Finding New Common Proper-Motion Binaries by Data Mining

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Abstract: This paper presents new common proper-motion binaries detected by applying well-known statistical criteria over large subsets of the astrometric catalogs available online. All the pairs have been confirmed by checking the photographic plates and are not included in the Washington Double Star Catalog. An initial measurement of separation and position angle has been obtained for each pair.

Editor's note: this paper underwent review by professional astronomers.

Introduction

Common proper-motion binaries (CPMBs from now on) are pairs of stars where the two components share noticeable and very similar proper motion. Although not all the CPMBs need to correspond to orbiting binaries, their similar motion is a first clue that points out these pairs as possible candidates to true binaries.

The purpose of this research was to find new CPMBs not detected up to now in the available astrometric catalogs. The idea, of course, is not new: it was used for instance by Greaves (2004), who detected 705 new pairs in the UCAC2 catalog (Zacharias N. et al., 2004). In this study, we use the catalog NOMAD and discriminate CPM pairs by using the statistical criteria presented by Halbwachs (Halbwachs, 1983). The NOMAD catalog includes data from different catalogs such as UCAC2, USNOB1 (Monet D. et al., 2003), Tycho2 (Hog E. et al., 2000) and others, and therefore it is not a primary source. However, from the point of view of data mining this combination of data seemed very convenient since it allows for relating stars of different catalogs.

The Data Mining Process

Our main selection criteria used for distinguishing the new pairs was Halbwachs' selection criteria for distinguishing physical and optical pairs from their proper motion:

$$(\boldsymbol{\mu}_1 - \boldsymbol{\mu}_2)^2 < -2\,(\sigma_1^2 + \sigma_2^2)\ln(0.05)$$
$$\mu \geq 50 \text{ mas/yr}$$
$$\rho/\mu < 1000 \text{ yr}$$

where $\boldsymbol{\mu}_1$, $\boldsymbol{\mu}_2$ are the two proper motion vectors, σ_i is the mean error of the projections on the coordinate axes of $\boldsymbol{\mu}_i$, μ is the smaller proper motion vector module between $\boldsymbol{\mu}_1$ and $\boldsymbol{\mu}_2$, and ρ is the angular separation of the two stars. The first condition indicates whether the hypothesis $\boldsymbol{\mu}_1 = \boldsymbol{\mu}_2$ is admissible with a 95% confidence considering the given errors σ_1 and σ_2. The second condition establishes that the proper motion must be ≥ 50 mas/yr for both components of the pair, while the third condition is an empirical way of relating the separation and the modulus of the proper movement vector.

The initial database consisted of around three million entries of the NOMAD catalog. All were stars with:

- Visual magnitude < 17,
- Proper motion > 0 in both axes, and
- Positive declination, i.e. only northern stars were included.

The entries were obtained through VizieR (Allende & Dambert 1999), and were filtered following the next steps:

1. First, the second Halbwachs criterion was applied, deleting all the entries with proper motion vector module $\mu < 50$ ms/yr. We also removed the entries where the error σ was more than 25% of μ, since usually in these cases the entries do not correspond to

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stars in the photographic plates. After this step, the set of entries was reduced to about 120 000 entries. We applied first the second criterion because it can be checked faster than the first one, and therefore it results more convenient for dealing with a large database.

2. The first Halbwachs criterion was then applied to combine the entries in pairs. Only about 600 pairs fulfilled this criterion.

3. The coordinates were crossed with the WDS (Mason et al., 2003), looking for WDS entries in a radius of 2 minutes. It was found that 115 pairs were already included in the catalog (most of them LDS and GIC pairs). Also the lists of new pairs in Lépine & Shara (2002), Lépine & Bongiorno (2007), and Chanamé & Gould (2003) were checked, finding that these pairs were already in the WDS and that consequently they had been considered already.

4. When examining the remaining pairs, it became apparent that a large number of the NOMAD entries in the list that didn't correspond to the Tycho2, USNOB1 or UCAC2 catalogs and did not appear in the photographic plates. Therefore, a final filter was applied, keeping only those pairs with the two stars in any of the Tycho2, USNOB1 or UCAC2. After this last filter 273 pairs were kept as "candidate" CPMBs.

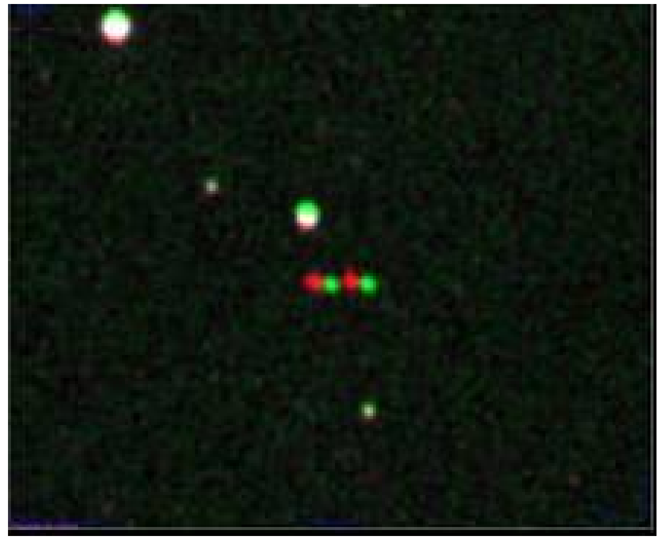

Figure 1: The ALADIN composite image showing the movement of the pair CBL 11 between 1954 (green) and 1990 (red)

Checking the photographic plates

In spite of all the initial filters, most of the 273 candidates didn't correspond to CPMBs in the photographic plates: galaxies, influence of bright stars, or crowded areas were typical situations where the entries did not match pairs of stars. Therefore, a final examination of each candidate pair was undertaken by using the photographic plates of the first and second Palomar Observatory Sky Surveys (Reid I.N. et al., 1991) available at Aladin (Bonnarel, F. et al., 2000). For every pair, a POSSI and a POSSII image was selected and combined, either by the RGB or the blink utilities of ALADIN, observing whether two stars with noticeable movement really existed in the expected place. See Figure 1 for an example. All the uncertain cases were discarded, leaving a set of 111 pairs.

Measuring the new pairs

Table 1 lists the new pairs. Since they are not in the WDS, the identifier CBL, corresponding to the author in this catalog, has been chosen for numbering the pairs. The astrometry of the pairs from the 2MASS catalog has been employed. The table includes the USNO-B1 identifier and J2000 coordinates of the primary, followed by the visual magnitudes of both components, position angle, separation and the date registered in the 2MASS catalog. It is worth noticing that for every pair in the list the dates for both components in the 2MASS catalog were usually the same. When this was not the case the values were so close that choosing one or another didn't affect the date displayed in the table. Using the astrometric data the condition 3 of the Halbwachs criterion was applied. This resulted in the rejection of only one pair in the list. The remaining 110 pairs are included in Table 1. Figure 2 is an image of one of the pairs. Table 2 lists the relevant proper motion data on these selected pairs, obtained from UCAC2, Tycho2, USNOB1, or YB6. While examining the plates, it was found that CBL 30 was in fact a triple system. The PM of the third star in the

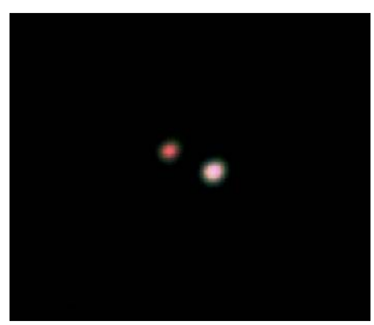

Figure 2: CBL 78. DSI Pro camera with LRGB filters.

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Table 1: Measures of the New Pairs

NAME	USNO-B1.0	RA DEC	MAGS		PA	SEP	DATE	NOTES
CBL 1	1353-0003961	001028.93+452338.9	10.883	14.21	229.5	22.99	1998.842	
CBL 2	1444-0011384	001954.91+542703.8	13.4	14.33	111.6	22.00	2000.71	
CBL 3	1447-0012444	002107.56+544653.1	12.38	13.74	332.1	18.01	2000.743	
CBL 4	1287-0007926	002417.61+384223.1	12.21	13.54	115.3	29.15	1998.769	
CBL 5	1407-0013541	002712.68+504425.3	16.34	16.62	359.2	22.96	1998.848	(6)
CBL 6	1418-0017624	003032.07+514914.0	8.898	4.98	39.6	44.17	1998.848	
CBL 7	1110-0006139	003126.48+210130.5	14.55	15.44	228.2	12.46	1997.758	
CBL 8	1426-0031534	005656.07+523624.0	16.13	16.87	11.3	23.06	2000.003	
CBL 9	1154-0015804	011252.89+252828.6	11.736	12.99	326.9	58.92	1997.832	
CBL 10	1147-0015351	011300.89+244541.3	13.37	15.68	64.5	22.80	1997.832	
CBL 11	1062-0020609	015751.37+161332.0	15.98	16.27	90.5	12.22	1998.878	
CBL 12	1043-0020587	020134.39+142225.9	12.04	12.95	215.1	61.19	1997.701	
CBL 13	1356-0049068	020619.92+453803.7	10.235	11.343	317.4	49.95	1998.823	
CBL 14	1429-0089815	023928.67+525523.2	11.778	13.19	51.0	12.68	1999.804	(2)
CBL 15	1409-0078686	025459.28+505852.9	8.573	13.32	203.6	34.19	1999.14	(2)
CBL 16	1281-0063374	030035.78+380825.9	11.58	13.33	287	22.55	1998.791	
CBL 17	1096-0034009	030106.07+193649.4	11.239	15.12	193.8	31.01	2000.022	
CBL 18	1168-0036646	030257.20+264949.6	14.59	14.87	287.4	19.19	1997.881	
CBL 19	1358-0081082	031716.45+455327.6	11.511	13.29	232.2	48.20	2000.126	
CBL 20	1151-0077593	053018.38+251120.5	9.859	13.71	292.8	42.63	1997.961	
CBL 21	0953-0080081	060803.53+052120.3	14.71	16.41	246.6	9.78	1999.894	
CBL 22	1341-0171738	062813.24+440822.9	13.07	13.14	190.9	53.56	1998.837	
CBL 23	1048-0128030	065426.55+145312.7	14.19	15.31	80.9	20.63	1999.247	
CBL 24	1246-0150520	072830.99+343704.4	12.23	13.96	86.7	34.23	1998.9	
CBL 25	1496-0177151	073327.51+593707.1	10.399	13.38	300.3	9.93	2000.225	(2) (4)
CBL 26	1252-0153135	073604.63+351709.9	12.77	13.93	286.9	22.10	1998.9	
CBL 27	1434-0189951	073813.82+532819.1	13.09	13.35	13.4	11.14	1999.859	(4)
CBL 28	1267-0158795	074409.07+364633.0	10.351	12.56	0.4	17.81	1998.27	(4)
CBL 29	1305-0187245	075505.48+403116.7	12.63	13.03	199.1	65.57	1998.276	
CBL 30AB	1487-0179640	080208.67+584612.5	8.402	10.94	239.1	23.35	1998.993	
CBL 30AC	1487-0179640	080208.67+584612.5	8.402	?	227.1	25.38	1998.993	(3)

Table 1 continues on next page.

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Table 1, continued: Measures of the New Pairs

NAME	USNO-B1.0	RA DEC	MAGS		PA	SEP	DATE	NOTES
CBL 31	1222-0199621	083309.74+321736.6	12.669	12.72	167.9	25.91	1998.218	
CBL 32	1175-0206398	084614.32+273541.3	7.294	10.504	173.9	41.07	1998.096	(5)
CBL 33	1435-0195073	090020.84+533209.1	9.634	12.146	113.7	29.48	1999.826	
CBL 34	1183-0183155	090232.02+282226.8	12.38	13.2	150.2	20.43	1998.89	(4)
CBL 35	1709-0032816	092834.47+805620.2	13.41	15.75	327.9	14.88	2000.042	
CBL 36	1301-0199025	093529.58+400613.5	10.438	12.17	131.9	13.23	1998.254	
CBL 37	1346-0214538	093815.48+443641.2	12.268	13.64	127.3	30.31	1999.141	
CBL 38	1350-0214920	095029.75+450501.3	7.424	12.41	10.8	53.06	1998.322	
CBL 39	1095-0176204	095239.48+193331.0	10.686	16.12	324.7	35.39	1998.063	
CBL 40		095500.70+483418.6	12.65	13.2	303.3	9.79	2000.17	(1)
CBL 41	1371-0247225	101259.22+471032.5	9.936	11.207	154.7	30.88	1999.141	
CBL 42	1518-0186169	103928.41+614902.4	9.993	13.41	151.8	46.73	1999.119	
CBL 43	1414-0218500	104208.57+512856.8	12.48	13.05	182	11.48	1998.936	
CBL 44	1220-0212432	104227.80+320526.4	11.059	13.02	327.5	14.82	1998.358	(2)
CBL 45	1475-0257755	105731.83+573301.4	11.076	13.48	24.6	23.44	2000.17	
CBL 46	1538-0178230	105903.58+635023.6	11.6	13	177.5	55.32	1999.092	
CBL 47	1132-0203695	105933.14+231547.1	10.838	11.88	182.7	19.83	1998.081	
CBL 48	1119-0215346	111354.31+215833.3	11.179	12.306	189.7	15.54	1999.272	
CBL 49	1353-0223882	111438.30+452055.2	10.487	10.667	38.3	64.18	1999.245	
CBL 50	1460-0216441	113140.46+560138.2	10.844	13.36	220.2	20.56	1999.905	
CBL 51	1405-0224403	114810.23+503557.1	13.18	13.25	303.6	36.96	1999.01	
CBL 52	1439-0216861	120547.60+535456.2	9.226	11.875	350.1	54.54	1999.021	
CBL 53	1600-0096810	123312.67+700308.3	13.39	13.43	26.9	26.28	1999.215	
CBL 54	1101-0213789	123711.56+200926.0	9.75	12.76	284	15.81	1999.313	(2)
CBL 55	1228-0268478	124700.48+325028.2	11.452	13.34	20.1	54.06	1998.183	
CBL 56	1459-0230437	132151.65+555404.2	9.281	12.41	76.3	25.07	1999.253	
CBL 57	1413-0245337	135451.37+512249.9	11.185	12.35	109.8	27.06	1999.376	
CBL 58	1420-0274134	142736.02+520408.0	11.013	13.46	289.1	13.41	2000.203	(2)
CBL 59	1419-0271126	143414.26+515958.7	11.986	12.602	298.4	21.68	2000.348	
CBL 60	1353-0255955	151423.82+451809.3	11.397	13.4	160.0	11.05	1999.395	
CBL 61	1197-0243959	161130.74+294234.2	14.73	16.11	185.4	15.92	1999.429	

Table 1 continues on next page.

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Table 1, continued: Measures of the New Pairs

NAME	USNO-B1.0	RA DEC	MAGS	PA	SEP	DATE	NOTES
CBL 62	1187-0242471	161327.73+284350.	10.543 13.01	255.9	26.43	1999.428	
CBL 63	1367-0281313	161533.40+464623.7	15.77 16.66	160.8	44.14	1999.349	
CBL 64	1383-0279390	162552.67+482011.9	9.41 12.72	151.4	30.71	1998.462	
CBL 65	1493-0233771	162736.64+592211.8	10.439 12.96	322.0	12.70	1999.317	(2)
CBL 66	1316-0292197	171011.98+413914.3	10.482 13.54	331.6	22.60	1998.355	
CBL 67	1258-0257226	172138.79+354924.9	7.453 12.77	236.9	26.71	1998.274	(2)
CBL 68	1638-0096060	172312.27+734945.6	12.118 15.12	358.5	44.62	1999.39	
CBL 69	1300-0276871	172942.05+400351.1	13.14 13.7	243.7	12.47	2000.193	
CBL 70	1415-0281135	173727.32+513211.8	12.3 13.03	93.2	14.67	2000.256	
CBL 71	1260-0264228	174222.59+360448.8	9.38 11.135	195.6	26.77	1999.42	
CBL 72	1170-0333739	175050.13+270106.0	14.85 15.54	173.5	12.63	2000.201	
CBL 73	1351-0290580	180209.25+450628.2	12.64 13.74	292.5	31.72	1998.438	
CBL 74	1244-0267987	180511.26+342937.6	11.671 13.6	245.1	11.18	1998.29	(2)
CBL 75	1283-0322893	181538.79+381949.9	9.885 10.853	206.9	18.52	1998.405	
CBL 76	1431-0322292	181653.63+530852.1	10.755 11.784	8.5	44.87	2000.335	
CBL 77	1249-0279065	182702.20+345945.5	9.981 13.85	68.7	39.20	2000.256	
CBL 78	1269-0348025	190627.50+365745.0	10.855 11.442	66.9	25.12	1998.391	
CBL 79	1378-0417325	194543.80+474843.7	13.1 14.07	262.4	19.22	1998.449	
CBL 80	1351-0354479	195725.12+450724.7	15.21 16.03	66.6	17.70	2000.354	
CBL 81	1376-0418238	200014.11+473709.0	9.548 10.702	256.7	43.90	1998.902	
CBL 82	1170-0539954	200834.71+270415.9	14.09 14.43	320.3	24.32	1997.772	
CBL 83	1291-0409283	202841.83+391117.9	8.667 13.88	172.0	41.81	1998.471	
CBL 84	1325-0475984	204049.99+423110.5	14.62 15.99	160.1	15.95	1998.839	
CBL 85	1352-0390855	204335.50+451410.9	13.31 14.1	165.8	17.69	1998.839	
CBL 86	1186-0526736	204926.75+283955.2	10.693 15.86	317.4	53.66	1999.869	
CBL 87	1406-0375283	204953.89+503608.0	9.894 15.42	1.5	24.94	1999.467	
CBL 88	1073-0653047	204956.64+171813.7	14.38 15.11	103.8	43.45	2000.335	(4)
CBL 89	1442-0341333	205545.06+541646.1	11.966 16.87	145.5	14.50	2000.838	
CBL 90	1203-0545171	210911.99+302329.8	13.39 13.94	112.8	54.50	1999.754	
CBL 91	1641-0117598	211347.82+740857.1	15.4 16.84	167.8	32.70	1999.773	
CBL 92	1411-0392234	212509.09+510932.0	12.129 13.41	341.7	9.07	2000.504	(2)
CBL 93	1264-0490109	212511.74+362850.9	14.09 15.62	56.63	12.91	2000.901	

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Table 1, continued: Measures of the New Pairs

NAME	USNO-B1.0	RA DEC	MAGS		PA	SEP	DATE	NOTES
CBL 94	1437-0362140	213137.11+534549.3	16.25	16.97	49.1	13.65	2000.504	
CBL 95	1078-0719224	214236.18+174835.5	13.64	16.12	222.3	37.13	1998.733	
CBL 96	1384-0425519	214314.94+482759.9	10.44	13.87	116.5	46.55	2000.767	
CBL 97	1249-0490039	215636.23+345953.3	13.1	14.45	61.8	20.60	2000.759	
CBL 98	1408-0434291	220421.06+504855.7	10.175	13.38	314.0	37.10	1999.702	
CBL 99	1144-0547052	221045.20+242504.6	10.241	16.08	135.2	72.02	1997.843	
CBL 100	1138-0544492	221120.70+235305.3	13.02	14.53	348.6	21.59	1997.843	
CBL 101	1390-0450716	221652.56+490251.5	8.63	11.315	180.2	48.67	1999.764	
CBL 102	1382-0525713	222537.82+481353.7	9.468	16.07	17.86	45.45	2000.857	
CBL 103	1510-0327596	222937.99+610029.8	16.11	16.62	279.5	19.88	1999.746	
CBL 104	1294-0507568	224342.95+392847.9	10.273	12.81	8.9	62.72	1998.774	
CBL 105	1191-0585926	230517.40+291138.6	15.96	16.88	247.4	8.33	1997.876	
CBL 106	0980-0730247	230622.56+080123.0	12.289	16.73	226.0	13.56	2000.688	
CBL 107	1486-0374980	230738.45+583716.7	9.707	16.84	71.0	30.69	1998.982	
CBL 108	1554-0278711	234600.91+652503.2	15.22	15.69	225.4	28.66	1999.787	
CBL 109	1381-0599542	234619.17+480839.1	10.846	11.471	216.2	53.84	1999.765	
CBL 110	0948-0596504	234934.29+045337.3	7.993	11.27	20.1	30.89	2000.622	(5)

Table Notes:

1. Primary in NOMAD but not in USNO-B1.0. NOMAD identifier: 1385-0209435
2. Secondary in NOMAD but not in USNO-B1.0
3. C component is in 2MASS but not in NOMAD, visual magnitude unknown
4. Pair with one MS and one SD according to the RPM criterion, possibly non-physical
5. Two MS or two SD stars, with the line connecting the two points in the RPM diagram not parallel to their corresponding MS or SD track for disk and halo binaries
6. Primary SD, secondary WD

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Table 2: Proper motion of each component (mas/yr)

NAME	m_1	σ_1	m_2	σ_2
CBL 1	(-51.1, 69.1)	(.6, .8)	(-48, 68)	(3, 2)
CBL 2	(48, -28)	(3, 2)	(46, -22)	(4, 2)
CBL 3	(70.5, 10.5)	(4.5, 4)	(76, 10)	(1, 2)
CBL 4	(-53.3, -10.7)	(1.1, .7)	(-50, -2)	(7, 6)
CBL 5	(74, 24)	(4, 5)	(72, 26)	(2, 1)
CBL 6	(104.4, -22.1)	(.8, .6)	(104, -20)	(3, 3)
CBL 7	(64, 52)	(3, 3)	(62, 52)	(2, 3)
CBL 8	(108, 60)	(1, 1)	(100, 58)	(2, 5)
CBL 9	(66, 27.5)	(1.2, .9)	(60, 30)	(4, 1)
CBL 10	(65.9, 21.8)	(3.1, 3)	(66, 22)	(2, 2)
CBL 11	(160, 66)	(2, 5)	(150, 64)	(4, 1)
CBL 12	(36.9, 50.7)	(2.7, 2.6)	(38, 48)	(5, 2)
CBL 13	(35.4, -49.6)	(1.1, 1.2)	(34.1, -51.4)	(1.7, 1.3)
CBL 14	(50.8, -49.9)	(.6, 1)	(55.7, -59.6)	(9, 9)
CBL 15	(104.1, -43.3)	(.9, .9)	(107.2, -42.8)	(9, 9)
CBL 16	(88.9, -77.2)	(2.1, .7)	(94, -76)	(5, 5)
CBL 17	(41.8, 35.4)	(1.3, 1.3)	(46, 38)	(4, 3)
CBL 18	(62, 46)	(2, 4)	(66, 44)	(1, 1)
CBL 19	(80.7, -88.4)	(1.1, 1.1)	(78, -92)	(4, 1)
CBL 20	(31.2, 44)	(.8, .7)	(30, 44)	(2, 2)
CBL 21	(122, 40)	(5, 5)	(128, 42)	(2, 6)
CBL 22	(-34, -44)	(5, 2)	(-34, -46)	(4, 8)
CBL 23	(48, 44)	(1, 1)	(48, 44)	(1, 1)
CBL 24	(97.5, -53.4)	(5.9, 7.2)	(92, -48)	(3, 3)
CBL 25	(14.5, -48.5)	(2.7, 2.7)	(12.2, -59.4)	(9, 9)
CBL 26	(34, -80)	(1, 3)	(34, -82)	(3, 3)
CBL 27	(50, 24)	(13, 7)	(58, 38)	(7, 5)
CBL 28	(-50.4, -25.1)	(.7, .9)	(-56, -30)	(0, 8)
CBL 29	(42, -28)	(1, 4)	(50, -24)	(3, 3)
CBL 30	(52.7, -26.8)	(1.3, 1.3)	(51.8, -21.8)	(2.3, 2.3)
CBL 31	(-52.7, -40.4)	(1, 1)	(-56, -40)	(3, 0)

Table 2 continues on next page.

Finding New Common Proper-Motion Binaries by Data Mining

Table 2, continued: Proper motion of each component (mas/yr)

NAME	m_1	σ_1	m_2	σ_2
CBL 32	(3, -81.8)	(1, .8)	(1.8, -82.5)	(.7, .9)
CBL 33	(-43.8, 24.5)	(1.1, 1.3)	(-45.2, 22.5)	(3.2, 3)
CBL 34	(-38.4, -88.3)	(1.4, 5.7)	(-38, -90)	(3, 2)
CBL 35	(54, 66)	(3, 4)	(56, 62)	(2, 3)
CBL 36	(28.3, -54.7)	(.7, .7)	(37.7, -57.8)	(9, 9)
CBL 37	(-50.6, -13.7)	(.7, .7)	(-50, -8)	(4, 2)
CBL 38	(-81.9, -94.5)	(.6, .4)	(-84.4, -95.8)	(3.4, .7)
CBL 39	(50.2, 36)	(.7, .8)	(48, 34)	(2, 2)
CBL 40	(173.1, -10)	(9, 9)	(147.3, 2.3)	(9, 9)
CBL 41	(-125, 9.9)	(1, 1.1)	(-123.8, 11.4)	(.7, .7)
CBL 42	(-53.2, -70.7)	(1.8, 1.8)	(-48, -70)	(2, 2)
CBL 43	(-86, -58)	(6, 12)	(-86, -62)	(5, 8)
CBL 44	(-77.7, -26.5)	(1, .7)	(-81.8, -34)	(9, 9)
CBL 45	(-72.7, -28.6)	(3.2, 3.2)	(-72, -24)	(2, 2)
CBL 46	(-60, -21.1)	(5, 5.2)	(-62, -16)	(1, 5)
CBL 47	(44.6, -37.8)	(1, .7)	(46, -34)	(7, 4)
CBL 48	(-73.8, -6.2)	(.7, 1.1)	(-71.2, -7.7)	(2.2, 2.2)
CBL 49	(-51.7, 7.9)	(.6, .6)	(-52.9, 8.1)	(.7, .6)
CBL 50	(-57.2, -52)	(3.7, 3.7)	(-54, -52)	(3, 3)
CBL 51	(-52, 16)	(2, 2)	(-50, 16)	(2, 1)
CBL 52	(-108.7, -82)	(1.3, 1.3)	(-111.2, -78.5)	(4, 4.4)
CBL 53	(-68, 10)	(2, 3)	(-70, 14)	(1, 3)
CBL 54	(-91.9, -14.8)	(3.7, 2.3)	(-110.2, -16.7)	(9, 9)
CBL 55	(40.6, -66.3)	(1, 1.4)	(40, -60)	(6, 2)
CBL 56	(-68.7, -2.5)	(.8, .9)	(-60, -10)	(8, 5)
CBL 57	(-55, 27.3)	(1.8, 1.8)	(-58, 22)	(4, 2)
CBL 58	(-64.5, 13)	(1.6, 1.6)	(-68.3, 13.6)	(9, 9)
CBL 59	(-52.5, -5)	(3.3, 3.1)	(-60.8, -2.6)	(3.6, 3.2)
CBL 60	(48.7, -15.1)	(.8, .9)	(56.9, -24)	(9, 9)
CBL 61	(32, 48)	(6, 2)	(34, 44)	(1, 0)
CBL 62	(60.8, -78.5)	(.7, .7)	(58, -74)	(5, 2)

Table 2 continues on next page.

Finding New Common Proper-Motion Binaries by Data Mining

Table 2, continued: Proper motion of each component (mas/yr)

NAME	m_1	σ_1	m_2	σ_2
CBL 63	(48, 58)	(2, 4)	(52, 58)	(3, 2)
CBL 64	(52.5, -64.9)	(1.8, 1.8)	(58, -54)	(8, 13)
CBL 65	(-73.5, 44.7)	(2.7, 2.7)	(-91.3, 47.7)	(9, 9)
CBL 66	(-6.8, 92.6)	(1, 1.2)	(-6, 94)	(3, 4)
CBL 67	(-16.2, 58.7)	(.5, .7)	(-20.8, 58.4)	(9, 9)
CBL 68	(106.5, 123.5)	(2.1, 2.2)	(104, 118)	(3, 4)
CBL 69	(-66, -50)	(12, 6)	(-66, -48)	(13, 6)
CBL 70	(-78, 28.5)	(7, 6.5)	(-76, 18)	(2, 3)
CBL 71	(-17.1, -143.6)	(2.1, 1.8)	(-14, -140.8)	(.7, 1)
CBL 72	(44, 36)	(3, 1)	(44, 36)	(2, 5)
CBL 73	(-64, -84)	(6, 3)	(-60, -86)	(5, 0)
CBL 74	(-39.3, 75.6)	(.7, .7)	(-49.4, 67)	(9, 9)
CBL 75	(21.1, 98.9)	(.7, .8)	(18.9, 98)	(1.5, .7)
CBL 76	(4.7, 58.3)	(2.6, 2.3)	(4, 67)	(3.3, 3.1)
CBL 77	(2.2, -75)	(1.4, 1.5)	(2, -74)	(1, 6)
CBL 78	(42.9, 35.8)	(.8, 1)	(42.6, 36.5)	(1, 1)
CBL 79	(82, 36)	(7, 0)	(76, 36)	(1, 6)
CBL 80	(130, 224)	(3, 4)	(124, 232)	(1, 7)
CBL 81	(64.4, 65.4)	(1.6, 1.6)	(63.3, 67.9)	(2.6, 2.3)
CBL 82	(50, 40)	(2, 4)	(46, 42)	(2, 2)
CBL 83	(28.4, 49.8)	(.7, .7)	(28, 54)	(3, 1)
CBL 84	(32, 46)	(4, 6)	(32, 42)	(2, 2)
CBL 85	(138, 68)	(2, 0)	(138, 74)	(1, 4)
CBL 86	(23.7, 60.8)	(1.2, 1.4)	(26, 60)	(1, 3)
CBL 87	(106, 85.7)	(1.8, 1.8)	(110, 92)	(4, 5)
CBL 88	(52, 38)	(9, 3)	(48, 38)	(1, 2)
CBL 89	(39.8, 39.8)	(3.3, 3.1)	(42, 44)	(3, 4)
CBL 90	(38, 54)	(3, 1)	(40, 54)	(2, 3)
CBL 91	(30, 74)	(2, 3)	(32, 74)	(3, 3)
CBL 92	(41.7, 30)	(3.1, 2.7)	(35.9, 41.2)	(9, 9)
CBL 93	(66, 48)	(3, 1)	(70, 46)	(3, 0)

Table 2 continues on next page.

Finding New Common Proper-Motion Binaries by Data Mining

Table 2, continued: Proper motion of each component (mas/yr)

NAME	m_1	σ_1	m_2	σ_2
CBL 94	(86, 28)	(3, 4)	(80, 30)	(1, 3)
CBL 95	(36, 42)	(2, 2)	(34, 42)	(2, 1)
CBL 96	(60.3, 31.1)	(1.6, 1.5)	(56, 34)	(8, 0)
CBL 97	(84.2, 34.7)	(5.3, 6.5)	(84, 32)	(3, 2)
CBL 98	(65.5, 37.2)	(1.6, 1.6)	(68, 38)	(2, 3)
CBL 99	(68.7, 56.5)	(.8, 1.1)	(70, 62)	(6, 2)
CBL 100	(44, 28)	(3, 5)	(48, 30)	(1, 2)
CBL 101	(79.5, 57.2)	(1.5, 1.5)	(79.7, 60.7)	(3.2, 2.8)
CBL 102	(104.7, 103.9)	(1.3, 1.3)	(98, 110)	(4, 5)
CBL 103	(56, 50)	(1, 2)	(52, 52)	(2, 2)
CBL 104	(76.4, 55.3)	(.7, .7)	(78, 58)	(2, 4)
CBL 105	(36, 46)	(4, 4)	(40, 48)	(7, 4)
CBL 106	(90.2, 27)	(3.9, 3.1)	(88, 30)	(3, 1)
CBL 107	(116, 67.2)	(1.6, 1.6)	(112, 64)	(4, 4)
CBL 108	(52, 26)	(2, 1)	(54, 24)	(3, 1)
CBL 109	(50.5, -.8)	(1, .8)	(53.2, -.7)	(.9, .9)
CBL 110	(54.5, 22.8)	(1, .5)	(53.2, 20.7)	(2.4, 3.8)

(Continued from page 157)

photographic plates seems to be very similar to that of the other two components, but no entry in the available catalogs includes data that can confirm this suspicion.

Reduced Proper Motion Diagram

The Reduced Proper Motion (RPM) diagram and its associated RPM discriminator η were introduced by Salim & Gould (2003) and have been proposed for discriminating binaries in Chanamé and Gould (2003). The diagram plots the V_{RPM}, defined as $V_{RPM} = V + 5 \log \mu + 5$, with V the apparent magnitude and μ the proper movement in arcseconds per year, versus a color. It can be considered as a kinematic equivalent of the HR diagram which uses the V_{RPM} as a substitute of the star's intrinsic luminosity. The discriminator η is defined as $\eta = V_{RPM} - 3.1\,(V\text{-}J) - 1.47|\sin b| - 2.73$, with *b* the Galactic Latitude of the star. According to this discriminator, stars are classified as disk (or main sequence, MS) if $h < 0$, as halo (or subdwarf, SD) if $0 < h < 5.15$ and as white dwarf (WD) if $h > 5.15$. The idea is that both components of a binary must have similar metallicities and proper motions, although possibly different luminosities. The criterion used in Chanamé and Gould (2003) is that the members of a pair are considered unrelated when:

- It is composed of one MS and one SD. 5 pairs verify this property: CBL 25, CBL 27, CBL 28, CBL 34, and CBL 88.
- It is composed of two MS or two SD stars, but the line connecting the two points in the diagram is not approximately parallel to their corresponding MS or SD track for disk and halo binaries (Figure 12 of Salim and Gould 2003). CBL 32 and CBL 110 are in this situation. It must be noticed that in some cases the module of the vectors connecting the points was too short to discriminate clearly whether the line was correctly oriented.

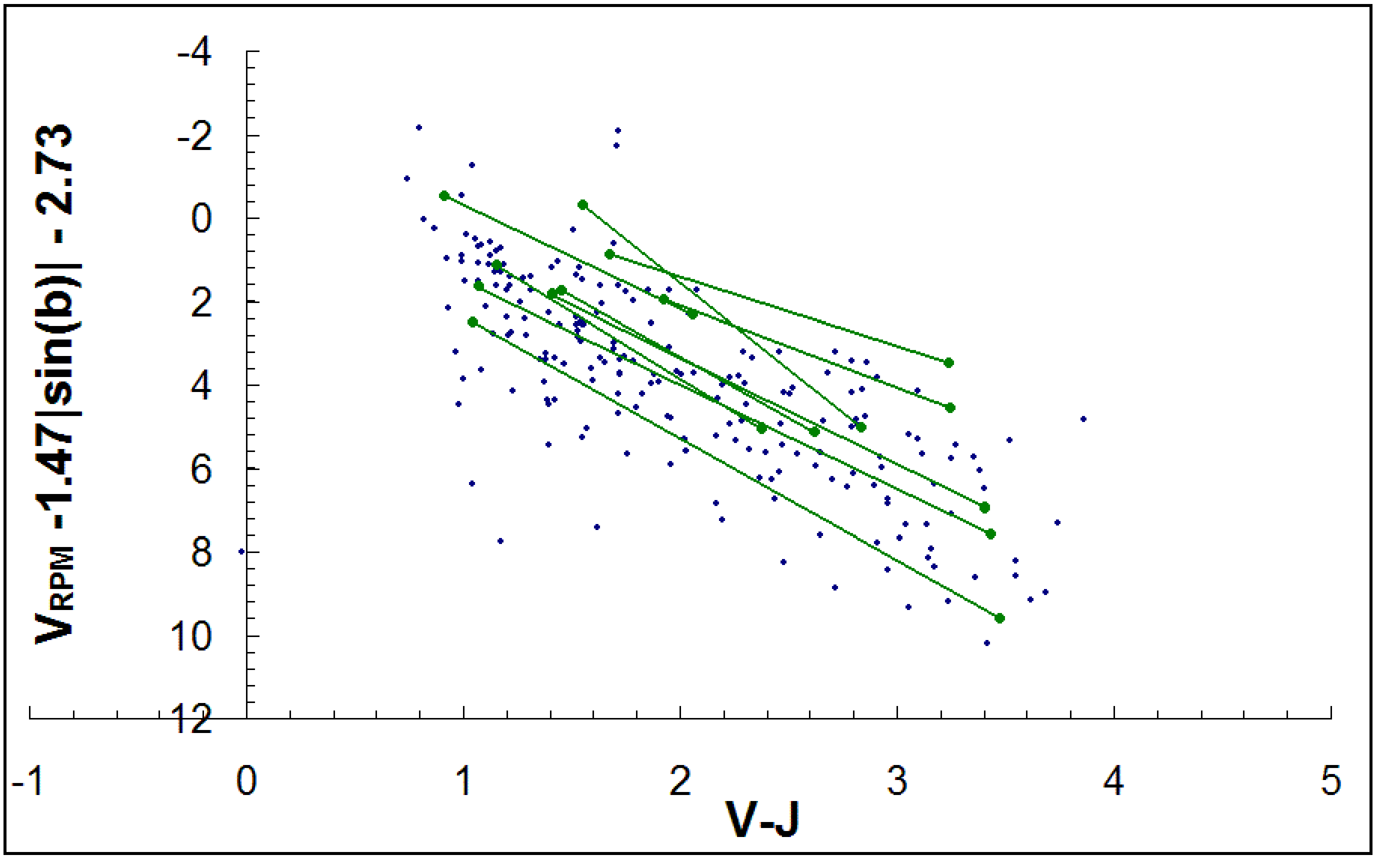

Figure 3: Reduced Proper Motion diagram including some of the lines connecting the new CPMBs.

Therefore 7 of the 110 pairs are possibly non-physical pairs (see notes (4) and (5) in Table 1). The RPM diagram for the new CPMBs can be seen in Figure 3. A few lines including some of the pairs are depicted in the diagram. It is worth noticing that only one WD was found, the secondary of CBL 5, and that there are very few pairs with SD components. This is an effect of our initial filtering of stars with visual magnitude >17, since WD and SD components are usually fainter.

Conclusions and Future Work

We have shown that new CPMBs not included in the WDS can be still found in the catalogs. A list of 110 such new pairs have been obtained and their existence verified in the photographic plates. All of them verify the Halbwachs criteria, although according the criteria based on the RPM diagram, 7 of these 110 CPMBs must be taken with caution.

Although data mining has proven to be an efficient tool for finding new CPMBs, during the visual inspection of the “candidate pairs” some other possible new pairs not included in the catalogs were found. They are not included in the Table 1 since their PM data were not found explicitly. These pairs will be left as future work.

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