# A focus on L dwarfs with measured parallax

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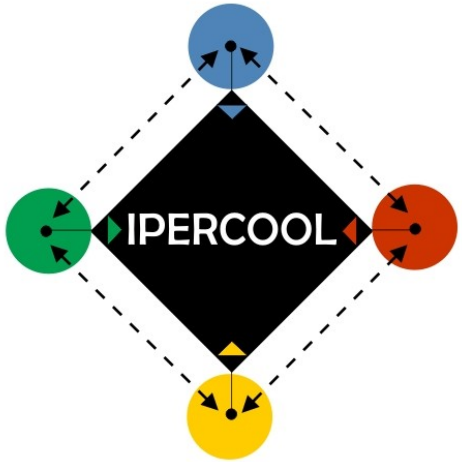
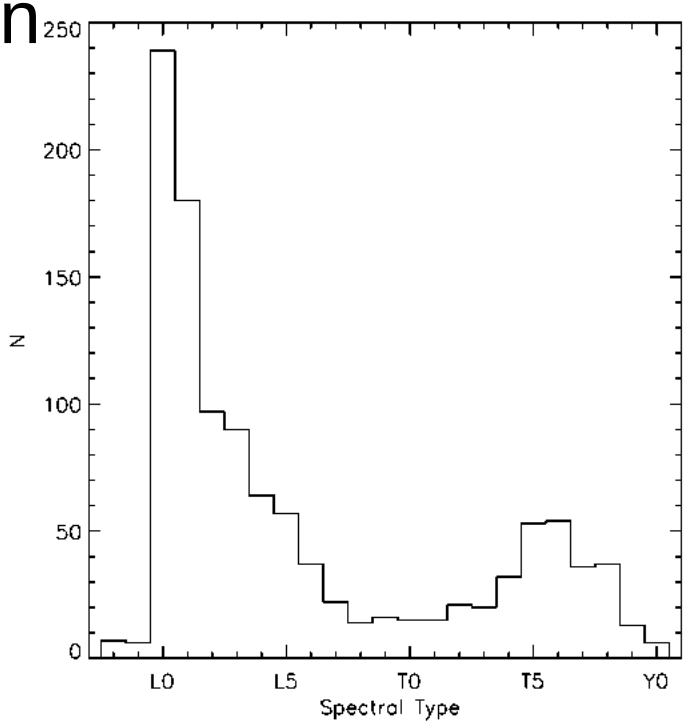


# outline

- 1.Introduction
- 2.Sample
  - 2.1 Liverpool Telescope parallax results
  - 2.2 Literature objects
- 3.Binarity of the Liverpool Telescope targets
- 4. kinematics of this L dwarf sample
- 5.Gaia magnitude of this sample

# 1. Introduction

- Importance of Parallax (and proper motion)
- DwarfArchive~ 1300 L and T
- Number of L dwarfs ~900
- To see property of L population



# 2. Sample

- 2.1 Liverpool Telescope parallax results 2.1.1 Data
- Telescope --aperture 2-m, SDSS z band 2K*2K CCD
- Targets-from DwarfArchive --no parallax in 2004 -- brighter z~18-- with smallest photometric distance
- Observations -- mainly 2008 -- 2011--2.5+ years
- Defringe,Centroids-CASU(precision), Wang et al. 2014

# Table: targets

**Table 1.** Observations of the targets.

| No., Object | R.A. (h:m:s ) | Decl. (°:':") | z-mag (mag) | SpT | frames (04,08,11,sum) | Δt (yrs) | Binarity sep(") |
|---|---|---|---|---|---|---|---|
| 1 , SD0423-0414 | 04 23 48.6 | -04 14 04 | 17.33 | L7.5 [1] | 0,27,21,48 | 3.2y | 0.614[2] |
| 2 , 2M0717+5705 | 07 17 16.3 | +57 05 43 | *17.23* | L6.5[3] | 0,42,6,45 | 2.9y | - |
| 3, SD0758+3347 | 07 58 40.3 | +32 47 23 | 17.97 | T2[4] | 3,38,33,74 | 3.4 | - |
| 4 , SD0857+5708 | 08 57 58.5 | +57 08 51 | 17.74 | L8[5] | 0,45,18,63 | 3.2y | - |
| 5 , SD1017+1308 | 10 17 07.5 | +13 08 40 | 16.74 | L3[6] | 0,26,10,36 | 3.5y | 0.104[7] |
| 6 , SD1104+1959 | 11 04 01.2 | +19 59 21 | 17.22 | L4[6] | 0,39,24,63 | 3.5y | - |
| 7 , SD1239+5515 | 12 39 27.2 | +55 15 37 | 17.52 | L5[8] | 0,42,23,67 | 3.5y | 0.21[9] |
| 8, SD1300+1912 | 13 00 42.5 | +19 12 35 | 15.14 | L1[10] | 0,18,30,48 | 3.5y | - |
| 9 , SD1515+4847 | 15 15 00.8 | +48 47 42 | 16.72 | L6 [6] | 0,29,30,59 | 3.5y | - |
| 10 , SD2028+0052 | 20 28 20.3 | +00 52 26 | 17.04 | L3 [1]1 | 0,30,40,70 | 3.8y | - |

Note. The coloum for magnitude, italic indicate estimated magnitude, roman indicate SDSS-z magnitude.
References. [1]Kirkpatrick et al. (2008),[2]Burgasser et al. (2005),[3]Faherty et al. (2009),[4]Burgasser et al. (2006), [5]Geballe et al. (2002),[6]Cruz et al. (2003),[7]Bouy et al. (2003),[8]Kirkpatrick et al. (2000), [9]Gizis et al. (2003),[10]Gizis et al. (2000),[11]Reid et al. (2008).

# 2. Sample

- 2.1.2 parallax and proper motion
- Software-- Torino Observatory Parallax Program (Smart et al. 2003, 2007) -- relative to absolute: Galaxy model of Mendez & van Altena(1996).
- Parallax and proper motion results, calibration with the literature ones:

# Figure -- parallax ellipse

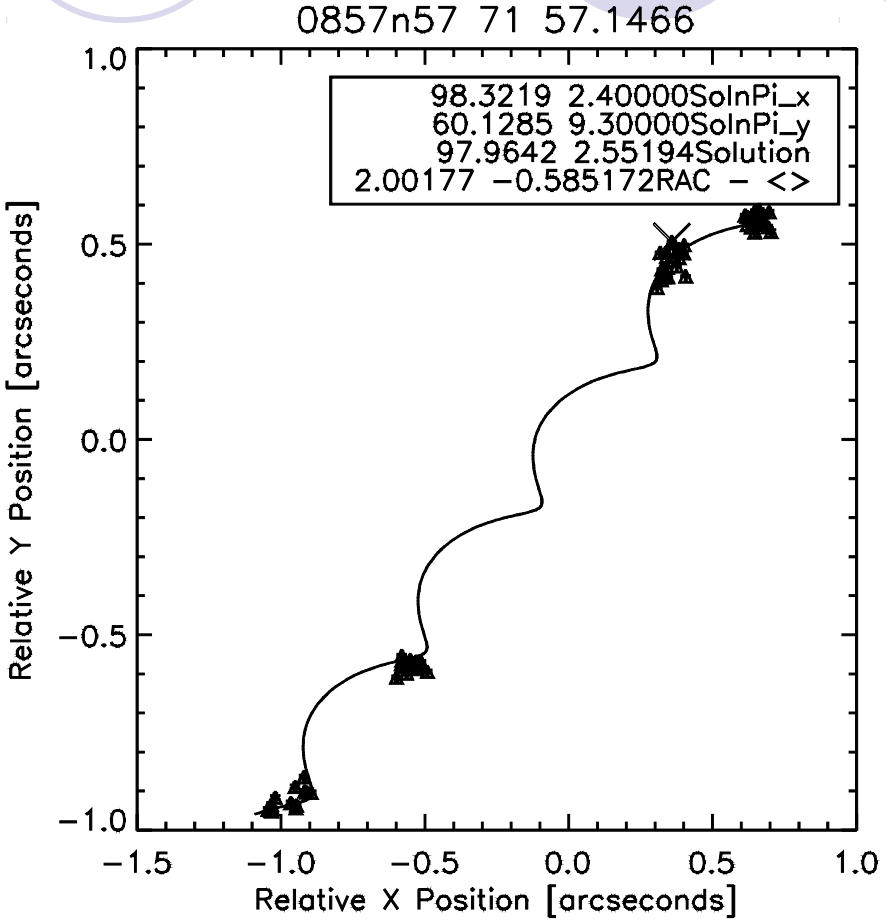



Fig. 1 Observations over-plotted with the parallax solution of D0857+5708

# Table-parallax results

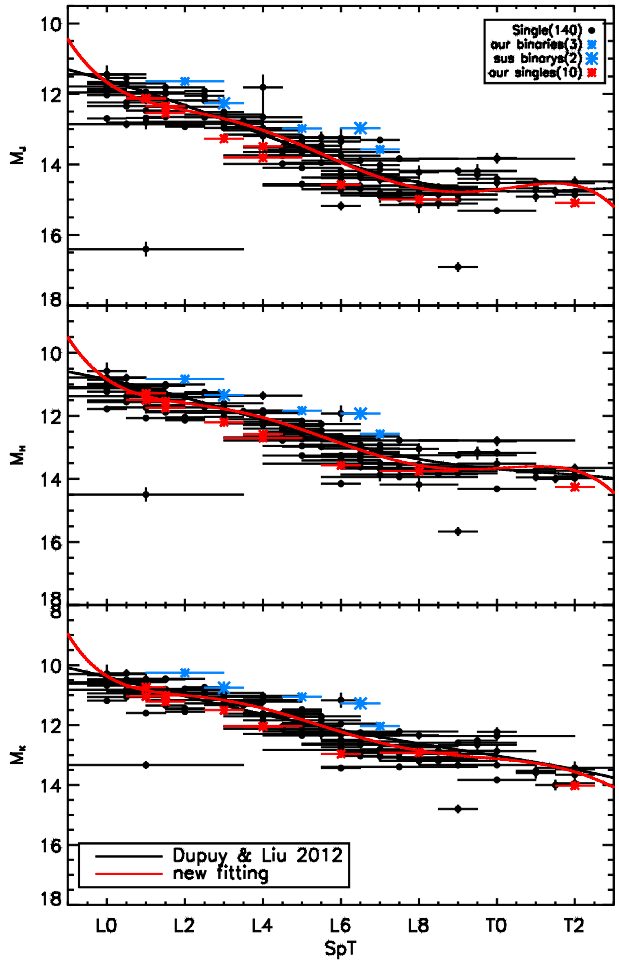
**Table 2.** Parallax and proper motions for the seven L/T dwarfs.

| Obj. Name | $N_1, N_2$ | $\Delta$t | $\pi$ | COR | $\mu_\alpha cos\delta$ | $\mu_\delta$ | $\pi$ | $\mu_\alpha cos\delta$ | $\mu_\delta$ |
|---|---|---|---|---|---|---|---|---|---|
| SD0423-0414 | 50,13 | 4.33 | 66.3±3.7 | 1.5 | -325.6±1.8 | 83.1±1.5 | 73.3±1.4[1] | -325.3±1.0 | 93.1±0.9 |
| 2M0717+5705 | 48,27 | 4.22 | 46.4±2.3 | 1.4 | -18.0±1.6 | 54.3±1.3 | - | -17.99±17.87 | 67.17±15.13[3] |
| SD0758+3347 | 62,16 | 4.18 | 106.9±4.6 | 1.5 | -230.7±1.7 | -327.7±2.1 | - | -204.23±18.01 | -316.21±12.42 [3] |
| SD0857+5708 | 71,9 | 4.15 | 98.0±2.6 | 2.0 | -400.0±1.7 | -374.9±1.7 | - | -413.61±20.52 | -353.43±16.85[3] |
| SD1017+1308 | 55,5 | 4.10 | 32.3±2.8 | 2.5 | 61.0±1.4 | -116.3±1.5 | 30.0± 1.6[1] | 44.1±0.7 | -114.3±0.6 |
| SD1104+1959 | 66,5 | 4.08 | 66.2±1.9 | 2.2 | 55.9±0.7 | 126.6±0.7 | - | 75 | 139[4] |
| SD1239+5515 | 43,6 | 4.04 | 45.0±2.1 | 2.0 | 131.7±2.0 | -2.6±1.4 | 42.4±1.7[1] | 125.2±1.1 | 0.04±1.1 |
| SD1300+1912 | 42,10 | 3.48 | 76.4±1.8 | 2.0 | -789.0±1.1 | -1237.2±1.0 | - | -784 | -1255[5] |
| SD1515+4847 | 43,6 | 3.46 | 123.8±5.0 | 1.7 | -930.4±4.1 | 1469.3±2.2 | - | -950 | 1471[4] |
| SD2028+0052 | 54,79 | 3.74 | 39.1±1.6 | 1.2 | 96.9±0.8 | -9.0 ±0.8 | - | 114 | 7[4] |

# 2. Sample

- 2.2 Literature objects
- we collect a sample L dwarfs with measured parallax and proper motions from the literature --Dupuy & Liu 2012 online compendium, Marocco et al. 2013,Sahlmann et al. 2014 and Wang et al. 2014 (5 targets have parallax derived from Liverpool telescope)--170 of  L to T2 dwarfs
- 2MASS, WISE and Gaia G magnitudes, parallax and proper motion are collected or calculated
- WSIE magnitudes are updated allwise new data

# 3.Binarity of the Liverpool Telescope targets




- Black solid circles -- the literature single objects(non Liverpool Telescope objects)
- Red asteris -- 5 Liverpool Telescope targets(10 this paper, five Wang et al.2014)
- Small blue asterisks -- known literature binaries,
- Large blue asterisks -- suspected binaries in this paper.

Fig.2 SpT-mag diagram in 2MASS system.

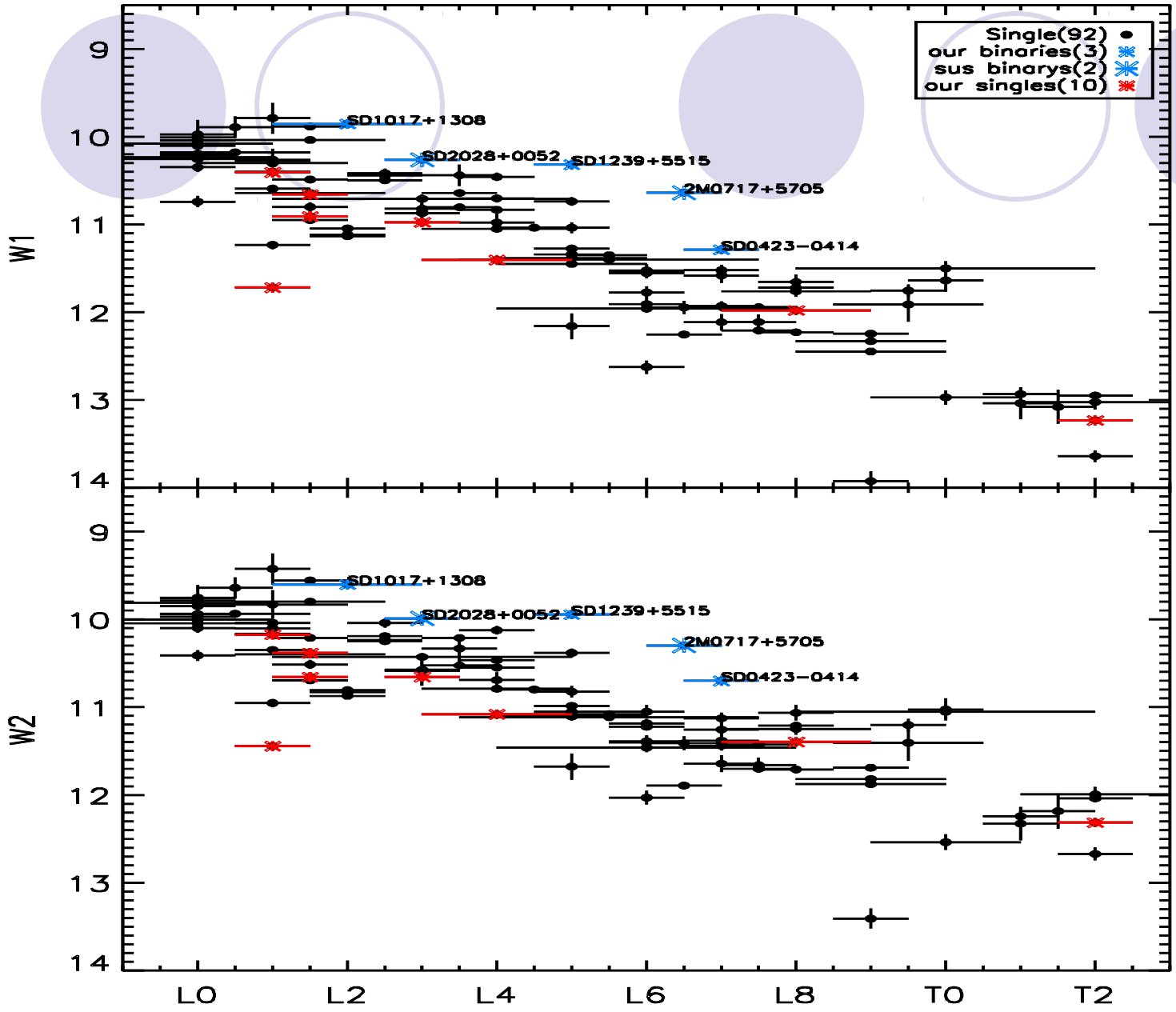



Fig.3 SpT-mag diagram in WISE system. Same symbols for this figure

- The new fitting red line has small different with the Dupuy & Liu one.
- Two suspected  equal mass binary : 2M0717+5705 and SD2028+0052-- further confirmation

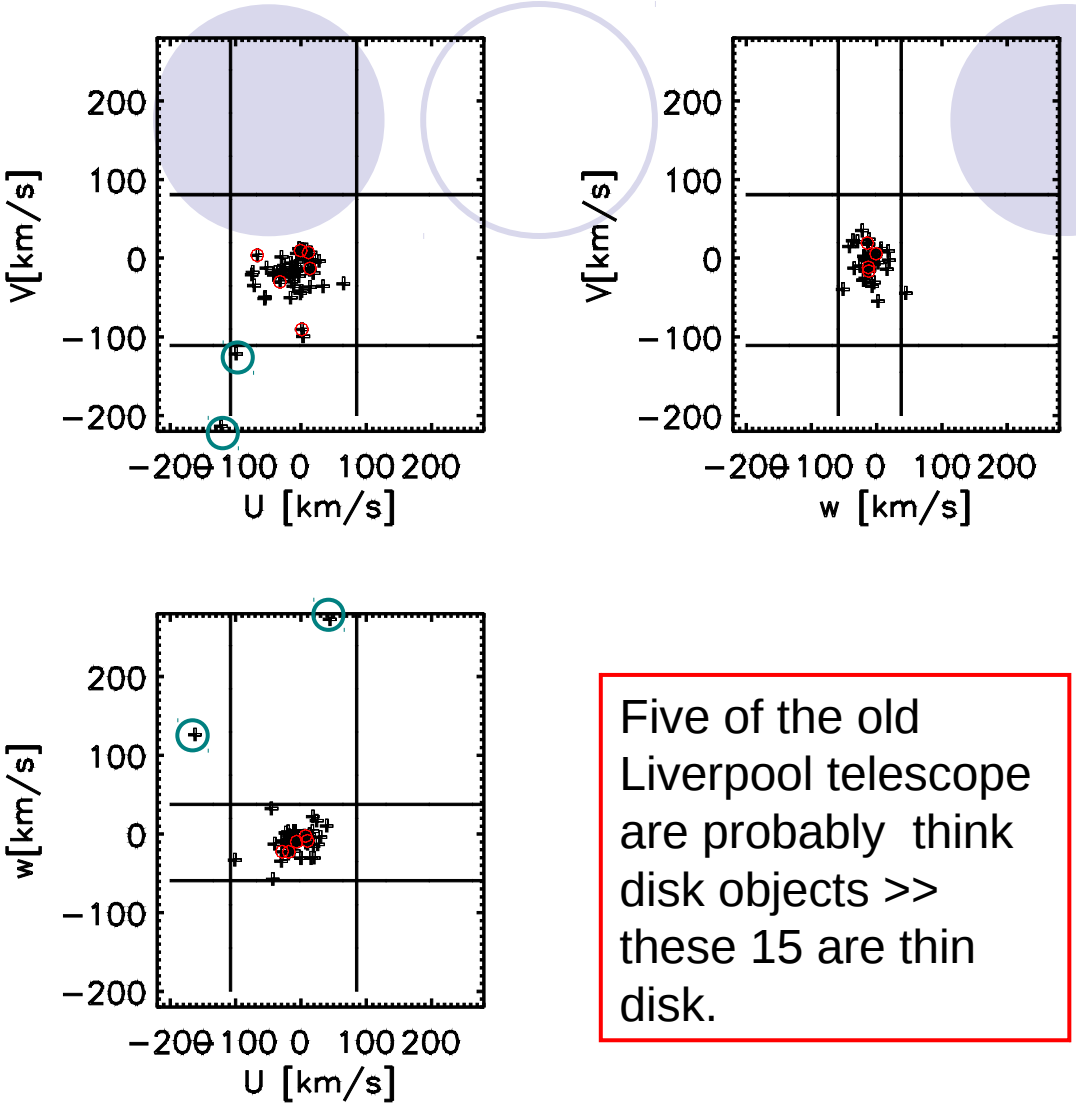
# 4.Kinematics of this L dwarf sample

- Parallax, proper motion, radial velocity ( assuming 0) >> U V W velocity no STR correction
  - Component affected the most leave blank, two components derived for each object
- Average <U,V W>= -11.1, -15.1,-10.7
- σfor U V W= 32.1, 32.0,16.2
- Compare with literature:

  $(\sigma_u,\sigma_v,\sigma_w)$=(33.8,28.0,16.3) Seifahrt et al. (2010).

# U V W velocity table (a portion of the whole)

| Name | $\mu_\alpha cos\delta$ | $e_{\mu_\alpha cos\delta}$ | $\mu_\delta$ | $e_{\mu_\delta}$ | Dist. | $e_{Dist.}$ | Ref | $U$ | $V$ | $W$ |
|---|---|---|---|---|---|---|---|---|---|---|
| 2M0717+5705 | -18.0 | 1.6 | 54.3 | 1.3 | 21.6 | 1.1 | 1 | — | 5.57 | -0.72 |
| SD2028+0052 | 96.9 | 0.8 | -9.0 | 0.8 | 25.6 | 1.0 | 1 | -6.17 | — | -10.05 |
| SD0423-0414 | -325.6 | 1.8 | 83.1 | 1.5 | 15.1 | 0.8 | 1 | — | 19.08 | -14.11 |
| SD1017+1308 | 61.0 | 1.4 | -116.3 | 1.5 | 31.0 | 2.7 | 1 | 14.04 | -13.24 | — |
| SD1239+5515 | 131.7 | 2.0 | -2.6 | 1.4 | 22.2 | 1.0 | 1 | 11.92 | 7.04 | — |
| SD1300+1912 | -789.0 | 1.1 | -1237.2 | 1.0 | 13.1 | 0.3 | 1 | 1.62 | -90.67 | — |
| 2M0141+1804 | 405.2 | 1.1 | -48.7 | 0.9 | 22.8 | 1.1 | 1 | -31.86 | -30.19 | — |
| SD1717+6526 | 150.2 | 1.0 | -109.3 | 0.6 | 17.5 | 1.1 | 1 | 10.33 | — | -8.95 |
| 2M1807+5015 | 27.2 | 1.0 | -130.2 | 1.5 | 12.9 | 0.3 | 1 | 7.66 | — | -2.73 |
| 2M2238+4353 | 324.3 | 0.5 | -121.0 | 0.4 | 18.5 | 0.6 | 1 | -18.24 | — | -22.86 |
| 2M2242+2542 | 382.0 | 0.9 | -64.6 | 0.7 | 20.9 | 1.2 | 1 | -28.44 | — | -22.64 |
| SD0758+3347 | -230.7 | 1.7 | -327.7 | 2.1 | 9.4 | 0.4 | 1 | — | -12.01 | -12.32 |
| SD0857+5708 | -400.0 | 1.7 | -374.9 | 1.7 | 10.2 | 0.3 | 1 | — | -16.66 | -12.03 |
| SD1104+1959 | 55.9 | 0.7 | 126.6 | 0.7 | 15.1 | 0.4 | 1 | -0.19 | 9.43 | — |
| SD1515+4847 | -930.4 | 4.1 | 1469.3 | 2.2 | 8.1 | 0.3 | 1 | -66.49 | 3.64 | — |
| GJ 1001B | 643.552 | 2.418 | -1494.312 | 3.001 | 13.00 | 0.70 | 2 | 3.526 | -99.30 | — |
| GJ 1001C | 643.552 | 2.418 | -1494.312 | 3.001 | 13.00 | 0.70 | 2 | 3.526 | -99.30 | — |

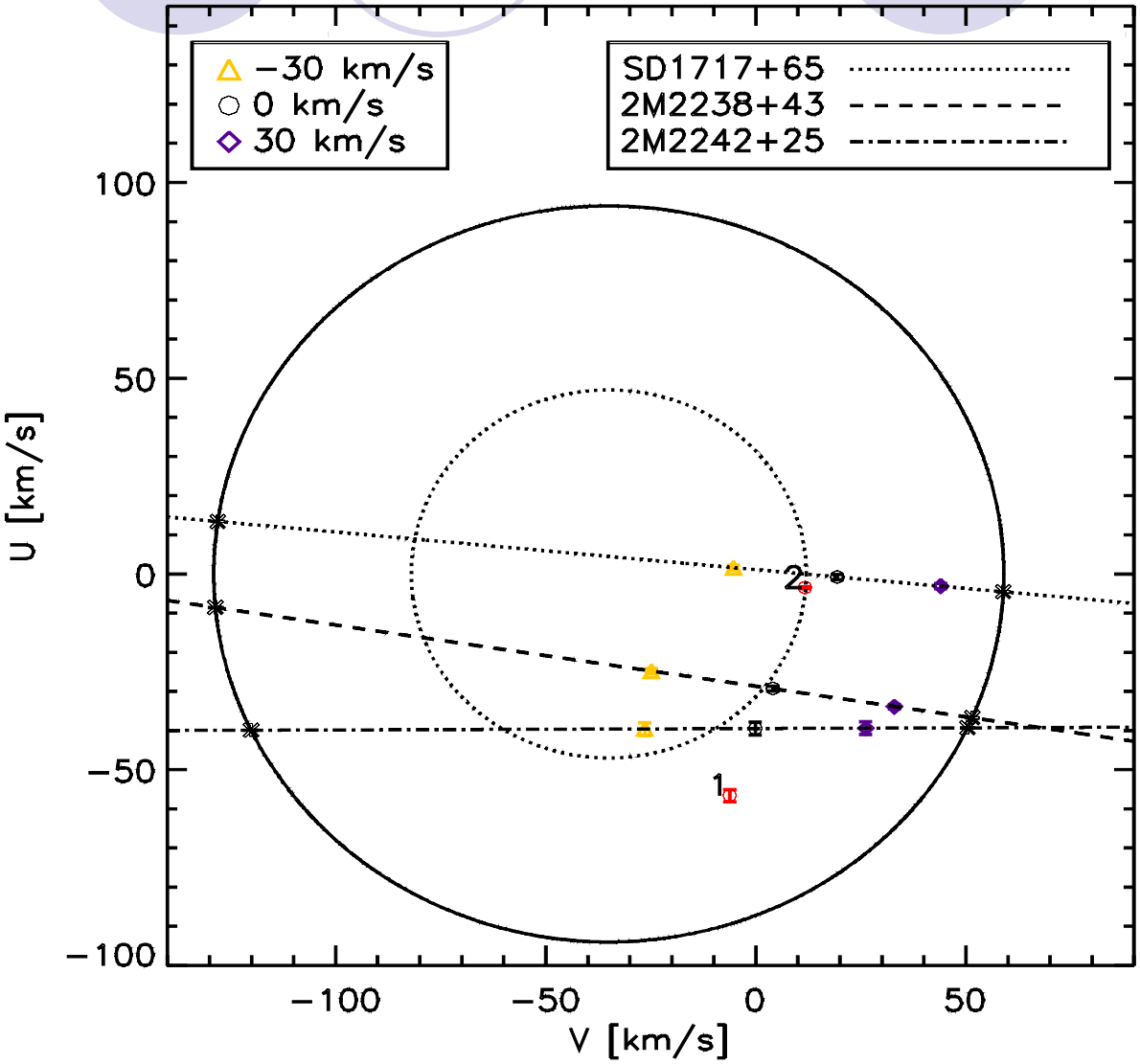



Five of the old Liverpool telescope are probably think disk objects >> these 15 are thin disk.

Fig.4 U- V, V-W and W-U space velocity. Each object has only two component of the three.

- Black plus symbols– literature non Liverpool telescope objects
- Red solid circles– 15 Liverpool Telescope targets
- Vertical and horizontal lines indicate 3 sigma limit of the U VW.
- Black plus exceeding the 3 sigma limit are literature sub L dwarfs
- Our targets are clustered with in 3 sigma limits

Wang et al 2014



# 5.Gaia magnitude of this sample

- We used a 2MASS J- Gaia G relation for different spectral type to derive the G magnitude.
- At least 59 in our L dwarf Sample are brighter than G=20.

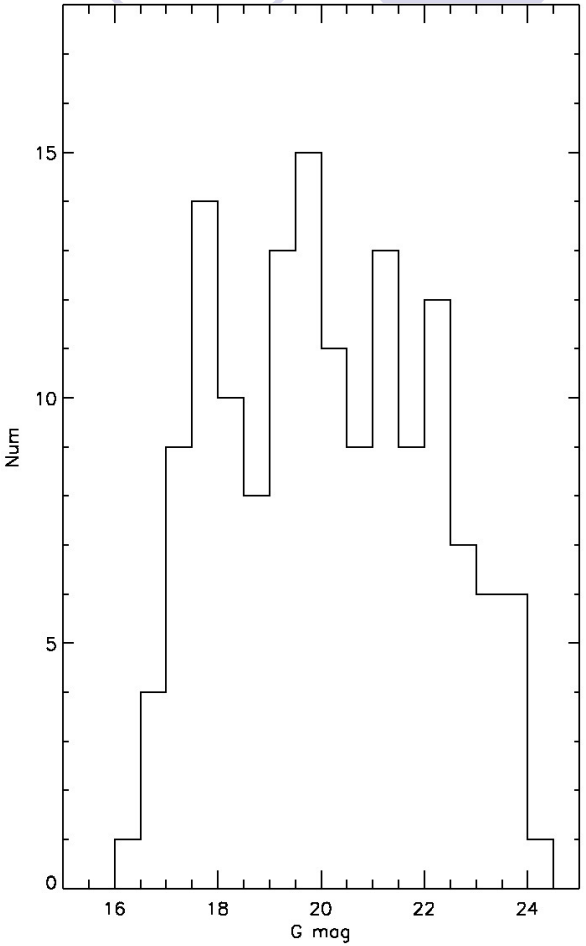



Fig. 5 G-number histogram.

# Conclusion

- Parallax of ten L/ early T dwarfs with 2 meter Liverpool Telescope
- SpT-mag diagram-- 2 suspected equal mass Binaries
- U V W velocity scatter for L dwarfs consistent with literature
- Gaia G magnitude & Nearly a half ( 59 out of 170) observable to Gaia

# further work

- Temperature of the ten Liverpool Telescope
- Confirmation of the two suspected binaries

# Thanks !

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