Unreported High Proper Motion Northern Double Stars in the LSPM Catalog

Part 1 - Stars to 90 arc seconds separation

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Abstract: Data mining the LSPM catalog has yielded 51 previously unreported double stars in the northern sky with each pair showing a large shared proper motion.

Introduction

It is always exciting when a new catalog is made available through the Vizier system. All the more so when, in July 2005, a detailed survey of high proper motion stars appeared.

The LSPM catalog, Lepine+ 2005, is a comprehensive list of 61,977 stars north of the J2000 celestial equator that have proper motions larger than 0.15"/yr (local-background-stars frame). All the northern stars listed in the Luyten Half-Second and New Luyten Two-Tenths catalogs have been re-identified and positions, proper motions and magnitudes re-evaluated. Positions are given with an accuracy of <~100mas at the 2000.0 epoch and absolute proper motions are given with an accuracy of ~8 mas/yr. Corrections to the local-background-stars proper motions have been calculated and absolute proper motions in the extra-galactic frame are given. The LSPM data can be accessed via the Vizier web pages at:

http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=I/298

Methodology

Once the positional data has been downloaded the mathematics involved in calculating the separation and position angle between two stars is relatively simple.

Using RA (α) and Dec (δ) values in decimal degrees:

$$\Delta\delta = (\delta_2 - \delta_1)$$

$$\Delta\alpha = (\alpha_2 - \alpha_1)\cos(\delta_1)$$

Then, the separation (ρ) and position angle (θ) are given by

$$\rho = \sqrt{(\Delta\delta)^2 + (\Delta\alpha)^2}$$

$$\theta = \arctan(\Delta\alpha / \Delta\delta)$$

The three main complications are the quantity of data to be processed, the fact that astronomical position angle is measured from north in an anti-clockwise direction and that arctan yields two results, 180 degrees apart, if only positional data is used in the calculation. These problems were resolved by using a computer to aid data processing, by a simple arithmetical tweak to convert *Microsoft Excel* angles to the format required by astronomers and by combining positional data with magnitude data so that only position angles measured from the brighter to the fainter source were reported.

Purpose built software (Nicholson, 2005), written by C Whiting, was used to carry out the initial analysis. The method used was as follows:

- The stars were arranged in order by right ascension.

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- The software then calculated the distance between any given star and its neighbours in this list. If the distance was greater than 90 arc seconds then no further processing was done because, regardless of the declination, no two stars differing by more than 90 arc seconds in right ascension could possibly lie within a total of 90 arc seconds of each other.
- For pairs of stars found to be within 90 arc seconds in right ascension the declination was then used to calculate the total distance between the two stars. If the total distance was greater than 90 arc seconds no further processing was done.
- For pairs of stars within a total of 90 arc seconds the position angle was calculated using the standard formula and measuring from the brighter star to the fainter star.
- The resulting data was then written to a standard text tile in the format agreed between the programmer and myself.

The 15,286 stars of magnitude 14.0 or brighter yielded 429 "candidate pairs" of stars. This figure needed to be compared with the result that would be obtained on a purely random basis.

Imagine you have a catalogue that contains N stars and these are uniformly distributed across the northern hemisphere of the sky (2.675×10^{11} as^2) then the probability of having a star in any one arc second area, P_a, is $N / 2.675 \times 10^{11}$.

In the case of the LSPM, N = 15,288. This gives a value of $P_s = 5.75 \times 10^{-8}$.

The probability that there no other stars within a radius of r arc seconds is:

$$P = (1 - P_a)^A$$

where A = the area of the circle surrounding the star

The upper limit of 90 arc seconds, following the example of Greaves (2004), was chosen since the aim of this initial experiment was to find strong candidates for common proper-motion pairs rather than larger numbers of far less certain associations.

The probability that there is no companion within 90 arc seconds is 99.85%. This means that 0.15% of stars would be expected, on a purely random basis, to have a companion within this distance. This is equivalent to approximately 11 pairs with separations between 0 and 90 arc seconds.

The 429 "candidate pairs" were not all new discoveries – following filtering to remove those already recorded in the LDS Catalogue: Doubles with Common Proper Motion (Luyten 1940-87) and in the Washington Visual Double Star Catalog, 1996.0 (Worley+, 1996) the number was reduced to 72 pairs.

The candidates were then checked against two further criteria:

1. If the difference in the quoted proper motion for the two stars in right ascension or declination was >0.016 arcsec/yr (twice the quoted error) the pair was eliminated. 21 pairs were eliminated at this stage.
2. If the pair was found to be within 30 arcmin of the center of an open cluster listed in the New Catalog of optically visible open clusters and candidates it would have been eliminated (Dias+, 2002). No pairs were eliminated.

Results

Table 1 provides a listing in the standard format of all the common proper motion pairs found. Table 2 provides detail of the proper motion of both components of each pair. It is somewhat surprising that these pairs have not been reported previously.

Conclusions

Each component of a common proper-motion pairs can be considered to be at the same distance from the observer, of the same age and subject to the same degree of reddening (Greaves, 2004). They are an interesting group to research because they do not fall into either of the extensively studied groups of orbiting binaries or open clusters.

Forty of the 51 pairs exhibit a catalogued V-J magnitude difference, a measure of the stars' color, of <1.0 but 8 pairs have a difference of >2.5. This diversity clearly has implications for any theory on the origin of such objects.

It is to be hoped that these new discoveries will be included in the Washington Double Star Catalog.

References

Greaves, J., 2004, "New northern hemisphere common proper-motion pairs", Mon. Not. R. Astron. Soc. 355, 585-590

Nicholson, M., 2005, "The Daventry Double Star Survey", J. Br. Astron. Assoc. 115, 338-342

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Websites

Catalog of Northern stars with annual proper motions larger than 0.15", Lepine+ 2005
http://vizier.u-strasbg.fr/viz-bin/VizieR?source=I/298

The Washington Visual Double Star Catalog, 1996.0, Worley 1996
http://vizier.u-strasbg.fr/viz-bin/VizieR?-source=I/237

#	RA J2000	DE J2000	Mag 1	Mag 2	PA (deg)	Sep. (as)	Date
1	00 10 56.07	+48 06 37.5	8.41	10.72	46.89	23.90	2000.000
2	00 40 06.26	+50 14 15.5	10.88	12.96	311.17	24.91	2000.000
3	01 41 51.50	+47 46 23.2	12.39	12.43	358.54	3.42	2000.000
4	02 48 40.72	+13 44 48.0	10.79	11.35	18.75	14.19	2000.000
5	03 02 09.83	+26 00 46.2	13.27	13.35	356.23	11.07	2000.000
6	03 27 52.36	+14 50 49.7	12.75	12.75	299.14	3.74	2000.000
7	03 30 28.34	+54 17 37.7	8.88	11.71	252.01	78.86	2000.000
8	03 44 48.90	+57 01 41.6	11.32	11.49	315.95	16.56	2000.000
9	04 07 57.53	+04 44 37.8	13.53	13.87	287.59	2.51	2000.000
10	04 10 38.31	+20 02 25.9	12.33	12.33	227.32	3.34	2000.000
11	04 12 48.86	+19 53 52.3	10.32	10.54	228.87	5.02	2000.000
12	04 45 25.41	+29 55 28.5	11.34	11.67	145.46	84.18	2000.000
13	06 20 53.28	+54 24 59.6	9.56	12.86	139.49	78.48	2000.000
14	07 26 40.04	+26 58 51.5	10.93	10.98	150.58	5.44	2000.000
15	07 31 36.14	+62 01 11.5	12.03	13.54	74.57	22.93	2000.000
16	07 47 27.92	+33 51 56.8	13.53	13.9	226.20	49.07	2000.000
17	07 48 07.48	+50 13 03.3	11.2	11.25	341.92	31.21	2000.000
18	08 15 33.20	+11 25 51.5	7.71	9.75	238.36	31.87	2000.000
19	08 21 26.46	+34 18 22.4	11.7	17.46	100.79	72.26	2000.000
20	08 26 45.45	+32 50 00.0	10.83	10.88	1.46	2.72	2000.000
21	08 45 53.45	+31 07 19.4	11.07	11.99	301.73	21.01	2000.000
22	08 52 58.17	+29 31 44.5	11.14	11.16	156.15	4.14	2000.000
23	08 57 42.11	+55 22 00.1	13.63	13.72	258.67	12.16	2000.000
24	10 38 40.78	+11 32 22.1	13.23	13.74	122.65	7.93	2000.000
25	11 22 44.74	+30 17 40.5	11.98	12.48	85.15	4.47	2000.000
26	11 32 23.31	+76 39 18.0	11.53	12.25	261.19	63.30	2000.000

Table 1: Listing of common proper motion pairs found in this study. *Continued on page 71.*

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#	RA J2000	DE J2000	Mag 1	Mag 2	PA (deg)	Sep. (as)	Date
27	11 43 53.14	+33 18 30.6	13.4	13.4	222.74	3.38	2000.000
28	11 55 36.20	+73 30 19.1	12.59	12.66	150.88	3.33	2000.000
29	12 04 56.96	+17 28 35.9	8.66	13.4	206.53	27.21	2000.000
30	12 52 16.15	+38 35 40.0	13.8	13.9	158.38	10.61	2000.000
31	13 24 29.41	+41 12 00.8	11.07	11.6	172.57	8.31	2000.000
32	13 44 27.16	+77 13 50.9	9.45	13.63	291.29	66.57	2000.000
33	14 33 05.25	+55 27 33.7	9.62	11.71	333.60	28.93	2000.000
34	15 10 36.61	+39 23 12.7	13.01	13.3	53.92	8.30	2000.000
35	16 04 56.80	+39 09 23.4	6.66	12.86	280.36	70.28	2000.000
36	17 15 27.74	+30 52 36.6	11.33	13.6	166.20	15.03	2000.000
37	17 20 23.19	+20 16 57.4	9.83	13.83	124.15	4.50	2000.000
38	18 26 24.59	+11 20 57.4	13.09	13.09	190.35	7.80	2000.000
39	19 34 37.08	+50 39 11.3	11.22	11.33	50.69	28.81	2000.000
40	19 49 18.13	+41 34 56.9	7.53	10.47	67.05	66.84	2000.000
41	20 43 35.49	+45 14 10.7	12.98	13.58	165.83	17.69	2000.000
42	21 57 30.78	+28 56 13.4	8.76	13.98	189.31	85.01	2000.000
43	22 04 17.31	+09 51 34.6	11.53	13.44	135.47	40.44	2000.000
44	22 05 46.11	+65 38 50.7	10.53	11.65	315.74	6.75	2000.000
45	22 31 05.73	+45 08 42.4	7.69	13.74	7.66	62.21	2000.000
46	22 45 41.77	+41 12 10.5	9.04	10.79	323.13	21.08	2000.000
47	22 46 49.75	+19 01 01.0	9.01	13.05	89.68	25.55	2000.000
48	23 27 46.08	+12 23 40.9	12.54	13.77	278.68	11.61	2000.000
49	23 50 02.80	+05 30 46.0	9.62	10.87	124.78	11.18	2000.000
50	23 54 29.69	+29 38 17.7	8.51	12.55	201.94	22.49	2000.000
51	23 55 36.04	+00 41 45.0	9.23	13.6	253.20	12.97	2000.000

Table 1, cont.: Listing of common proper motion pairs found in this study.

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#	PRIMARY pmRA arcsec/yr	SECONDARY pmRA arcsec/yr	PRIMARY pmDE arcsec/yr	SECONDARY pmDE arcsec/yr
1	0.169	0.168	0	0.003
2	0.146	0.143	-0.071	-0.073
3	0.256	0.209	-0.105	-0.108
4	0.115	0.114	-0.105	-0.104
5	0.161	0.161	-0.08	-0.08
6	0.172	0.172	-0.14	-0.14
7	0.147	0.125	-0.12	-0.13
8	0.113	0.116	-0.161	-0.158
9	0.166	0.166	-0.025	-0.025
10	0.045	0.045	-0.213	-0.213
11	0.247	0.241	-0.019	-0.028
12	0.001	0.002	-0.156	-0.16
13	-0.094	-0.092	-0.173	-0.159
14	-0.132	-0.139	-0.106	-0.105
15	0.025	0.025	-0.16	-0.16
16	0.179	0.124	-0.148	-0.096
17	-0.033	-0.035	-0.154	-0.154
18	-0.198	-0.198	-0.233	-0.23
19	-0.133	-0.111	-0.149	-0.116
20	0.034	0.039	-0.177	-0.184
21	0.002	0.025	-0.153	-0.16
22	0.083	0.084	-0.134	-0.144
23	0.164	0.164	0.065	0.065
24	-0.004	-0.004	-0.167	-0.167
25	0.146	0.146	-0.078	-0.078
26	0.115	-0.155	-0.6	-0.163
27	-0.215	-0.215	-0.081	-0.081
28	-0.224	-0.224	-0.08	-0.08
29	0.03	0.019	-0.209	-0.188
30	-0.084	-0.084	0.126	0.126

Table 2: Proper motion of each pair. Column 1 contains running numbers of the pairs, columns 2 and 3 contain proper motion data in right ascension taken directly from the catalog. Columns 4 and 5 contain proper motion data in declination taken directly from the catalog. *Continued on page 73.*

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#	PRIMARY pmRA arcsec/yr	SECONDARY pmRA arcsec/yr	PRIMARY pmDE arcsec/yr	SECONDARY pmDE arcsec/yr
31	0.084	0.084	-0.141	-0.141
32	-0.165	0.026	-0.055	-0.181
33	-0.115	-0.098	-0.14	-0.133
34	-0.121	-0.136	0.099	-0.223
35	-0.572	-0.547	0.052	0.055
36	-0.182	-0.182	-0.171	-0.171
37	-0.053	-0.032	-0.176	-0.161
38	-0.014	-0.014	-0.266	-0.266
39	0.046	0.046	0.174	0.173
40	0.104	0.106	-0.176	-0.176
41	0.138	0.138	0.065	0.065
42	0.167	0.166	0.029	0.031
43	0.175	0.175	0.076	0.076
44	-0.312	-0.312	0.211	0.211
45	-0.174	-0.167	0.038	0.027
46	0.161	0.153	0.116	0.116
47	-0.064	-0.057	-0.176	-0.173
48	0.144	0.147	0.071	0.069
49	0.128	0.126	-0.097	-0.11
50	0.001	0.009	-0.192	-0.188
51	0.232	0.242	-0.002	-0.006

Table 2, cont.: Proper motion of each pair. Column 1 contains running numbers of the pairs, columns 2 and 3 contain proper motion data in right ascension taken directly from the catalog. Columns 4 and 5 contain proper motion data in declination taken directly from the catalog.

Martin Nicholson is a retired teacher who lives in Daventry, England. He has been a double star observer for 5 years and has contributed many measurements of previously neglected doubles to the Washington Double Star Catalog. He also makes photometric observations for the AAVSO.