two with proper motions greater than 1" yr^{-1}. The tangential velocities range from 10.60 to 129 km s^{-1}, including two between 50 and 100 km s^{-1}.

4.3.2.1 LP 991-84

LP 991-84 has the second largest preliminary relative parallax, 115.7 ± 3.1 mas, which corresponds to a distance of 8.64 ± 0.24 pc. It is confirmed as a nearby star and a new member of the 10-pc sample. Two more seasons plus photometry are probably necessary in order to finalize this parallax.

4.3.2.2 LHS 1363

The distances for LHS 1363 listed in Table 4.4 range from 9.8 to 12.42 pc. Although the spectroscopic distance estimated in 4.2.2 places LHS 1363 within the 10-pc sample, the preliminary relative parallax of 80.5 ± 3.7 mas indicates otherwise. The parallactic distance falls within the errors of the spectroscopic distance estimate. At least two seasons plus photometry are required to finalize this parallax.

4.3.2.3 2MA 0251-0352

2MA 0251-0352 is interesting because it has the highest preliminary proper motion in this subsample. The CTIOPI preliminary proper motion of 2.1537 ± 0.0086” yr^{-1} in 149.4 ± 0.44º agrees with the measurement of 2.185 ± 0.057” yr^{-1} in 149.300º (Deacon, Hambly, & Cooke 2005). At a distance of 12.7 ± 1.2 pc, it has a tangential velocity of 129 ± 11 km s^{-1}, which is also the highest in this subsample. Three more seasons plus photometry may be required to finalize the parallax and proper motion.

4.3.2.4 2MA 0921-2104

2MA 0921-2104 is another high proper motion star. The CTIOPI preliminary proper motion of 940.5 ± 2.8 mas yr^{-1} in 164.1 ± 0.30º is slightly lower than the measurement of 965 ± 16 mas yr^{-1} in 162.600º last year (Deacon, Hambly, & Cooke 2005). At a distance of 11.48 ± 0.35 pc, it has a tangential velocity of 51.2 ± 1.5 km s^{-1}. Two more seasons plus photometry may be required to finalize the parallax and proper motion.

4.3.2.5 LP 932-83

LP 932-83 has one of the smallest preliminary relative parallaxes, 38.6 ± 5.8 mas, which corresponds to a distance of 25.9 ± 4.6 pc. It is probably not a member of the solar neighborhood. However, its error is large enough that it may still be a nearby star. Reid and Cruz (2002) estimated that it was only 14.1 ± 2.4 pc away. Because the ratio of the parallactic distance to spectroscopic distance is 1.8, the possibility that it is a close binary is discussed in 4.6.9. In addition, the *LDS Catalogue* (Luyten 1987; hereafter *LDS*) identifies it as a common proper motion pair with LTT 9210; this possibility is discussed further in 4.6.7. Another season of observations plus additional photometry should be sufficient to finalize this parallax.

4.3.2.6 2MA 2306-0502

2MA 2306-0502 is another high proper motion star. At the 0.9-meter telescope, CTIOPI measured a preliminary proper motion of 1.0356 ± 0.0081” yr^{-1} in 117.9 ± 0.87º, which is in agreement with both the value of 1.0358 ± 0.0018” yr^{-1} in 117.1 ± 0.19º obtained by the CTIOPI 1.5-meter program (Costa *et al*. 2006) and the measurement of 1.042 ± 0.025” yr^{-1} in 119.700º made by Deacon, Hambly, and Cooke (2005). At a distance of 12.41 ± 0.62 pc, it has a tangential velocity of 60.9 ± 3.0 km s^{-1}. Three more seasons plus photometry may be required to finalize the parallax and proper motion.

4.3.3 Dropped Stars

During the course of observations, eleven stars in the subsample were dropped from the astrometric program. Of these, LHS 2397a is now being actively observed and is discussed below. Table 4.9 summarizes the observational status of the other stars and their standing as nearby stars is revisited in section 4.5. A rough preliminary parallax was calculated for LP 834-32 using only eleven frames. If the quality of the available frames for LHS 2024, 2MA 2351-2537, and LP 704-15 is adequate, similar rough parallaxes might be calculated for these regions as well. The resulting distance estimates would be the best indicator of whether to resume observations in the future.

TABLE 4.9
ASTROMETRIC OBSERVATIONS OF DROPPED STARS

Star	# Observations Eve.	# Observations Morn.	Started	Comment
LP 655-43	1	0	2003 Dec	
LP 716-10	1	0	2003 Dec	
LHS 2024	5	4	2003 Dec	rough preliminary parallax possible
LP 671-8	0	0		not set-up
2MA 1155-3727	0	0		not set-up
LP 734-34	0	0		not set-up
LP 615-149	0	0		not set-up
LHS 5226	0	0		not set-up
CE 303	0	0		not set-up
2MA 2351-2537	9	3	2004 Aug	rough preliminary parallax possible
LP 704-15	2	5	2003 Dec	rough preliminary parallax possible

NOTE.—Rough preliminary parallax calculated for LP 834-32 used only eleven frames.

LHS 2397a was initially included in this CTIOPI subsample. The SPP observed it previously, but the Siding Spring observations are too sparse for the measurement of a parallax and proper motion. Additional review of the literature revealed an earlier absolute trigonometric parallax of 70 ± 2 mas (Monet *et al*. 1992), which puts it at a distance of 14.3 ± 0.4 pc and establishes it as a proven member of the nearby star sample. In addition, further review of the literature produced a V_{JM} magnitude of 18.3 ± 0.2 (Salim & Gould 2003). Either datum would have excluded this star from this subsample. During a periodic pruning of the CTIOPI observing list, it was dropped without having been set-up because it was too faint for easy observation (T. Henry

2006, private communication). However, Freed, Close, & Siegler (2003) resolved it into two components.

On further consideration, such very low-mass binary within 20 pc is an important system for the RECONS Masses and Stellar Systems with Interferometry (MASSIF) program, which seeks to improve the mass-luminosity relationship at both ends of the main sequence (Henry 2004). From models, the mass of LHS 2397aB, the brown dwarf companion, was estimated to be 0.061–0.069 solar mass units ($M_\odot$) (Freed, Close, & Siegler 2003); currently the lowest dynamically determined mass is 0.074 ± 0.005 $M_\odot$ for GJ 1245 (Henry 2004). Therefore, LHS 2397a was re-instated to CTIOPI and observations began in 2005 February. As of 2006 August 16, nineteen evening and twelve morning frames have been collected so a preliminary parallax would be possible. In addition, recent CTIOPI joint photometry indicates that the system has an I_{KC} equal to 14.86 ± 0.02 mag, which is brighter than the I-band selection limit of sixteenth magnitude.

4.4 PHOTOMETRY

Because V_J, R_{KC}, and I_{KC} photometry is used both to correct for DCR and to convert relative parallaxes to absolute ones, all stars on the astrometry observing program are also photometric targets. Final photometry is best with at least three independent observations. As of 2006 July 20, final photometry is available for three stars, as listed in Table 4.10 along with fourteen other stars that have at least one night of photometric observations. The algorithms used for DCR correction and reduction to absolute are not very sensitive to small errors in photometry; therefore a single observation in each filter will suffice (W.-C. Jao 2004, 2006, private communication). As of 2006 May 26, photometry was included in the astrometric reductions for sixteen stars.

The stars in this subsample were observed using the same telescope for photometry as astrometry. Nightly bias and dome flat fields were taken for use during the preliminary reduction of the observations. Each star is observed in the available V_J, R_{KC}, and I_{KC} filters on photometric nights with a sufficient exposure time to ensure a signal-to-noise ratio of at least 100 for the possible nearby star without saturating the potential reference stars (Jao *et al*. 2005). Fields of standard stars from the work of Landolt (1992) and Graham (1982) were also observed throughout the night in order to determine the transformation equations; the selected fields contain an average of ten standard stars each. Because many of the CTIOPI stars are fairly red, including this particular subsample, at least one red standard star, with (V-I) greater than 3.7, is also observed. Over the course of a photometric night, four or five standard fields are usually observed two or three times each (Jao *et al*. 2005)

TABLE 4.10

PHOTOMETRY FOR POSSIBLE NEARBY STARS

Star	V_J[a] (mag)	R_{KC}[b] (mag)	I_{KC}[c] (mag)	#[d]	J (mag)	H (mag)	K_S (mag)
LP 991-84	…	…	…		9.209 ± 0.023	8.629 ± 0.034	8.274 ± 0.026
LHS 1363	…	…	…		10.481 ± 0.024	9.858 ± 0.021	9.485 ± 0.020
G75-35	…	…	…		9.199 ± 0.022	8.581 ± 0.061	8.246 ± 0.027
2MA 0251-0352	…	…	…		13.059 ± 0.027	12.254 ± 0.024	11.662 ± 0.019
LP 888-18	…	…	…		11.360 ± 0.022	10.700 ± 0.022	10.264 ± 0.019
LP 889-37	…	…	…		9.775 ± 0.027	9.164 ± 0.025	8.823 ± 0.023
LHS 5094	…	…	…		9.303 ± 0.024	8.718 ± 0.025	8.411 ± 0.019
2MA 0429-3123	17.471 ± 0.026	15.859 ± 0.023	14.052 ± 0.019	1	10.874 ± 0.024	10.211 ± 0.024	9.770 ± 0.022
LP 834-32	…	…	…		8.240 ± 0.023	7.646 ± 0.031	7.406 ± 0.024
LP 655-43	…	…	…		9.730 ± 0.023	9.136 ± 0.023	8.818 ± 0.021
LP 716-10	…	…	…		10.502 ± 0.022	9.965 ± 0.022	9.606 ± 0.019
LP 776-25	…	…	…		7.740 ± 0.021	7.146 ± 0.031	6.891 ± 0.027
2MA 0517-3349	19.833 ± 0.054	17.382 ± 0.014	14.955 ± 0.010	1	12.004 ± 0.022	11.317 ± 0.024	10.832 ± 0.024
LP 717-36	…	…	…		8.454 ± 0.026	7.882 ± 0.033	7.623 ± 0.027
LHS 2024	…	…	…		10.070 ± 0.023	9.489 ± 0.022	9.136 ± 0.021
LHS 6167	13.809 ± 0.019	12.298 ± 0.015	10.394 ± 0.016	1	8.605 ± 0.027	8.074 ± 0.040	7.733 ± 0.017
2MA 0921-2104	…	…	…		12.779 ± 0.024	12.152 ± 0.022	11.690 ± 0.023
G 161-71	13.757 ± 0.013	12.265 ± 0.011	10.360 ± 0.011	2	8.496 ± 0.024	7.919 ± 0.024	7.601 ± 0.018
LP 671-8	…	…	…		8.877 ± 0.023	8.254 ± 0.042	7.970 ± 0.027
LP 731-76	14.431 ± 0.026	13.028 ± 0.022	11.220 ± 0.028	1	9.512 ± 0.023	8.965 ± 0.022	8.640 ± 0.021
BD -10°3166[e]	10.034 ± 0.026	9.593 ± 0.022	9.186 ± 0.028	1	8.611 ± 0.032	8.300 ± 0.040	8.124 ± 0.026
LHS 2397a	19.44 ± 0.11	17.245 ± 0.024	14.862 ± 0.016	1	11.928 ± 0.021	11.233 ± 0.025	10.735 ± 0.023

TABLE 4.10 (CONTINUED)
PHOTOMETRY FOR POSSIBLE NEARBY STARS

Star	V_J[a] (mag)	R_{KC}[b] (mag)	I_{KC}[c] (mag)	#[d]	J (mag)	H (mag)	K_S (mag)
2MA 1155-3727	…	…	…		12.811 ± 0.024	12.040 ± 0.026	11.462 ± 0.021
LP 734-34	…	…	…		9.292 ± 0.024	8.684 ± 0.034	8.412 ± 0.027
LP 615-149	…	…	…		8.763 ± 0.030	8.123 ± 0.034	7.852 ± 0.020
LHS 5226	…	…	…		9.516 ± 0.023	8.969 ± 0.022	8.674 ± 0.023
CE 303	…	…	…		11.785 ± 0.022	11.082 ± 0.022	10.669 ± 0.024
LHS 2783	…	…	…		8.971 ± 0.018	8.391 ± 0.047	8.089 ± 0.023
LP 739-2	…	…	…		9.728 ± 0.021	9.174 ± 0.021	8.887 ± 0.020
LHS 2880	13.863 ± 0.014	12.509 ± 0.011	10.779 ± 0.012	2	9.040 ± 0.032	8.453 ± 0.040	8.163 ± 0.029
2MA 1507-2000	18.768 ± 0.068	16.704 ± 0.021	14.283 ± 0.022	1	11.713 ± 0.023	11.045 ± 0.022	10.661 ± 0.021
LHS 3056	12.858 ± 0.019	11.631 ± 0.015	10.048 ± 0.016	1	8.507 ± 0.026	7.862 ± 0.027	7.582 ± 0.020
2MA 1534-1418	19.189 ± 0.052	16.693 ± 0.014	14.153 ± 0.017	2	11.380 ± 0.023	10.732 ± 0.022	10.305 ± 0.023
LP 869-19	13.222 ± 0.014	11.9309 ± 0.0092	10.284 ± 0.011	3	8.692 ± 0.019	8.079 ± 0.038	7.816 ± 0.031
LP 869-26	14.102 ± 0.011	12.6468 ± 0.0083	10.8505 ± 0.0078	3	9.169 ± 0.029	8.571 ± 0.044	8.265 ± 0.027
LP 870-65	13.019 ± 0.015	11.7485 ± 0.0092	10.097 ± 0.012	3	8.559 ± 0.027	8.012 ± 0.049	7.701 ± 0.029
LP 756-3	13.742 ± 0.029	12.484 ± 0.018	10.850 ± 0.022	1	9.349 ± 0.027	8.728 ± 0.034	8.435 ± 0.021
LP 984-92	13.369 ± 0.029	12.049 ± 0.018	10.320 ± 0.022	1	8.681 ± 0.02	8.057 ± 0.034	7.793 ± 0.026
LP 876-10	12.583 ± 0.024	11.291 ± 0.017	9.600 ± 0.020	2	8.075 ± 0.023	7.527 ± 0.055	7.206 ± 0.021
LP 932-83	…	…	…		9.342 ± 0.02	8.780 ± 0.051	8.474 ± 0.021
2MA 2306-0502	…	…	…		11.354 ± 0.022	10.718 ± 0.021	10.296 ± 0.023
LP 822-101	…	…	…		8.877 ± 0.027	8.290 ± 0.059	8.004 ± 0.023
2MA 2351-2537	…	…	…		12.471 ± 0.026	11.725 ± 0.022	11.269 ± 0.026

TABLE 4.10 (CONTINUED)

PHOTOMETRY FOR POSSIBLE NEARBY STARS

Star	V_J[a] (mag)	R_{KC}[b] (mag)	I_{KC}[c] (mag)	#[d]	J (mag)	H (mag)	K_S (mag)
LP 704-15	…	…	…		8.636 ± 0.021	8.074 ± 0.029	7.806 ± 0.031

NOTES.—[a]central wavelength 547.5 nanometers (nm)

[b]central wavelength 642.5 nm

[c]central wavelength 807.5 nm

[d]Number in "#" column is the number of observations included.

[e]BD -10°3166 was not part of the sample of possible nearby stars but is included as a possible common proper motion companion to LP 731-76.

REFERENCES.—V_J, R_{KC}, and I_{KC} photometry is from this work. J, H, and K_S photometry is from 2MASS.

The CTIOPI photometry pipeline is described by Jao *et al*. (2005, Jao 2004). Instrumental magnitudes are measured in a 7" radius around stars of interest: parallax candidates, reference stars, or photometric standard stars. The sky background is obtained from an annulus with inner and outer radii of 20" and 25", respectively, around the each star of interest. The Image Reduction and Analysis Faculty (Tody 1986, 1993; hereafter IRAF[14]) fitparams task performs a least-squares calculation to determine the transformation coefficients (a_1, a_2, a_3, a_4, b_1, b_2, b_3, b_4, c_1, c_2, c_3, c_4) that will convert the instrumental magnitudes (m_V, m_R, m_I) of standard stars to those (V, R, I) measured by Landolt (1992) using the following equations

$$\begin{aligned} V &= m_V + a_1 + a_2 AM + a_3(m_V - m_I) + a_4(m_V - m_I)AM \\ R &= m_R + b_1 + b_2 AM + b_3(m_R - m_I) + b_4(m_R - m_I)AM \\ I &= m_I + c_1 + c_2 AM + c_3(m_R - m_I) + c_4(m_R - m_I)AM \end{aligned} \qquad (4.5)$$

where AM represents air mass (Jao 2004). Once the transformation coefficients have been established for a particular night, they are applied to the stars of interest in the fields taken of parallax stars.

The formal errors associated with the V_J, R_{KC}, and I_{KC} photometry in Table 4.10 represent a combination of the errors associated with the standard star transformations for a specific night and the photon error of a particular stellar image. The stars with multiple observations indicate a night-to-night variation of 0.031 magnitude in V_J and 0.014 in R_{KC} and I_{KC}. For another RECONS sample observed at CTIO,

[14]IRAF is distributed by the National Optical Astronomy Observatories, which are operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation.

Henry *et al.* (2004) found larger night-to-night variation in the latter two bands: 0.031 magnitude in V_J, 0.021 in R_{KC}, and 0.020 in I_{KC}. Table 4.11 compares the V_J photometry obtained by CTIOPI with the values available in literature.

Infrared photometry from 2MASS has been included in Table 4.10. The J, H, and K_S errors reported are the total photometric uncertainties. The errors are usually between 0.02–0.03 magnitudes, but range from 0.017 in K_S for LHS 6167 up to 0.061 in H band (1.662 μm; Cohen, Wheaton, & Megeath 2003) for G 75-35.

With a distance and apparent magnitude, calculating absolute magnitude and estimating stellar mass is possible. Table 4.11 lists the absolute V_J magnitudes obtained in this study. Table 4.12 lists the absolute K_S magnitudes calculated from 2MASS photometry along with mass estimates. To obtain masses, the 2MASS J and K_S photometry was transformed to the California Institute of Technology system defined by Elias *et al.* (1982, hereafter CIT with K_{CIT} = 2.2 μm) using the equations by Carpenter (2006). This transformation is necessary to use the K_{CIT}-band mass-luminosity relationship derived by Delfosse *et al.* (2000), which is appropriate for low mass stars no fainter than 9.5 magnitude.

The recent incorporation of a photometric variability model expands the astrometric and photometric reduction software described in Jao (2004); this model

TABLE 4.11
V-BAND PHOTOMETRY FOR POSSIBLE NEARBY STARS

Star	V_{JM} (mag) From Literature	V_{JM} (mag) From CTIOPI	Distance (pc)	Type[b]	M_V[a] (mag)	References	Comment
LP 991-84	14.517 ± 0.007	…	8.64 ± 0.24	r	14.83 ± 0.31	1	
G75-35	13.800 ± 0.002	…	11.83 ± 0.54	r	13.43 ± 0.50	1	
LP 888-18	18.26 ± 0.25	…	13.44 ± 0.70	r	17.62 ± 0.62	2	
LP 889-37	14.52 ± 0.02	…	16.9 ± 1.6	r	13.4 ± 1.0	3	
LHS 5094	14.02 ± 0.02	…	14.0 ± 1.0	r	13.28 ± 0.80	3	
2MA 0429-3123	…	17.471 ± 0.026	15.14 ± 0.89	a	16.57 ± 0.64		binary
LP 834-32	12.38 ± 0.02	…	16.5 ± 1.4	r	11.29 ± 0.89	3	
LP 776-25	11.61 ± 0.02	…	14.1 ± 2.2	r	10.9 ± 1.6	3	
2MA 0517-3349	…	19.833 ± 0.054	17.1 ± 1.3	a	18.67 ± 0.79		
LP 717-36	12.56 ± 0.02	…	18.4 ± 1.2	r	11.24 ± 0.70	3	
LHS 6167	13.76 ± 0.02	13.809 ± 0.019	9.73 ± 0.28	a	13.87 ± 0.32	3	
G 161-71	13.73 ± 0.02	13.757 ± 0.013	14.16 ± 0.56	a	13.00 ± 0.44	3	
LP 731-76	14.39 ± 0.02	14.431 ± 0.026	14.42 ± 0.53	a	13.64 ± 0.41	3	
BD -10°3166[c]	9.223 ± 0.048	10.034 ± 0.026	50 ± 29	a	6.5 ± 4.2	4, 5	
LHS 2397a	18.26 ± 0.25	19.44 ± 0.11	14.29 ± 0.42	a	18.66 ± 0.35	2, 6	binary
LHS 2783	13.39 ± 0.02	…	19.6 ± 1.2	r	11.93 ± 0.66	3	
LP 739-2	14.41 ± 0.02	…	17.3 ± 1.1	r	13.22 ± 0.70	3	
LHS 2880	13.83 ± 0.02	13.863 ± 0.014	25.8 ± 2.2	a	11.80 ± 0.89	3	
2MA 1507-2000	…	18.768 ± 0.068	22.8 ± 1.7	a	16.98 ± 0.80		
LHS 3056	12.84 ± 0.02	12.858 ± 0.019	19.10 ± 0.71	a	11.45 ± 0.41	3	

TABLE 4.11 (CONTINUED)

V-BAND PHOTOMETRY FOR POSSIBLE NEARBY STARS

Star	V_{JM} (mag) From Literature	V_{JM} (mag) From CTIOPI	Distance (pc)	Type[b]	M_V[a] (mag)	References	Comment
2MA 1534-1418	…	19.189 ± 0.052	11.09 ± 0.28	a	18.96 ± 0.29		
LP 869-19	13.21 ± 0.02	13.222 ± 0.014	18.4 ± 1.1	a	11.90 ± 0.63	1	
LP 869-26	14.078 ± 0.016	14.102 ± 0.011	13.97 ± 0.68	a	13.38 ± 0.54	1	new binary
LP 870-65	13.01 ± 0.26	13.019 ± 0.015	17.9 ± 1.5	a	11.76 ± 0.88	1	
LP 756-3	13.762 ± 0.024	13.742 ± 0.029	17.4 ± 1.4	a	12.54 ± 0.88	1	
LP 984-92	13.381 ± 0.026	13.369 ± 0.029	18.9 ± 2.0	a	12.0 ± 1.1	1	
LP 876-10	12.618 ± 0.012	12.583 ± 0.024	7.41 ± 0.19	a	13.23 ± 0.28	1	
LP 932-83	13.93 ± 0.02	…	25.9 ± 4.6	r	11.8 ± 1.7	7	
LP 822-101	13.12 ± 0.00	…	22.7 ± 4.5	r	11.4 ± 1.9	1	

NOTES.—[a]Absolute visual magnitude on Johnson-Morgan system based on CTIOPI V_J photometry when available and on literature values otherwise.

[b]An "a" in the Type column indicates that the distance is from a preliminary absolute parallax while an "r" indicates that the distance is calculated from a preliminary relative parallax.

[c]BD -10°3166 was not part of the sample of possible nearby stars but is included as a possible common proper motion companion to LP 731-76.

REFERENCES.—(1) Reid *et al*. 2003; (2) Salim & Gould 2003; (3) Reid, Kilkenny, & Cruz 2002; (4) Høg *et al*. 2000; (5) Hipparcos; (6) Monet *et al*. 1992; (7) Ryan 1992

TABLE 4.12

STELLAR MASSES ESTIMATED FROM INFRARED PHOTOMETRY

Star	K_S 2MASS[a] (mag)	Distance (pc)	Type[c]	M_K 2MASS (mag)	Stellar Masses[b] ($M_{\odot}$)	Comment
LP 991-84	8.274 ± 0.026	8.64 ± 0.24	r	8.590 ± 0.064	0.134 ± 0.043	
LHS 1363	9.485 ± 0.020	12.42 ± 0.60	r	9.01 ± 0.10	0.111 ± 0.043	
G75-35	8.246 ± 0.027	11.83 ± 0.54	r	7.880 ± 0.098	0.187 ± 0.043	
2MA 0251-0352	11.662 ± 0.019	12.7 ± 1.2	r	11.15 ± 0.19	…	too faint for M-L relationship
LP 888-18	10.264 ± 0.019	13.44 ± 0.70	r	9.62 ± 0.11	…	too faint for M-L relationship
LP 889-37	8.823 ± 0.023	16.9 ± 1.6	r	7.68 ± 0.19	0.206 ± 0.047	
LHS 5094	8.411 ± 0.019	14.0 ± 1.0	r	7.67 ± 0.15	0.207 ± 0.045	
2MA 0429-3123	9.77 ± 0.022	15.14 ± 0.89	a	8.87 ± 0.12	0.118 ± 0.043	binary
LP 834-32	7.406 ± 0.024	16.5 ± 1.4	r	6.31 ± 0.17	0.397 ± 0.052	
LP 776-25	6.891 ± 0.027	14.1 ± 2.2	r	6.15 ± 0.30	0.427 ± 0.070	
2MA 0517-3349	10.832 ± 0.024	17.1 ± 1.3	a	9.67 ± 0.15	…	too faint for M-L relationship
LP 717-36	7.623 ± 0.027	18.4 ± 1.2	r	6.30 ± 0.13	0.398 ± 0.049	
LHS 6167	7.733 ± 0.017	9.73 ± 0.28	a	7.793 ± 0.062	0.195 ± 0.043	
2MA 0921-2104	11.69 ± 0.023	11.48 ± 0.35	r	11.391 ± 0.068	…	too faint for M-L relationship
G 161-71	7.601 ± 0.018	14.16 ± 0.56	a	6.845 ± 0.085	0.310 ± 0.044	
LP 731-76	8.64 ± 0.021	14.42 ± 0.53	a	7.845 ± 0.080	0.190 ± 0.043	
BD -10°3166[d]	8.124 ± 0.026	50.2 ± 29.3	a	4.62 ± 0.80	0.74 ± 0.17	
LHS 2397a[e]	10.735 ± 0.023	14.29 ± 0.42	a	9.960 ± 0.066	…	too faint for M-L relationship
LHS 2783	8.089 ± 0.023	19.6 ± 1.2	r	6.63 ± 0.13	0.343 ± 0.047	binary
LP 739-2	8.887 ± 0.020	17.3 ± 1.1	r	7.70 ± 0.13	0.204 ± 0.045	
LHS 2880	8.163 ± 0.029	25.8 ± 2.2	a	6.10 ± 0.17	0.435 ± 0.053	

TABLE 4.12 (CONTINUED)
STELLAR MASSES ESTIMATED FROM INFRARED PHOTOMETRY

Star	K_S 2MASS[a] (mag)			Distance (pc)			Type[c]	M_K 2MASS (mag)			Stellar Masses[b] ($M_\odot$)			Comment
2MA 1507-2000	10.661	±	0.021	22.8	±	1.7	a	8.87	±	0.15	0.118	±	0.043	
LHS 3056	7.582	±	0.020	19.10	±	0.71	a	6.177	±	0.080	0.421	±	0.038	
2MA 1534-1418	10.305	±	0.023	11.09	±	0.28	a	10.080	±	0.058		…		too faint for M-L relationship
LP 869-19	7.816	±	0.031	18.4	±	1.1	a	6.50	±	0.12	0.365	±	0.047	
LP 869-26	8.265	±	0.027	13.97	±	0.68	a	7.54	±	0.10	0.221	±	0.044	possible new binary
LP 870-65	7.701	±	0.029	17.9	±	1.5	a	6.44	±	0.17	0.375	±	0.051	
LP 756-3	8.435	±	0.021	17.4	±	1.4	a	7.23	±	0.17	0.257	±	0.047	
LP 984-92	7.793	±	0.026	18.9	±	2.0	a	6.41	±	0.21	0.381	±	0.056	
LP 876-10	7.206	±	0.021	7.41	±	0.19	a	7.856	±	0.057	0.189	±	0.043	
LP 932-83	8.474	±	0.021	25.9	±	4.6	r	6.41	±	0.33	0.380	±	0.071	
2MA 2306-0502	10.296	±	0.023	12.41	±	0.62	r	9.83	±	0.11		…		too faint for M-L relationship
LP 822-101	8.004	±	0.023	22.7	±	4.5	r	6.23	±	0.36	0.412	±	0.078	

NOTES.—[a]K_S photometry is from 2MASS.

[b]Stellar masses calculated using the K_{CIT} band mass-luminosity relationship from Delfosse *et al*. (2000). K_S (2MASS) was transformed to K_{CIT} using the transformations by Carpenter (2006). Errors are calculated from errors in photometry plus estimated errors associated with mass-luminosity relationship used.

[c]An “a” in the Type column indicates that the distance is from a preliminary absolute parallax while an “r” indicates that the distance is calculated from a preliminary relative parallax.

[d]BD -10°3166 was not part of the sample of possible nearby stars but is included as a possible common proper motion companion to LP 731-76.

[e]Distance for LHS 2397a is based on trigonometric parallax in Monet *et al*. (1992).

follows the methodology of Honeycutt (1992; Henry *et al*. 2006). Instrumental magnitudes for the parallax star and its reference stars are obtained for each astrometric observation and plotted. After the variability of the stars of interest to this study was evaluated in 2006 May, a problem with the magnitudes derived in this manner has been detected. Flares and significant photometric variation detected by the old software are still valid (W.C. Jao 2006, private communication); however, during the final parallax reduction, the variability of these stars will be re-checked using the revised software.

All M stars are probably variable at the 0.02–0.10 magnitude level over long periods (Bessell 1991). None of the possible nearby stars demonstrated any changes in brightness of 0.1 magnitude or greater. Five of twelve reference stars for LP 717-36 show excursions in magnitude on 2004 September 26 that are probably due to the bright sky background just before dawn. Five of nine reference stars for LP 822-101 show excursions in magnitude on 2004 November 20 that are also probably due to the bright sky background that night; one of its reference stars shows some evidence of flaring (W. C. Jao 2006, private communication).

4.5 SPECTROSCOPY

The initial subsample of forty-three stars included eighteen stars either with no spectral type or at most with spectral type "MVe." These stars were added to the RECONS spectroscopy program on the 1.5-meter CTIO telescope, which is described by Henry *et al*. (2004). Later, the spectroscopy-observing list was expanded to include a total of forty stars from this sample.

Stars are observed with the Ritchey-Chrétien spectrograph using grating 32 and the Loral 1,200 x 800 pixel charge-coupled device (CCD) detector. This combination provides 0.86-nm resolution from 600 to 950 nm. The resulting spectra were reduced using IRAF for bias subtraction and flat-fielding with either dome or sky flats. The appropriate flats were used to remove fringing. Next, the ALLSTAR program (Henry *et al*. 2002) compared the new spectra to those available in its library of approximately 500 late type stars.

As of 2006 September 30, spectral types were available for thirty-two nearby stars, which are listed in Table 4.13. The expected error in these spectral types is ± 0.5 subclass. For comparison, Table 4.13 also lists the initial spectral types taken from the literature when selecting this subsample.

When provided in the literature, the errors associated with these values were also ± 0.5 subclass. In addition, Scholz, Meusinger, and Jahreiß (2005) recently published new spectral types for *NLTT* stars. Lodieu *et al*. (2005) also published new spectral types for red, high-proper motion stars in the southern hemisphere with formal errors of 0.5 subclasses for optical spectra. With the inclusion of these spectral types, all stars in this subsample now have spectral types.

TABLE 4.13
SPECTRAL TYPES FOR POSSIBLE NEARBY STARS

Star	Spectral Types from Literature Initial	Recent	RECONS	References	Comment
LP 991-84	…	…	M4.5V	1	
LHS 1363	M6.5V	…	M5.5V	2, 1	
G 75-35	M4.0V	M4.5V	M4.0V	3, 4, 1	
2MA 0251-0352	L3	…	…	2	
LP 888-18	M7.5V	M8.0V	M8.0V	2, 12, 1	
LP 889-37	…	…	M4.5V	1	
LHS 5094	…	…	M4.5V	1	
2MA 0429-3123	M7.5V	…	M6.5V	2, 1	joint, see Table 4.15
LP 834-32	…	…	M3.5V	1	
LP 655-43	…	M4.0V	M4.5V	4, 1	
LP 716-10	M5.5V	M5.5V	M5.0V	3, 4, 1	
LP 776-25	…	M3.0V	M3.0V	4, 1	
2MA 0517-3349	M8V	…	M8.0V	2, 1	
LP 717-36	…	M4.0V	M3.5V	4, 1	
LHS 2024	M4V	…	M4.5V	5	
LHS 6167	M4-5	M5.0V	M4.5V	6, 4, 1	
2MA 0921-2104	L2	…	…	7	
G 161-71	M5Ve	M5.0V	M5.0V	8, 4, 1	
LP 671-8	M3-4	M4.0V	…	6, 4	
LP 731-76	M4-5	M5.0V	M4.5V	6, 4, 1	
BD -10°3166[a]	K0V	…	K4.0V	9, 1	
LHS 2397a	M8.5V	…	M8.0V	10, 1	joint, see Table 4.19
2MA 1155-3727	L2	…	…	12	
LP 734-34	…	M4.0V	M4.0V	4, 1	
LP 615-149	…	M3.5V	M3.5V	4, 1	
LHS 5226	…	M4.5V	M4.0V	4, 1	
CE 303	M8V	M8.0V	…	2, 12	
LHS 2783	M4V	…	…	5	joint, not yet resolved
LP 739-002	…	M4.0V	M4.0V	4, 1	
LHS 2880	M4.5V	…	…	5	
2MA 1507-2000	M7.5V	…	…	2	
LHS 3056	M4V	…	…	5	
2MA 1534-1418	M8V	…	…	11	
LP 869-19	…	M4.0V	M4.0V	4, 1	
LP 869-26	…	M5.0V	M4.5V	4, 1	joint, poss. new binary
LP 870-65	…	M4.5V	M4.0V	4, 1	
LP 756-3	M5-6	M4.0V	M4.0V	13, 4, 1	
LP 984-92	…	…	M4.5V	1	

TABLE 4.13 (CONTINUED)
SPECTRAL TYPES FOR POSSIBLE NEARBY STARS

Star	Spectral Types from Literature Initial	Recent	RECONS	References	Comment
LP 876-10	…	M4.0V	M4.0V	4, 1	
LP 932-83	…	M5.0V	M4.5V	4, 1	
2MA 2306-0502	M7.5V	…	…	2	
LP 822-101	…	M3.0V	M3.5V	4, 1	
2MA 2351-2537	L1	M9.0V	M8.5V	7, 12, 1	
LP 704-15	M3V	…	M3.5V	5, 1	

NOTES.—Papers that estimate errors in spectral type give errors of ± 0.5 subclasses. The error in RECONS spectral types is ± 0.5 subclasses.
REFERENCES.—(1) T. D. Beaulieu 2006, private communication; (2) Cruz *et al*. 2003; (3) Cruz & Reid 2002; (4) Scholz, Meusinger, & Jahreiß 2005; (5) Reid, Hawley, & Gizis 1995; (6) Gigoyan, Hambaryan, & Azzopardi 1998; (7) K. I. Cruz 2003, private communication; (8) Torres *et al*. 2000; (9) Butler *et al*. 2000; (10) Gizis *et al*. 2000; (11) Gizis 2002; (12) Lodieu *et al*. 2005; (13) Abrahamyan *et al*. 1997

With additional spectral type information now available and final 2MASS photometry, spectroscopic distance estimates may be made or updated for those stars in the subsample dropped from the astrometric program. Table 4.14 provides revised spectroscopic distance estimates calculated in the manner described in 4.2.2 along with recent distance estimates from the literature, where available. The status of each of these possible nearby stars is discussed in more detail below.

TABLE 4.14

REVISED SPECTROSCOPIC DISTANCE ESTIMATES FOR POSSIBLE NEARBY STARS

Star	Spectral Type	Literature[a] Distance (pc)	Spectroscopic[b] Distance (pc)	References	Comment
LP 655-43	M4.5V	18.7 ± 3.7	15.3 ± 5.4	1, 2	
LP 716-10	M5.0V	14.2 ± 2.8	17.7 ± 6.2	1, 2	
LHS 2024	M4.5V	13.9 ± 1.8	17.9 ± 6.3	1, 3	
LP 671-8	M4.0V	12.6 ± 2.5	12.0 ± 4.3	2	
2MA 1155-3727	L2	12.6 …	120 ± 110	5	poor spectroscopic estimate
LP 734-34	M4.0V	15.4 ± 3.1	15.3 ± 5.4	1, 2	
LP 615-149	M3.5V	15.5 ± 3.1	14.6 ± 5.1	1, 2	
LHS 5226	M4.0V	13.6 ± 2.7	13.0 ± 4.7	1, 2	
CE 303	M8.0V	13.6 ± 1.6	12.1 ± 3.5	6	
2MA 2351-2537	M8.5V	16.0 ± 1.9	15.6 ± 4.5	1	
LP 704-15	M3.5V	13.2 ± 1.7	13.8 ± 4.8	1, 4	

NOTES.—[a]Distance estimates from literature include photometric and spectroscopic techniques.

[b]Spectroscopic distance estimates are from this work as discussed in section 4.2.2.

REFERENCES.— (1) T. D. Beaulieu 2006, private communication; (2) Scholz, Meusinger, & Jahreiß 2005; (3) Reid, Hawley, & Gizis 1995; (4) Reid & Cruz 2002; (5) K. I. Cruz 2003, private communication; (6) Lodieu *et al*. 2005

4.5.1 LP 655-43

The photometric distance estimate by Reid, Kilkenny, and Cruz (2002) for LP 655-43 is 14.7 ± 1.2 pc, which places it just inside the 15-pc limit for the selection of this subsample. Based on it being a M4.5V star (T. D. Beaulieu 2006, private communication), a spectroscopic distance of 15.3 ± 5.4 pc was estimated. It has a V_{JM} magnitude of 14.44 ± 0.02 (Reid, Kilkenny, & Cruz 2002). LP 665-43 is still a possible nearby star; RECONS should eventually consider reinstating it.

4.5.2 LP 716-10

LP 716-10 is another star at the edge of the 15-pc selection limit for this subsample. Cruz and Reid (2002) estimated the distance spectroscopically as 14.3 ± 1.8 pc, just inside the 15-pc selection limit for this subsample. They assigned it a spectral type of M5.5V, which agrees with Scholz, Meusinger, & Jahreiß (2005). The recent RECONS spectral type is slightly earlier, M5.0V (T. D. Beaulieu 2006, private communication), which places is at a greater distance of 17.7 ± 6.2 pc. In addition, LP 716-10 would be difficult to observe with the CTIO 0.9-meter telescope because its $V_{photographic}$ is only 15.97 ± 0.25 (Salim & Gould 2003). Had this photometry been considered during sample selection, LP 716-10 would not have been included in the subsample.

4.5.3 LHS 2024

The photometric and spectroscopic distance estimates to LHS 2024 vary. Reid and Cruz (2002) estimated the distance to LHS 2024 as 13.9 ± 1.8 pc using spectral indices. Based on a spectral type of M4.5V (T. D. Beaulieu 2006, private communication), a spectroscopic distance of 17.9 ± 6.3 pc was calculated, which would be outside the 15-pc selection limit. Its V_E magnitude of 15.0 ± 0.01 (Eggen 1987; Ryan 1989) is at the limit of what can be observed easily at the CTIO 0.9-meter telescope. Therefore, LHS 2024 was dropped after nine observations. LHS 2024 is still a possible nearby star. Depending on the quality of the frames available, a rough preliminary parallax may be obtained from the current observations. Such an estimate would be the best method of determining whether further observations should be considered.

4.5.4 LP 671-8

LP 671-8 appears to be a nearby star based on photometric and spectroscopic estimates. The estimated photometric distance is 13.3 ± 1.8 pc (Reid, Kilkenny, & Cruz 2002. Using a spectral type of M3-4 (Gigoyan, Hambaryan, & Azzopardi 1998), a spectroscopic distance of 15.3 ± 5.3 pc was calculated, but, using the more recent spectral type of M4.0V (Scholz, Meusinger, & Jahreiß 2005), a spectroscopic distance of 12.0 ± 4.3 pc is obtained. Reid, Kilkenny, and Cruz (2002) also provide a V_{JC} magnitude of 13.24 ± 0.02, which indicates LP 671-8 could be comfortably observed by the CTIO 0.9-meter telescope. LP 671-8 should continue to be of interest to RECONS.

4.5.5 2MA 1155-3727

Although 2MA 1155-3727 was initially accepted for parallax determination, it was dropped without being set-up. Cruz (2003, private communication) estimated the distance to 2MA 1155-3727 to be 12.6 pc and identified it as having spectral type L2. The method of spectroscopic distance estimates described in section 4.2.2 does not appear to work well when extrapolated to L dwarfs as shown in Table 4.4. Since this star was dropped from the subsample, Deacon, Hambly, and Cook (2005) identified it as a high proper motion object, moving 870 ± 40 mas yr^{-1} in 172.5°. 2MA 1155-3727 is a possible nearby brown dwarf and because so few brown dwarf parallaxes are available, it should remain of interest to RECONS.

4.5.6 LP 734-34

Henry *et al.* (2004) announced improved photometric relationships for RECONS distance estimation; the application of these to LP 734-34 might allow it to be properly prioritized within the larger RECONS program. After initially accepting this object for inclusion within the sample, it was dropped without being set up. Initially, Reid, Kilkenny, and Cruz (2002) estimated the photometric distance as 12.9 ± 1.16 pc. However, spectroscopic distance estimates placed this star just outside of the 15-pc selection limit. If the spectral type is M4.0V (T. D. Beaulieu 2006, private communication), a spectroscopic distance of 15.3 ± 5.4 pc may be estimated. For the same spectral type, Scholz, Meusinger, and Jahreiß (2005) calculated a distance of 15.4 ± 3.1 pc. LP 734-34 is still a possible nearby star.

4.5.7 LP 615-149

Initially, LP 615-149 was thought to be at the selection limit of this subsample because of a photometric distance estimate of 15.0 ± 1.7 pc (Reid, Kilkenny, & Cruz 2002). Recently, a distance of 14.6 ± 5.1 pc was estimated based on the RECONS spectral type of M3.5V. However, Scholz, Meusinger, and Jahreiß (2005) place it at a distance of 15.5 ± 3.1 pc based on the same spectral type. Although LP 615-149 was initially accepted for parallax determination, it was dropped without being set-up. LP 615-149 is still a possible nearby star. The application of the improved RECONS photometric distance relationships (Henry *et al*. 2004) to LP 615-149 might allow it to be properly prioritized within the larger RECONS program.

4.5.8 LHS 5226

LHS 5226 is apparently within 15 pc, and should remain of interest to RECONS. It was initially accepted for parallax determination, but was dropped without being set-up. Using photometry, Reid, Kilkenny, and Cruz (2002) estimated the distance to LHS 5226 as 12.5 ± 0.9 pc. Spectroscopically, assuming it is a M4.0V type star (T. D. Beaulieu 2006, private communication), the distance would be 13.0 ± 4.7 pc, which is consistent with the photometric estimate.

4.5.9 CE 303

Cruz *et al*. (2003) estimated the spectroscopic distance to CE 303 as 13.3 ± 1.1 pc and assigned it a spectral type of M8V. From that spectral type, a distance of 12.0 ± 3.5 pc was estimated in section 4.2.2. Lodieu *et al*. (2005) also identified CE 303 as an M8.0V star at a distance of 13.6 ± 1.6 pc and with a proper motion of 376 ± 2 mas yr^{-1} in 179 ± 1°. CE 303 continues to be a possible nearby star and should continue to be of interest to RECONS.

4.5.10 2MA 2351-2537

2MA 2351-2537 is an interesting object. K. I. Cruz (2003, private communication) estimated the distance to 2MA 2351-2537 as 13.2 pc and identified it as having spectral type L1. The method of spectroscopic distance estimates described in section 4.2.2 does not appear to work well when extrapolated to L dwarfs as shown in Table 4.4. Now that it is thought to have a spectral type of M8.5V (T. D. Beaulieu 2006, private communication), a revised spectroscopic distance estimate of 15.6 ± 4.5 pc is obtained, which is just beyond the selection limit of this subsample. Pokorny, Jones, and Hambly (2003) identified it as a high proper motion object, moving at 420 ± 30 mas

yr^{-1} in 60.44°. 2MA 2351-2537 was initially accepted for parallax determination but was dropped after twelve observations. 2MA 2351-2537 is still a possible nearby star or brown dwarf. Depending on the quality of the frames available, a rough preliminary parallax may be obtained from the current observations. Such an estimate would be the best method of determining whether further observations should be considered.

4.5.11 LP 704-15

The distance to LP 704-15 is estimated to be 13.2 ± 1.7 pc using spectral indices (Reid & Cruz 2002) which is consistent with a spectroscopic distance of 13.8 ± 4.8 pc obtained from the recent RECONS spectral type of M3.5V (T. D. Beaulieu 2006, private communication). Thus, it is slightly inside the study volume. LP 704-15 was initially accepted for parallax determination but was dropped after seven observations. LP 704-15 is still a possible nearby star. These frames might permit a rough preliminary parallax to be obtained and help determine whether further observations should be made. An additional consideration is the presence of LP 704-14, a possible common proper motion companion, in these frames as discussed in 4.6.8.

4.6 MULTIPLICITY

About 67% of systems containing solar-type stars appear to be multiples (Duquennoy & Mayor 1991), while the fraction of M dwarfs, like the majority of the stars in this subsample, that are the primary component of a multiple system appears to be closer to 32–42% (Henry & McCarthy 1990; Fischer & Marcy 1992). For the later types, M8.0-L0.5, Close *et al*. (2003) find that 15% have companions of similar or lower mass. In earlier work, Worley (1977) found that 38% of nearby systems and 22% of systems with an M dwarf primary were non-single. This subsample could be expected to include as many as eighteen binaries. As shown in Table 4.1 and discussed below, three close binaries and four common proper motion pairs had been previously identified.

In addition, CTIOPI resolved one new binary, LP 869-26, into two components and identified eleven stars that are at least 1.5 times more distant than their photometric or spectroscopic distances would indicate. If all of these identifications are confirmed, then the stars of this subsample are associated with eighteen binaries plus one triple star system, which would be within expectations. However, even the previously identified binaries could use additional observations to confirm and strengthen the assertion that they are physically related. Moreover, the apparently single stars discussed herein may eventually be resolved into additional components or have more distant companions identified.

4.6.1 2MA 0429-3123AB

Close (2003; Siegler *et al*. 2005) resolved 2MA 0429-9123 as a close, very low mass binary using the adaptive optics system on the Very Large Telescope (VLT). The stellar components are separated by 531 ± 2 mas with a 50^{+12}_{-11} year orbit; Table 4.15 lists additional physical characteristics. Although they argue that the probability of a chance alignment of 2MA 0429-3123 with a background L dwarf is negligible, they provide no proper motion for 2MA 0429-3123B. The photometric and spectroscopic distance estimates in Table 4.16 indicate the star is slightly closer than the distance calculated by preliminary absolute parallax. Such discrepancies can be evidence of a binary star; however, the two photometric estimates considered the nature of the double star. The individual components are not resolved in any of the CTIOPI observations through 2005 November 22. Additional observations of the individual objects are necessary to determine whether 2MA 0429-3123 is a binary or merely an optical double.

TABLE 4.15
CHARACTERISTICS OF 2MA 0429-3123AB

Characteristic	2MA 0429-3123A	2MA 0429-3123B	Reference	Comment
Spectral Type	M7.5 ± 1.5	L1.0 ± 1.5	1	photometric
I_{KC} (mag)	14.052 ± 0.019	…	2	1 joint observation
K_S (mag)	10.14 ± 0.03	11.12 ± 0.07	1	
Mass ($M_\odot$)	0.073–0.104	0.061–0.085	1	from models

REFERENCES.—(1) Siegler *et al*. 2005; (2) this work, section 4.4

TABLE 4.16
DISTANCE ESTIMATES FOR 2MA 0429-3123AB

Technique	Distance (pc)	Distance Ratio	Ref.	Comment
Absolute Parallax	15.14 ± 0.89	…	1	preliminary
Spectroscopic	9.7 ± 0.9	1.6	2	
Photometric (prob.)	11.1 …	1.4	3	separates components
Spectroscopic	8.9 ± 2.7	1.7	4	joint
Photometric	11 ± 2	1.4	5	resolved binary components

NOTE.—Distance ratio is the preliminary absolute parallax divided by the distance estimate from the corresponding technique.
REFERENCES.—(1) this work, section 4.3; (2) Cruz *et al*. 2003; (3) Close 2003; (4) this work, section 4.2.2; (5) Siegler *et al*. 2005

4.6.2 LP 731-76 and BD -10˚3166

The *NLTT* identifies LP 731-76 as a common proper motion companion to BD -10˚3166, which has gained significant attention as the host of an extrasolar planet (Butler *et al*. 2000). Luyten described it as having a separation of 180 mas and an orbital period of 219 days. Together, these stars are known as LDS 4041. More recent measurements listed in Table 4.17 do not appear to support the common proper motion identification. I. N. Reid (2004, private communication) also indicated that a comparison of Palomar Optical Sky Survey images with 2MASS images did not support the pairing and Scholz, Meusinger, and Jahreiß (2005) call it a "dubious common proper motion" pairing.

Photometric and spectroscopic distance estimates place these stars at significantly different distances, as shown in Table 4.18. The estimates for LP 731-76 range from 11 to 16 pc while those for BD -10˚3166 fall between 34 and 68 pc. The distance estimates from the SuperCosmos Sky Survey (Hambly *et al*. 2001; hereafter SSS) scans of photographic plates overlap but the CTIOPI photometric distances differ by more than three times their errors (Raghavan *et al*. 2006).

The preliminary relative and absolute parallaxes support the theory that LP 731-76 and BD -10˚3166 are too far apart to be related physically, as also shown in Table 4.7 and Table 4.18. The distance measurements do not overlap within the range of formal errors. However, they do overlap when the ranges are extended to twice the formal errors; the probability of such an occurrence is 14% (Beers 1957). The error associated with the preliminary relative parallax of BD -10˚3166 is especially large, 7.3 mas

TABLE 4.17

PROPER MOTIONS FOR LP 731-76 AND BD -10˚3166

Source	Proper Motion (mas yr^{-1}) LP 731-76	Proper Motion (mas yr^{-1}) BD -10˚3166	Position Angle of Proper Motion (degrees) LP 731-76	Position Angle of Proper Motion (degrees) BD -10˚3166	Comment
NLTT	203 …	203 …	250 …	250 …	identified as common proper motion pair
SSS	202 ± 10	189 ± 10	242 …	252 …	common proper motion within errors
UCAC2	245 ± 1	187 ± 2	245 ± 1	268.1 ± 0.4	proper motions appear different
CTIOPI	218.1 ± 4.5	184 ± 19	244.5 ± 2.2	272.5 ± 8.6	proper motions appear different, large errors

REFERENCES.—SSS proper motions are from Raghavan *et al*. 2006 and Hambly *et al*. 2001. CTIOPI values are preliminary proper motions from this work. UCAC2 is Zacharias *et al*. 2004.

TABLE 4.18

DISTANCE ESTIMATES FOR LP 731-76 AND BD -10˚3166

Method	Distance Estimates (pc) LP 731-76	Distance Estimates (pc) BD -10˚3166	References	Comment
Photometric	11.6 ± 0.8		1	motivated initial selection
Spectroscopic, based on M4.5	13.9 ± 4.9		2	too early for estimate (BD)
Spectroscopic, based on M5.0	11.0 ± 2.2		3	
Photometric		64	3	
Photometric, SSS—digitized photographic plates	16.4 ± 10.1	33.8 ± 8.8	4	
Photometric, RECONS—CCD observations	12.5 ± 2.0	66.8 ± 10.0	4	
Photometric, Ryan and Hipparcos		68	4, 5, 6	
Photometric and spectroscopic (M4-5V and K0V)	13	67	7	
Preliminary relative parallax	14.34 ± 0.58	57 ± 42	8	large parallax errors (BD)
Preliminary absolute parallax	14.42 ± 0.53	50 ± 29	8	large parallax errors (BD)

NOTE.—(9) describes the distance to BD -10˚3166 as “considerably less than 200 pc.”

REFERENCES.—(1) Reid, Kilkenny, & Cruz 2002; (2) section 4.2.2 of this work; (3) Scholz, Meusinger, & Jahreiß 2005; (4) Raghavan *et al*. 2006; (5) Ryan 1992; (6) Hipparcos; (7) Mugrauer *et al*. 2006; (8) section 4.3 of this work; (9) Butler *et al*. 2000 compared to the 4.7-mas average for the preliminary parallaxes in this study or the 3-mas threshold for final parallaxes. Only two stars in this subsample, LP 822-101 and LP 776-25, have larger errors. The quality of the parallax measured for BD -10˚3166 is also discussed in 4.3.1.3. The final trigonometric parallaxes for these stars from CTIOPI should resolve the issue and will probably uphold the growing consensus that these two stars are physically unrelated.

4.6.3 LHS 2397aAB

Freed, Close, and Siegler (2003) resolved LHS 2397a into a binary using the Hokupa'a adaptive optics system on the Gemini North telescope. They estimate this very low mass binary to have an orbital period of 22 years (Siegler *et al*. 2005) based on a separation of about 227.72 ± 0.3 mas (Freed, Close, & Siegler 2003); other physical characteristics of the stars are listed in Table 4.19. Although they argue that the probability of a chance alignment of LHS 2397a, a high proper motion star, with a background L dwarf is negligible, the agreement between the available proper motions is not great. Basri and Reiners (2006) failed to detect any variation in its radial velocity. The individual components are not resolved in any of the CTIOPI observations through 2006 May 15. Additional observations could provide better data for determining whether these two objects are physically related.

TABLE 4.19
CHARACTERISTICS OF LHS 2397aAB

Characteristic	LHS 2397aA	LHS 2397aB	Ref.	Comment
Spectral Type	M8.0V ± 1	…	1	joint
Spectral Type	M8 ± 1	L7.5 ± 1	2	photometric
I_{KC} (mag)	14.862 ± 0.016	…	3	1 joint observation
$I_{Cousins}$ (mag)	15.07 ± 0.03	19.49 ± 0.17	2	
K_S (mag)	10.80 ± 0.03	13.57 ± 0.10	2	
Mass ($M_\odot$)	0.089–0.094	0.068–0.069	2	from models
μ (mas yr^{-1})[a]	513.4 ± 7.8	555.1 ± 8.2	4, 2	poor agreement
μ (mas yr^{-1})[a]	515 ± 10[b]	…	5	
μ Position Angle (°)[c]	263.8 ± 0.9	259.6 ± 0.9	4, 2	
μ Position Angle (°)[c]	261 ± 5[b]	…	5	

NOTE.— [a]Proper motion measurements for LHS 2397a are used for LHS 2397aA.
[b]Error estimated from (6).
[c]Position angle of proper motion measurements for LHS 2397a are used for LHS 2397aA.
REFERENCES.—(1) T. D. Beaulieu 2006, private communication; (2) Freed, Close, & Siegler 2003; (3) this work, section 4.4; (4) Tinney 1996; (5) Luyten 1979; (6) Bakos, Sahu, & Nemeth 2002

4.6.4 LHS 2783AB

Eggen (1993) identified LHS 2783 as a binary member of the Hyades supercluster. He identified all stars within 20 pc of the Sun and with proper motions greater than 500 mas yr^{-1} as potential members of the Hyades supercluster. He, then, separated single members from binary members based on their total velocity; binary members, like LHS 2783, had total velocities between 30 and 40 km s^{-1}. The two components of this hypothetical binary have not been resolved. Treating LHS 2783 as a single star, he calculated an I-band distance modulus of 0.60 magnitudes, which corresponds to a distance of approximately 13.2 pc similar to the literature and spectroscopic distances listed in Table 4.4. When he took its binary nature into consideration, he obtained a distance modulus of 1.07 magnitudes, which corresponds to a distance of 16.37 pc. The latter is closer to the distance of 19.6 ± 1.2 pc from the preliminary relative parallax by CTIOPI. Although the discrepancy between the photometric and spectroscopic distances provides some support for the binary nature of this star, the current CTIOPI observations of LHS 2783 are unlikely to confirm Eggen's assertion.

4.6.5 LP 869-26AB

LP 869-26 was resolved as a binary star in 2006 May by CTIOPI as shown in Figure 4.6; a finding chart is also available in Appendix A. A review of the individual images and observer's notes indicated that it might be a binary because the point-spread function of this star did not match those of the reference stars. The second component appears to be at a distance of 730 ± 31 mas and 356.85 ± 0.13° east of north.

Earlier photometric and spectroscopic distance estimates placed LP 869-26 near the boundary of the 10-pc sample: 9 ± 1 pc, photometric (Reid *et al*. 2003); 10.7 pc, photometric (Jahreiß 2005); and 9 ± 2 pc, spectroscopic (Scholz, Meusinger, & Jahreiß 2005). Our preliminary absolute parallax indicates a slightly greater distance of 13.97 ± 0.68; part of the discrepancy may be due to unrecognized joint photometry of this pair. LP 869-26AB is clearly resolved in only a single frame at this time. Therefore, the possibility that LP 869-26B may be a faint background star cannot be eliminated. Additional observations are necessary to determine the nature of this new star and its relationship to LP 869-26A.

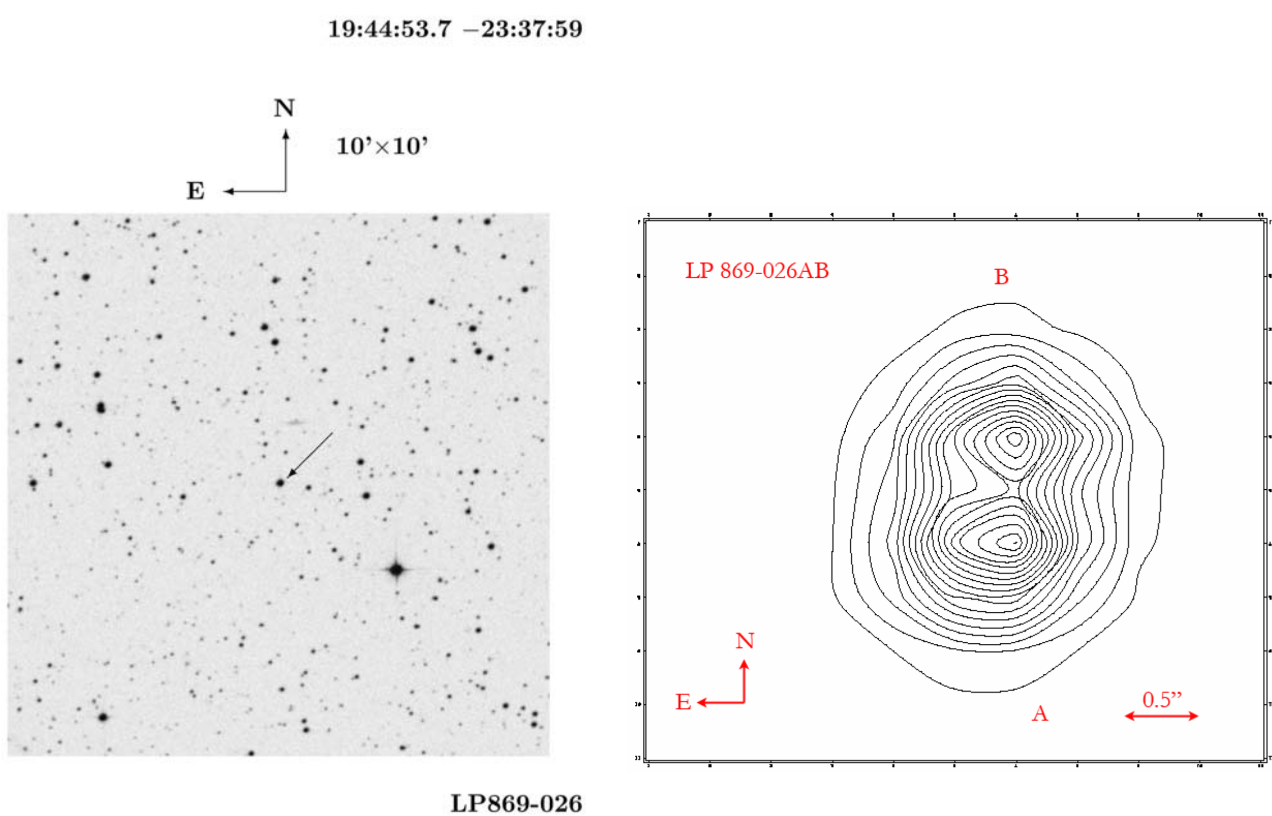

FIG. 4.6.— LP 869-026AB Finding Chart and Contours. (Finding Chart DSS2 Red Image © Anglo-Australian Observatory Board. Contours CTIOPI astrometry image taken on 2006 May 11). These contours are extracted from a 10-second exposure with 0.8” seeing through the R_{KC} filter using the IRAF imexamine task. The B component appears to be at a distance of 730 ± 31 mas and 356.85 ± 0.13º east of north. Annotations by R. J. Paterson, J. L. Bartlett, & J. L. Bartlett.

4.6.6 LP 984-92 and LP 984-91

The *NLTT* identifies LP 984-92 as a common proper motion companion to LP 984-91 with a 36” separation and a 133-day orbit. LP 984-91 also has a M4.5 companion, LHS 3524 (Song, Bessell, & Zuckerman 2002). The proper motions listed in Table 4.20 do not agree within the range of their formal errors. In addition, the CTIOPI preliminary relative parallax for LP 984-92 does not overlap with the Hipparcos absolute parallax for LP 984-91 within the range of formal errors (ESA 1997; hereafter Hipparcos). However, they do overlap when the ranges are extended to twice the formal errors; the probability of such an occurrence is 14% (Beers 1957). The error associated with the preliminary relative parallax of LP 984-92 is above the average for this work, 5.1 mas versus 4.7-mas average, and the error of the Hipparcos parallax for LP 984-01 is greater than 3 mas, the maximum error allowed in a final CTIOPI parallax. If the images of LP 984-91 are not saturated in the LP 984-92 observations, a new parallax for LP 984-91 could be measured using the same frames. Even if the final CTIOPI parallaxes for these stars show that they are not physically related, improved distance measurements for these members of the solar neighborhood will enhance the nearby star census.

TABLE 4.20
CHARACTERISTICS OF LP 984-92 AND LP 984-91

Characteristic	LP 984-92	LP 984-91[a]	Ref.	Comment
Spectral Type	…	M4.0 ± 0.5[b]	1	Pre-MS
V_{JM} (mag)	13.369 ± 0.029	11.70 …	2, 3	1 CTIOPI obs.
NLTT μ (mas yr^{-1})	206 ± 25[c]	206 ± 25[c]	4	identified cpm
UCAC2 μ (mas yr^{-1})	203 ± 14	249.2 ± 2.4	5	
CTIOPI μ (mas yr^{-1})	221.0 ± 6.3	…	6	preliminary
NLTT μ Position Angle (°)	120 …	120 …	4	identified cpm.
UCAC2 μ Position Angle (°)	126.6 ± 3.9	118.50 ± 0.52	5	
CTIOPI μ Position Angle (°)	123.0 ± 3.2	…	6	preliminary
Absolute Parallax (mas)	…	42.35 ± 3.37	3	
Relative Parallax (mas)	51.6 ± 5.1	…	6	preliminary

NOTE.— [a]LP 984-91 is a pre-main sequence (pre-MS) binary with a M4.5 companion, LHS 3524 (1).
[b]Error is estimated from (7).
[c]Error is estimated from (8).

REFERENCES.—(1) Song, Bessell, & Zuckerman 2002; (2) this work, section 4.4; (3) Hipparcos; (4) NLTT; (5) Zacharias *et al*. 2004; (6) this work, section 4.3; (7) Reid, Hawley, & Gizis 1995; (8) Gould & Salim 2003;

4.6.7 LP 932-83 and LTT 9210

LP 932-83 is the common proper motion companion of LTT 9210, which together are identified as LDS 4999. According to the *LDS*, their separation is 217.0”. As shown in Table 4.21, the proper motions are very close to being the same within the errors. However, within the range of formal errors, our preliminary relative parallax for LP 932-83 does not overlap with the absolute parallax of LTT 9210 from Hipparcos. The distances do overlap when the ranges are extended to twice the formal errors; the probability of such an occurrence is 14% (Beers 1957). The error associated with the preliminary relative parallax of LP 932-83 is above the average for this work, 5.8 mas versus 4.7-mas average. The quality of the parallax is also discussed in 4.3.2.5 and the possibility that LP 932-83 is also a close binary is mentioned in 4.6.9. The final trigonometric parallaxes for LP 932-83 from CTIOPI should resolve its relationship with LTT 9210 and will probably indicate that two stars are physically unrelated.

TABLE 4.21
CHARACTERISTICS OF LP 932-83 AND LTT 9210

Characteristic	LP 932-83			LTT 9210			Ref.	Comment
Spectral Type	M5.0V	±	0.5	K7V	…		1, 2	
V_{JM} (mag)	13.93	±	0.02	10.7	±	0.1	3, 4	
LDS μ (mas yr^{-1})	289			289			5	identified c.p.m.
UCAC2 μ (mas yr^{-1})	302	±	12	293.7	±	1.3	6	
CTIOPI μ (mas yr^{-1})	303.2	±	7.9				7	preliminary
LDS μ Position Angle (°)	216			216			5	identified c.p.m.
UCAC2 μ Position Angle (°)	213.1	±	2.3	215.87	±	0.25	6	
CTIOPI μ Position Angle (°)	220.9	±	3.0				7	preliminary
Absolute Parallax (mas)				23.03	±	2.04	8	
Relative Parallax (mas)	38.6	±	5.8				7	preliminary

REFERENCES.—(1) Scholz, Meusinger, & Jahreiß 2005; (2) Upgren *et al*. 1972; (3) Ryan 1992; (4) Høg *et al*. 2000; (5) *LDS*; (6) Zacharias *et al*. 2004; (7) this work, section 4.3; (8) Hipparcos

4.6.8 LP 704-15 and LP 704-14

The *NLTT* identifies LP 704-14 as a common proper motion companion to LP 704-15 with a separation of 20" and a 294-day orbit. As shown in Table 4.22, Salim and Gould (2003) measured essentially identical proper motions for the pair. Reid, Hawley, and Gizis (1995) calculated spectroscopic distances for these two objects that overlap within the errors. If a rough preliminary parallax is measured for LP 705-15 as discussed in 4.5.11, a similar measurement could be made for LP 705-14 as well to determine whether they are physically related.

TABLE 4.22
CHARACTERISTICS OF LP 704-15 AND LP 704-14

Characteristic	LP 704-15			LP 704-14			Ref.	Comment
Spectral Type	M3V			M4V			1	
Spectral Type	M3.5V						2	
V_{JM} (mag)	12.93	±	0.02	12.98	±	0.02	3	
NLTT μ (mas yr^{-1})	193			193			4	identified c.p.m.
Updated μ (mas yr^{-1})	210	±	6	210	±	6	5	good agreement
NLTT μ Position Angle (°)	84			84			4	identified c.p.m.
Updated μ Position Angle (°)	83	±	2	83	±	2	5	good agreement
Spectroscopic distance	20	±	6	13	±	4	1	same within errors

REFERENCES.—(1) Reid, Hawley, Gizis 1995; (2) T. D. Beaulieu 2006, private communication; (3) Weis 1991; (4) *NLTT*; (5) Salim & Gould 2003

4.6.9 Distance Discrepancies

The joint photometry of an unresolved binary will appear brighter than it would if its individual components were considered separately. The resulting photometric or spectroscopic distances will underestimate the actual distance to the star. For instance, a pair whose magnitudes differ by 0.75 magnitudes will appear about 18% closer than if only the flux from a single component was considered. The comparison of trigonometric parallax distance with that obtained from either photometric or spectroscopic techniques may signify the presence of an unknown companion. Several of the possible close binaries discussed above have such discrepancies in their distance measurements: 2MA 0429-3123, LHS 2397a, LHS 2783, and LP 869-26. The ratios of their parallactic distances to other distance measurements are 1.2–1.7, as listed in Table 4.4. Other stars in this study have parallactic distances at least 1.5 times one of their other distance measurements: LHS 6167, G 161-71, LHS 2880, 2MA 1507-2000, LHS 3056, LP 869-19, LP 870-65, LP 756-3, LP 984-92, LP 932-83, and LP 822-101. Future observations may resolve these latter eleven stars into binaries or future improvements in the photometric and spectroscopic distance relationships may reduce the current discrepancies that appear in Table 4.4.

4.7 DISCUSSION

This chapter contributes to the nearby star census by presenting preliminary parallaxes and proper motions for thirty-two possible nearby stars, which may be finalized in the next three observing seasons. In addition, new preliminary V_J, R_{KC}, and I_{KC} photometry for seventeen possible nearby stars and new spectroscopy for thirty-two possible nearby stars is also provided. Figure 4.7 plots the relationship between spectral type and 2MASS J-K_s color for the stars in this subsample plus 116 nearby stars listed in Table 4.3 for which this data was available; the three L dwarfs included do not yet have RECONS spectral types. This subsample of possible nearby stars appears consistent with the previously known nearby main sequence stars with no significant outliers. Figure 4.8 is a 2MASS-based infrared color-magnitude diagram for the possible nearby stars in this sample with preliminary parallaxes. The plot of absolute J magnitude versus J-Ks color shows the expected lower main sequence.

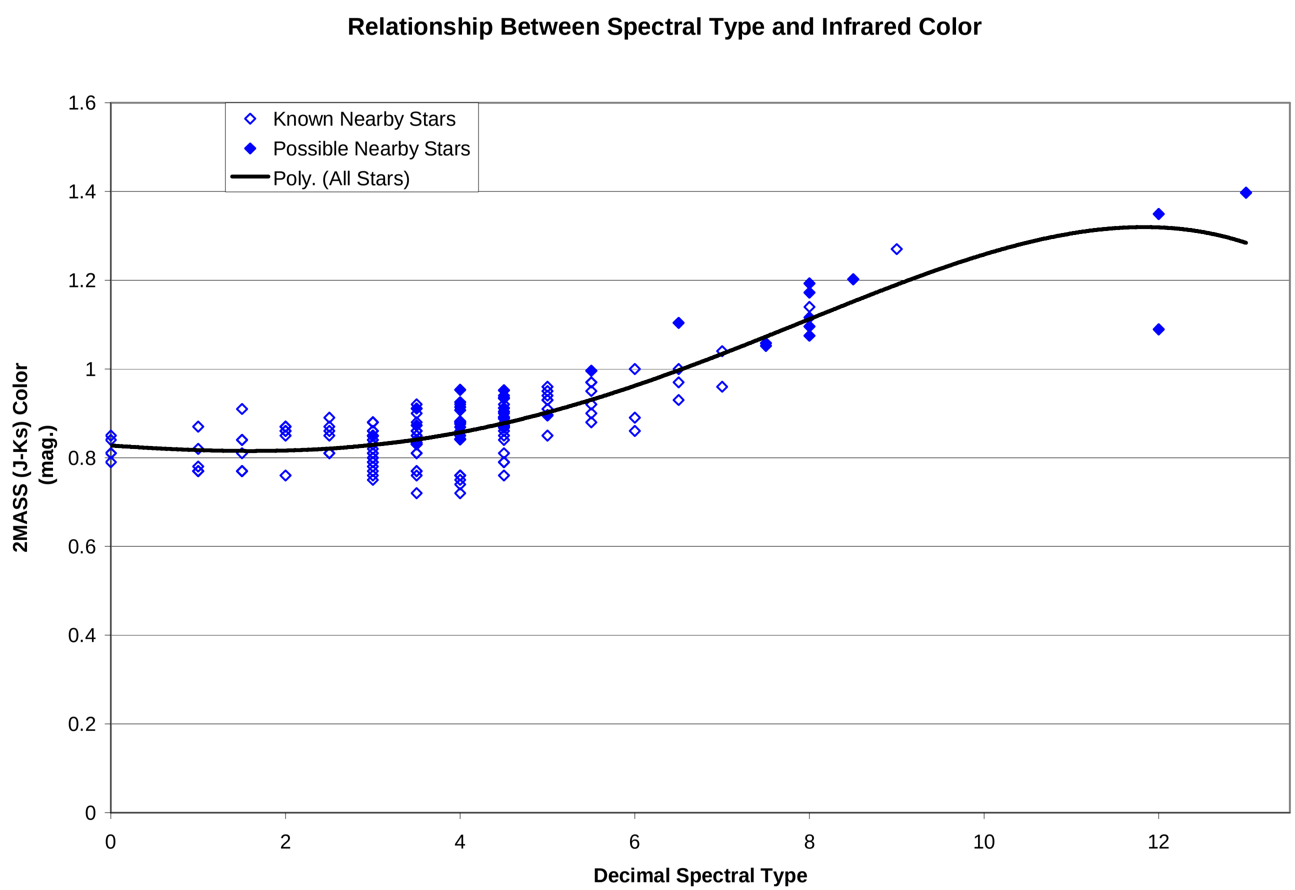

FIG. 4.7.— Infrared Color versus Spectral Type of Known and Possible Nearby Stars. Plot is based on data in Table 4.3 (open diamonds), which was provided by T. Henry (2003, private communication), and values for stars in this subsample (filled diamonds). The trend line is fourth-order polynomial fit to all the stars similar to those discussed in section 4.2.2.

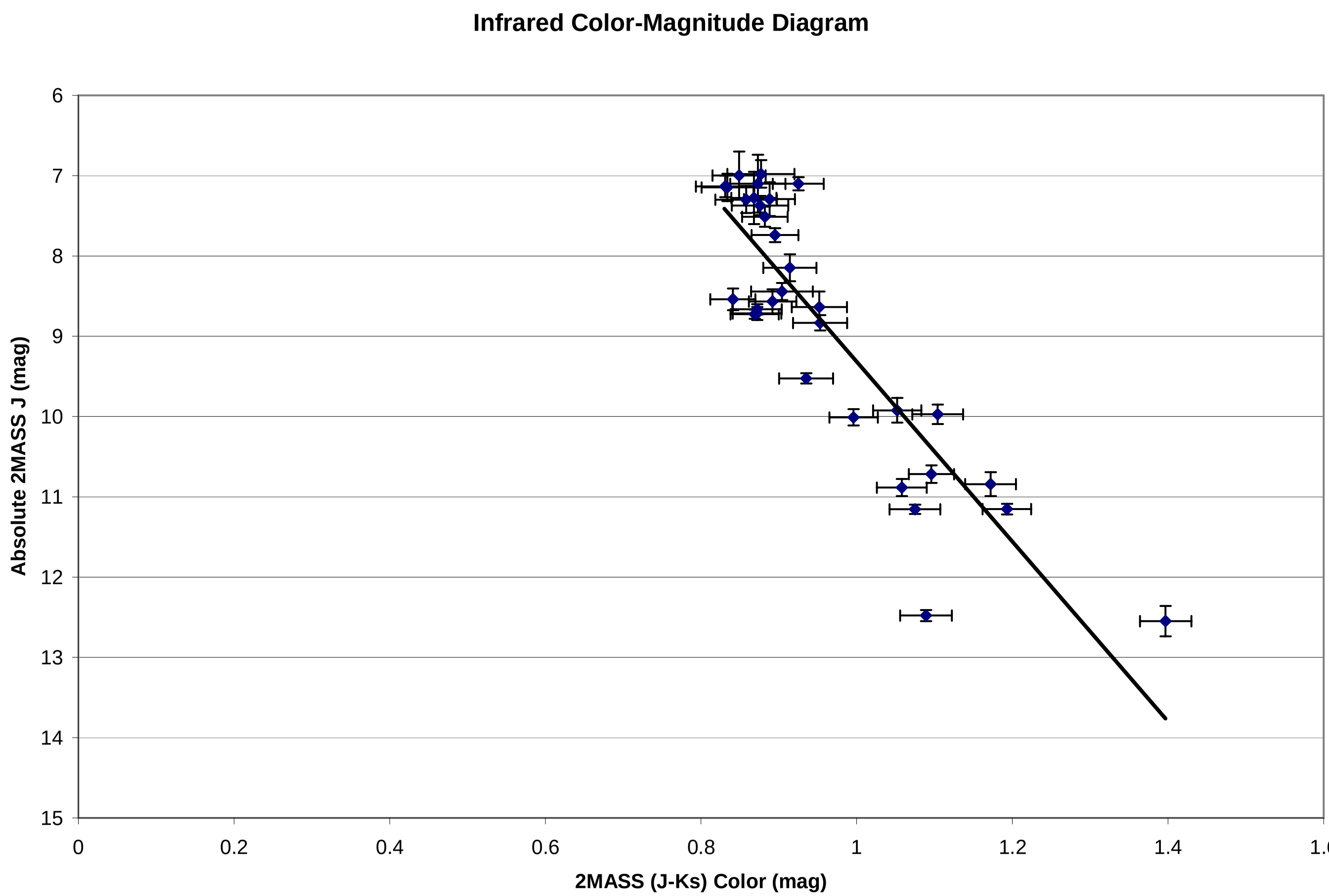

FIG. 4.8.— Infrared Color-Magnitude Diagram for Possible Nearby Stars. Plot is based on preliminary parallaxes from this work and 2MASS photometry.

Twenty-eight stars are confirmed as lying within 25 pc of the Sun, including three that appear to be new members of the 10-pc sample. The errors associated with the measurements of three more stars leave their status in doubt. One star, LP 869-26, was resolved into two stars; additional observations will provide more information about the relationship between the components of this possible new binary. All but three of the stars with preliminary proper motions have proper motions greater than 200 mas yr^{-1}, including nine stars with proper motions between 500 mas yr^{-1} and 1" yr^{-1} and two with proper motions greater than 1" yr^{-1}. The spectral types range from M3.0V through L3 and include objects as faint as 19.83 magnitudes in V_J. When completed this CTIOPI subsample with have contributed to our knowledge of the solar neighborhood and slightly reduced the number of missing systems within 10 pc.

When added to what we already know about the stars within the solar neighborhood, this study will enable enhanced approximations of the stellar luminosity function, the mass-luminosity relationship, stellar velocity distribution, and the stellar multiplicity fraction. The improvements in our knowledge of these functions will advance our understanding of stellar populations, stellar evolution, and star formation history and contribute to a better larger picture of galactic structure.