

Searching for New Double Stars with a Computer

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Abstract: The advent of computers with large amounts of RAM memory and fast processors, as well as easy internet access to large online astronomical databases, has made computer searches based on astrometric data practicable for most researchers. This paper describes one such search that has uncovered hitherto unrecognized double stars.

Introduction

Recently, four previously unlisted double stars were added to the Washington Double Star Catalog (WDS)¹ as a result of the process to be described in this article. They are shown in Table 1.

These pairs were located by a computer search of the fourth USNO CCD Astrographic Catalog² (UCAC4). Using the CD provided by the United States Naval Observatory³ (USNO), a suite of programs written in Perl and C was used to search the UCAC4 for candidate binary pairs that were not in the WDS.

Pairs that passed this test were then placed into a list for manual verification, using the Aladin⁴ tool.

Using Aladin, the candidate pair was manually examined. Pairs that seemed to be associated with nearby clusters were eliminated, as were pairs enmeshed in nebulosity to the point that they could not be accurately measured with Aladin. Pairs that passed these tests were then measured for position angle and separation,

using Aladin's UCAC4 template on the DSS plate, and placed in a final list of candidates.

The four entries from this final list of pairs were chosen based on their visibility in the summer sky from 39° north latitude, brightness, separation, and a large proper motion. These stars were observed from the Little Tycho Observatory, and then submitted to William Hartkopf⁵ of the USNO.

Search for Unlisted Double Stars from the UCAC4 Data

The instructions given below have been shown to work in a Linux development environment. While they can be replicated in other environments, e.g. an Apple Mac, or the Cygwin environment on a Windows PC, they have not been tested in these environments.

Obtain a copy of the UCAC4 data.

You'll need to send an email to brenda.hicks@navy.mil with "UCAC4" in subject and your full name and postal mailing address in the body of

Table 1: Double stars recently found by computer search and added to the WDS.

RA + Dec: J2000	UCAC4 Designation	Primary mv	Secondary mv
16:39:17.31 +26:27:28.92	583-54539	10.15	11.325
17:16:01.38 +25:16:05.87	577-56486	10.652	12.202
19:50:41.95 +20:18:29.21	552-99070	9.22	10.5
20:43:31.93 +52:16:35.77	712-76210	9.51	10.96

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your e-mail.

A CD of the data will be sent to your address. When it arrives, mount the CD(s) in your computer's CD drive and download the 900 UCAC4 declination zones to a directory on your computer.

Obtain a copy of the WDS data.

On a computer equipped with the wget program and connected to the internet, the following command should do the trick:

```
cd /DirectoryWhereYouWantToStoreTheData/
wget -r -O wdsData http://ad.usno.navy.mil/wds/
Webtextfiles/wdsweb_summ.txt
```

The file wdsData should now be downloaded to your current working directory:

```
DirectoryWhereYouWantToStoreTheData.
```

Getting the code

It is assumed that the reader is somewhat familiar with programming and the C and Perl languages in particular in this section.

Code can be obtained from [GitHub](#), or the author's web site, <http://www.mainsequence.org/html/wds/newPairs>.

In downloading code from the author's web site, you can list the program by left-clicking on the link below, and download it by right-clicking (Ctl-click on a Mac)

The WDS is listed in order of its positional Ids, a low precision J2000 coordinate designation, as opposed to a pair's precise coordinates. A short Perl program has been written to extract the precise coordinates from the WDS which can be downloaded from

[getWDS_PrecisionCoordinates.pl](#)

The program is run from the directory containing a recent copy of the WDS catalog.

The resultant file, WDS.pre, is then sorted using the unix sort command:

```
sort -n WDS.pre > wdsPrecisionCoordinates
```

As the UCAC4, as of this writing, consists of 113,780,093 stars, it was not efficient to search the entire declination range of the catalog for each of the candidates. MkUCAC4_Regions.c reads the catalog and then splits it into files, each of which covers approximately a square degree of sky. Stars that border (within 30") a square degree are also included in the file. In this way, when a candidate star is searched for possible companions, only a single square degree need be searched. The program also creates a list of possible primary candidate stars, all brighter than mvC (Default setting for this is 11000 = 11.0mv) that findUnlistedDoubles.c will use for the search. Click on the link below to download the code.

[mkUCAC4_Regions.c](#)

Edit the program's holding directory location in lines 65 and 68 to match where you would like its square degree files to be written. The directory used to store the UCAC4 data must also be changed in line 104.

The program can be compiled using this command:

```
gcc -std=gnu99 -O2 -o mkr -W mkUCAC4_Regions.c -lm
```

and run using this: mkr

Find candidate binary pairs not in the WDS from UCAC4 data

Now that we have the precision coordinates from the WDS and the UCAC4 data for the brighter stars stored in square degree files, we can search for pairs not in the WDS with findUnlistedDoubles.c. Click on the link below.

[findUnlistedDoubles.c](#)

Many of the search parameters set by both programs can be changed, the programs recompiled, and different results obtained. If a very loose set of parameters is used, many thousands of possible pairs can be generated. More restrictive parameters will result in fewer pairs. Once the user is familiar with editing and compiling the programs, many interesting lists can be generated. Each list takes only about 5 minutes to compile and create on the author's machine. It complies with a command similar to the one given above.

The program's output file is in HTML format. Read it in your browser by opening it as a file. A sample output can be seen at the link [listing 1](#).

The program ships with these default parameters. Their default values are the numbers in parentheses following the parameter's name:

- Only stars brighter than mvC (11000) are considered as primary candidates. Generally, the brighter the star, the more information about it is to be found in the literature, simplifying subsequent study. This can be changed by changing the value of mvC in mkUCAC4_Regions.c.
- Secondary stars must be brighter than mvS (12000) to be considered. This again can be changed by changing mvS in findUnlistedDoubles.c and mkUCAC4_Regions.c. Note that the UCAC4 does not list many stars fainter than 16.0mv (16000).
- The primary and secondary should be within dmV (1000) of each other. This is a fairly arbitrary restriction, and is used to simply cut down on the number of pairs found.

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- XXX (30) is the size of the region of sky that will be searched, in arc seconds. A box of sky twice this distance on a side will be searched for possible companions to a given candidate star. This can be changed by changing XXX in both `mkUCAC4_Regions.c` and `findUnlistedDoubles.c`. Note: The programs have only been tested with XXX set to 30". Change this at your own risk!
- The minimum separation between the stars should be `minSep` (10) arc seconds or more. Pairs are manually verified by examining them on DSS plates. A pair of stars with less separation can be very difficult to differentiate from a single star.
- The larger the maximum separation, `maxSep` (30), the less likely a pair will be physical. Unless XXX is changed, 30 should be the largest separation used.
- The average proper motion of the two stars must be larger than `minPM` (50) milliarcseconds per year (mas/yr). This will help to eliminate slow moving pairs that are optical.
- The difference between the average proper motion of the candidate pair and their individual proper motions should be less than a given quantity `pmR` (5). This condition helps to eliminate possible optical pairs, and is defined as the differences between the primary and secondary proper motions. For example, if a pair had an average proper motion of 70 mas/yr but one component was moving north of the average proper motion at 30 mas/yr, the other south at 20 mas/yr, the pair would be rejected because of their individually disparate, though large, proper motions.
- There must not be a binary listed by the WDS within XXX arc seconds of the candidate pair. Visual magnitudes were ignored for this condition, as many WDS listings show magnitudes different from the UCAC4 magnitudes.
- The program converts all of its angles to radian measure for calculation, and then back to degrees or hours, minutes, and seconds for output.
- The output coordinates are in a format such that you can easily drag and drop them into DSS display tools such as Aladin, GoogleSky, or WikiSky.
- When a parameter is changed, the changed program must be recompiled before the changes will take effect.
- Directories that hold the UCAC4, WDS, and output data are as found on the author's computer. These will probably need to be changed to fit the user's computer.

A sample list

A sample list of possible binary stars not in the WDS is given in Table 2 at the end of this article. Column headers are as follows:

- RA and Dec are the J2000 coordinates of the primary.
- `mv` and `m vb` are the visual magnitudes of the primary and secondary, respectively. They are in units of millimagnitudes, that is $9000 = 9.0mv$.
- `mv src` and `m vb src` are the source of the magnitude measurement, APASS (the AAVSO survey) or UCAC4 (the UCAC4 model magnitude).
- ρ is the separation of the pair, in arc seconds.
- Double Flag is the UCAC4 double flag for the primary.
- Primary and secondary proper motion in both right ascension and declination are given in milliarcseconds per century.
- A and B UCAC4 id give the UCAC4 declination zone and star number in that zone of the primary and secondary, respectively.
- Comments can be edited or added as further study of a pair is done.

Acknowledgments

The editorial assistance of Kathleen Bryant, Thomas Corbin, and R. Kent Clark are gratefully recognized.

References

- 1) The Washington Double Star Catalog, Brian D. Mason, Gary L. Wycoff, William I. Hartkopf, Geoffrey G. Douglass, and Charles E. Worley, 2001.
- 2) The Fourth US Naval Observatory CCD Astrograph Catalog (UCAC4), Zacharias, et al, 2012. <http://www.usno.navy.mil/USNO/astrometry/optical-IR-prod/ucac>
- 3) USNO web site: <http://aa.usno.navy.mil>
- 4) Aladin web site: <http://aladin.u-strasbg.fr>
- 5) William Hartkopf, Astrometry Department, U.S. Naval Observatory 3450 Massachusetts Ave, NW, Washington, DC 20392

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Table 2. Non-WDS Pairs

RA Dec	mv	mv src	mvb	mvb src	sep.	Dbl Flag	Pri PM in RA	Pri PM in Dec	Sec. PM in RA	Sec. PM in Dec	A UCAC4 id	B UCAC4 id
05:37:50.8 +43:01:42.54	9920	APASS	10306	APASS	17.32	3	-81	-13	-63	-19	666 960	666 961
05:39:32.51 -24:19:03.2	9564	APASS	10112	APASS	21.53	0	-142	-185	-149	-165	329 434	329 435
05:41:06.36 -24:34:06.80	9777	APASS	9958	APASS	20.79	0	-99	-92	-307	-168	328 446	328 447
05:42:39.68 -17:47:32.86	9880	APASS	10799	APASS	20.89	0	-52	-181	-126	-590	362 408	362 409
05:42:06.21 +12:24:25.20	9895	APASS	9976	APASS	26.60	0	23	-138	0	-134	513 464	513 465
05:07:34.24 -54:59:20.44	8717	APASS	9063	APASS	15.69	3	-483	535	-1031	-374	176 237	176 236
05:07:09.70 -18:18:07.83	9963	APASS	10690	APASS	27.23	0	-74	-46	-66	-57	359 326	359 325
06:15:49.19 +27:13:26.8	9889	APASS	9962	APASS	8.52	35	23	-67	-21	-100	587 720	587 719
06:18:28.41 -22:49:44.53	9974	APASS	10141	APASS	25.49	0	41	180	-76	164	336 559	336 558
06:34:30.0 +13:02:01.93	9713	APASS	10315	APASS	27.87	0	-16	-69	-9	-58	516 829	516 830
06:41:54.35 +23:56:02.41	9666	APASS	10431	APASS	27.95	0	16	-55	-24	-78	570 866	570 867
06:42:51.75 +26:25:09.4	9547	APASS	9564	APASS	25.01	0	-19	-76	-3	-71	583 879	583 881
06:43:16.39 -11:04:02.59	9920	APASS	10296	APASS	29.66	0	-64	129	-21	-30	395 656	395 655
06:43:28.69 +21:33:59.93	9278	APASS	9445	APASS	25.48	0	-12	-52	-81	-37	558 891	558 890
06:46:26.29 +20:52:52.31	9771	APASS	9777	APASS	11.40	36	-82	-109	-88	-135	555 927	555 926
06:48:42.82 +16:07:49.45	9988	APASS	10425	APASS	17.86	0	-421	-90	-419	-76	531 913	531 915
06:52:42.61 -05:25:59.44	9163	APASS	10136	APASS	18.74	36	-15	22	-80	22	423 772	423 771
06:53:40.34 -24:23:27.51	9207	APASS	10180	APASS	23.59	3	-90	-1520	-90	-1466	329 720	329 721
06:54:12.43 -12:52:56.67	10000	APASS	10856	APASS	22.34	0	-133	-45	-24	33	386 765	386 766
06:55:25.40 +13:48:55.72	9532	APASS	10269	APASS	22.77	0	32	-31	-42	-81	520 900	520 899
06:57:12.90 +11:00:36.72	9770	APASS	10408	APASS	22.10	0	-22	-70	-18	-62	506 857	506 856
06:57:42.60 -39:40:12.58	9679	APASS	10441	APASS	21.90	0	4	-44	-595	569	252 532	252 533
07:13:19.16 +12:25:29.44	9970	APASS	10556	APASS	22.02	0	-28	-320	-61	-37	513 980	513 981
07:15:00.56 -21:53:21.23	9181	APASS	9374	APASS	21.49	3	-136	191	-42	-19	341 870	341 869
07:15:57.1 -11:08:00.18	9909	APASS	10017	APASS	13.27	0	-72	8	-86	-10	395 859	395 858
07:16:17.25 -41:49:03.69	9748	APASS	10519	APASS	28.53	0	-51	-36	12	-77	241 613	241 612
07:18:41.98 -24:58:12.27	9495	APASS	9978	APASS	22.96	4	-41	80	-36	21	326 863	326 862
07:18:41.98 -24:58:12.27	9495	APASS	10479	APASS	18.24	4	-41	80	-43	53	326 863	326 868
07:19:50.28 +19:42:21.13	9407	APASS	10099	APASS	20.96	0	-46	-45	-45	-43	549 1055	549 1056
07:22:35.70 +06:19:40.23	9912	APASS	10912	APASS	26.02	0	-20	-91	-25	-111	482 1080	482 1082
07:33:07.89 -19:28:05.21	9739	APASS	10104	APASS	16.36	0	-173	153	-10	13	353 978	353 979
07:37:21.38 -28:05:21.72	9357	APASS	9521	APASS	26.41	0	-136	144	-54	85	310 992	310 991
07:38:53.92 -27:22:34.36	9956	APASS	10824	APASS	28.47	36	44	-239	-286	-158	314 961	314 962
07:42:07.78 -31:41:39.46	9450	APASS	9668	APASS	19.72	35	-194	142	-18	199	292 868	292 869
07:47:16.73 -57:16:01.96	9911	APASS	10170	APASS	26.91	0	-122	320	2	126	164 490	164 491
07:48:35.21 +42:50:53.81	9875	APASS	10608	APASS	24.27	0	-136	-57	-315	-381	665 1384	665 1383
07:50:10.53 -12:21:36.60	9452	APASS	10123	APASS	27.76	0	-96	-140	-11	26	389 1076	389 1077
07:54:19.82 -27:01:16.48	9914	APASS	10500	APASS	26.08	0	48	113	-50	151	315 1085	315 1084
07:58:01.13 -43:54:12.61	9682	APASS	10635	APASS	29.03	0	-78	61	-121	61	231 810	231 811
07:59:50.7 +19:46:58.2	9729	APASS	10547	APASS	18.55	0	-48	-24	-52	-662	549 1179	549 1180
07:07:14.49 -13:05:07.13	9395	APASS	10165	APASS	17.36	0	-72	-15	-64	-3	385 787	385 788
07:07:48.51 -02:49:56.75	9756	APASS	10543	APASS	28.41	0	-17	-74	-46	-54	436 1031	436 1032
07:08:09.72 +08:33:05.19	9591	APASS	10152	APASS	29.30	0	-88	8	-46	-58	493 1118	493 1120
08:10:49.46 -12:46:06.61	9979	APASS	10970	APASS	23.65	0	-134	-315	-19	-33	387 1249	387 1248

Table 2 continues on next page.

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Table 2 (continued). Non-WDS Pairs

RA Dec	mv	mv src	mvb	mvb src	sep.	Dbl Flag	Pri PM in RA	Pri PM in Dec	Sec. PM in RA	Sec. PM in Dec	A UCAC4 id	B UCAC4 id
08:12:07.94 -37:39:27.58	9562	APASS	9799	APASS	20.43	0	-39	34	-58	64	262 839	262 838
08:13:23.20 -32:29:59.67	9281	APASS	9364	APASS	8.15	0	-62	36	-1216	-802	288 1033	288 1032
08:21:02.30 +4:59:30.48	9988	APASS	10357	APASS	27.36	0	-564	-902	213	8	475 1289	475 1288
08:22:42.75 -12:05:00.27	9556	APASS	10498	APASS	14.05	36	-180	169	-54	-1	390 1282	390 1284
08:26:34.34 -23:05:01.24	9252	APASS	10142	APASS	24.31	0	-181	390	13	74	335 1406	335 1405
08:26:45.76 -31:20:45.97	9802	APASS	9933	APASS	29.55	0	-80	112	-117	137	294 1234	294 1233
08:30:46.92 -33:06:11.41	9893	APASS	10729	APASS	24.26	0	-37	-108	-45	18	285 1160	285 1161
08:34:00.5 -13:41:47.6	9751	APASS	10456	APASS	24.59	0	-120	-427	-9	36	382 1352	382 1353
08:40:21.21 -26:15:19.24	9837	APASS	9995	APASS	22.31	0	-139	40	-21	62	319 1483	319 1484
08:42:24.29 -37:21:43.79	9973	APASS	10757	APASS	29.18	0	-77	8	-60	-37	264 1134	264 1135
08:49:51.36 -52:04:29.41	9658	APASS	10367	APASS	23.19	0	-153	214	-89	110	190 723	190 724
08:50:07.33 -45:19:29.36	9289	APASS	10022	APASS	27.26	35	-26	56	-102	39	224 1037	224 1038
08:06:50.27 -30:47:28.40	9943	APASS	10384	APASS	20.02	0	-100	5	-70	-9	297 1109	297 1110
08:08:54.89 -24:49:15.73	9874	APASS	10812	APASS	21.10	0	1	14	-89	-80	326 1296	326 1295
09:00:48.10 -50:57:37.47	9912	APASS	10704	APASS	27.85	0	-353	333	8	90	196 799	196 800
09:10:59.84 -35:25:17.44	9749	APASS	10133	APASS	22.68	3	-84	35	67	71	273 1229	273 1227
09:14:25.3 -52:52:06.39	9940	APASS	10043	APASS	12.22	0	-128	-37	-105	-9	186 867	186 868
09:19:04.61 -44:10:31.68	9732	APASS	10391	APASS	17.54	35	-53	32	-17	43	230 1087	230 1088
09:20:15.2 +0:35:50.46	9755	APASS	10594	APASS	28.33	0	-194	5	-584	130	453 1479	453 1480
09:21:40.55 -44:55:41.10	9869	APASS	10159	APASS	20.20	0	-45	44	-129	9	226 1080	226 1079
09:30:05.52 -15:38:47.42	9918	APASS	10710	APASS	22.47	0	-102	20	-762	-475	372 1578	372 1577
09:31:19.76 -47:06:52.55	9859	APASS	10443	APASS	19.54	0	81	115	-153	-23	215 1119	215 1118
09:32:37.12 -52:42:00.7	9897	APASS	9996	APASS	15.18	35	-38	175	-93	11	187 920	187 919
09:36:42.24 -59:41:55.90	9753	APASS	10252	APASS	19.74	0	-93	66	-356	-1168	152 777	152 778
09:37:50.97 -36:14:53.91	9887	APASS	10617	APASS	23.44	0	46	-271	-46	-26	269 1380	269 1379
09:37:06.51 -51:35:38.26	9709	APASS	10148	APASS	10.57	0	-129	31	-344	1520	193 927	193 928
09:38:57.35 -33:45:03.43	9489	APASS	9555	APASS	21.97	0	-699	-826	-165	78	282 1486	282 1485
09:52:10.24 -53:53:47.1	9266	APASS	9313	APASS	10.78	0	-244	-75	-113	98	181 1105	181 1106
09:55:52.34 -56:07:10.83	9976	APASS	10000	APASS	20.19	0	0	193	-108	22	170 1028	170 1027
09:57:37.37 -54:40:33.74	9949	APASS	9964	APASS	19.58	3	-28	46	-80	47	177 1056	177 1057
09:06:36.90 -64:55:51.30	9802	APASS	10162	APASS	17.13	35	-81	97	-266	132	126 529	126 530
10:10:21.21 -67:15:48.21	8637	APASS	9010	APASS	21.83	3	-108	62	-1992	1789	114 651	114 652
10:13:28.6 -57:53:01.68	9923	APASS	10103	APASS	22.50	0	-307	338	-2	99	161 1037	161 1038
10:22:39.4 -37:44:59.69	9744	APASS	9849	APASS	28.41	0	-118	29	-496	115	262 1436	262 1435
10:24:28.70 -58:49:47.18	9061	APASS	9173	APASS	10.74	36	-147	222	-601	574	156 1168	156 1167
10:27:37.73 -57:38:23.71	9160	APASS	9195	APASS	8.98	36	-58	35	-121	-279	162 1168	162 1167
10:31:41.15 -57:18:37.66	8824	APASS	8850	APASS	9.15	0	0	0	-114	29	164 1208	164 1207
10:32:07.37 -32:10:33.15	9648	APASS	9666	APASS	22.02	0	34	-68	-120	-38	290 1683	290 1682
10:33:37.60 -59:35:21.28	9970	APASS	10009	APASS	16.75	0	-94	77	-164	127	153 1213	153 1212
10:42:33.6 -62:11:51.53	8933	APASS	9127	APASS	23.99	36	-124	-38	-101	29	140 995	140 994
10:44:05.54 -62:08:02.1	10000	APASS	10042	APASS	8.88	36	112	-250	-177	74	140 1007	140 1006
10:47:17.34 -62:06:38.44	9583	APASS	9632	APASS	14.56	2	-273	-8	-435	1950	140 1043	140 1044
10:49:33.17 -62:49:44.29	9880	APASS	10009	APASS	18.20	0	0	0	-102	78	136 956	136 957
10:50:40.32 -61:30:11.9	9756	APASS	9759	APASS	9.00	0	10	124	-100	4	143 1168	143 1169

Table 2 continues on next page.

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Table 2 (continued). Non-WDS Pairs

RA Dec	mv	mv src	mvb	mvb src	sep.	Dbl Flag	Pri PM in RA	Pri PM in Dec	Sec. PM in RA	Sec. PM in Dec	A UCAC4 id	B UCAC4 id
10:56:07.4 -59:48:17.76	9958	APASS	10099	APASS	14.87	35	0	0	-112	75	151 1531	151 1530
10:09:05.78 +0:22:56.95	9855	APASS	10824	APASS	26.63	0	9	104	-207	229	452 1620	452 1619
11:01:28.65 -61:58:58.1	9983	APASS	10200	APASS	14.09	35	-55	-17	-1940	-1673	141 1175	141 1176
11:16:01.70 -55:13:33.60	9757	APASS	9825	APASS	18.83	36	-65	16	-219	-27	174 1551	174 1552
11:17:57.39 -27:02:07.46	9774	APASS	9935	APASS	8.29	0	0	0	-580	27	315 1863	315 1864
11:36:15.97 -62:28:56.77	9397	APASS	9950	APASS	21.66	0	-431	-258	-5	21	138 1205	138 1206
11:36:22.4 -61:35:38.90	8983	APASS	9549	APASS	25.80	36	-61	70	-59	-196	143 1581	143 1580
11:36:32.49 -58:55:01.12	9842	APASS	10559	APASS	19.57	0	-88	3	-133	20	156 1840	156 1838
11:36:37.77 -34:38:47.0	8773	APASS	9201	APASS	4.72	3	0	0	-2156	1217	277 1678	277 1677
11:36:50.33 -61:40:07.77	9182	APASS	9327	APASS	7.30	25	-309	-451	-38	54	142 1597	142 1598
11:05:37.90 -58:45:49.18	9629	APASS	9880	APASS	25.25	0	-94	44	-86	48	157 1551	157 1550
11:05:56.36 -58:49:08.59	9365	APASS	9506	APASS	23.48	36	-55	62	-104	65	156 1559	156 1558
11:52:58.61 -64:25:11.23	9994	APASS	10163	APASS	24.03	35	-34	-47	-57	-51	128 948	128 949
11:53:32.52 -62:48:04.65	9534	APASS	9884	APASS	11.74	0	339	-74	-376	-93	136 1270	136 1269
12:00:20.94 -62:03:19.92	9635	APASS	9758	APASS	17.03	0	0	0	-494	0	140 1530	140 1531
12:10:01.88 -65:42:26.96	9917	APASS	9969	APASS	26.63	36	-62	-31	-38	11	122 990	122 989
12:31:05.42 -53:46:15.47	9757	APASS	10524	APASS	28.34	0	-99	-16	-19	66	182 1866	182 1867
12:36:01.95 -34:11:59.87	9861	APASS	10149	APASS	19.22	0	103	-54	-422	-331	280 1843	280 1842
12:46:22.69 -59:34:38.94	9804	APASS	10532	APASS	6.28	26	0	0	-99	-117	153 2264	153 2265
13:39:09.69 -64:01:11.70	9583	APASS	10452	APASS	9.60	35	-426	-156	-402	158	130 1530	130 1529
13:52:59.50 -45:03:05.79	9803	APASS	10751	APASS	26.53	0	-95	-35	-71	-18	225 1978	225 1977
13:07:20.69 -71:01:11.21	9884	APASS	9891	APASS	13.28	0	-188	285	-97	-40	95 854	95 855
14:26:09.33 -53:19:26.22	9994	APASS	10862	APASS	20.57	0	-111	-73	14	-92	184 2185	184 2184
14:31:29.43 -49:41:52.28	9962	APASS	10490	APASS	21.66	0	-131	-35	-26	-79	202 2079	202 2080
14:46:47.89 -54:05:30.50	9175	APASS	9764	APASS	22.18	0	-95	-128	-110	-50	180 2422	180 2423
14:55:38.58 -54:38:02.33	9916	APASS	10300	APASS	12.18	35	-39	-71	-50	9	177 2402	177 2401
14:57:45.30 -33:07:17.48	9616	APASS	10517	APASS	21.22	36	-151	50	-27	-217	285 2157	285 2156
14:08:51.20 -43:04:35.78	9791	APASS	10214	APASS	24.32	0	-226	-60	-168	-126	235 2047	235 2046
15:03:13.44 -40:11:38.72	9809	APASS	10030	APASS	29.24	0	84	-88	-285	-609	250 2041	250 2040
15:30:55.1 -63:20:54.21	9856	APASS	10398	APASS	21.78	36	-5	-172	-186	29	134 2312	134 2311
15:32:44.63 +12:44:27.42	9862	APASS	10352	APASS	10.32	36	-437	-112	-272	-67	514 1652	514 1651
15:51:14.35 -42:43:23.20	9881	APASS	10016	APASS	6.45	0	0	0	-150	-110	237 2411	237 2412
15:07:35.3 -54:19:54.81	9608	APASS	10544	APASS	25.10	0	-43	-15	-96	-28	179 2475	179 2474
16:19:18.35 -57:53:36.43	9378	APASS	10350	APASS	19.92	0	5	-31	-221	-238	161 2867	161 2865
16:33:32.25 -53:20:21.49	9422	APASS	10189	APASS	29.64	0	25	-62	-58	-197	184 2845	184 2846
16:38:51.31 -31:53:29.65	9857	APASS	10775	APASS	19.91	0	-36	-48	-77	-28	291 2510	291 2509
16:43:01.42 -40:42:33.90	9793	APASS	9931	APASS	11.29	0	0	0	-124	-243	247 2452	247 2451
16:51:52.61 -39:46:36.62	9840	APASS	10812	APASS	16.36	2	-78	-48	-51	-41	252 2373	252 2372
16:09:21.36 -60:39:12.84	9827	APASS	10393	APASS	27.57	2	-90	-76	-90	-34	147 3159	147 3157
17:34:29.26 -37:15:46.31	9933	APASS	10029	APASS	27.52	0	-32	-166	-4	55	264 2699	264 2698
17:04:48.3 -39:18:54.70	9998	APASS	10026	APASS	10.01	25	-92	-12	-1	-28	254 2457	254 2459
17:52:21.76 -52:48:08.79	9204	APASS	9249	APASS	8.93	0	-43	-121	-828	-1106	186 3207	186 3206
17:54:51.15 +10:42:47.53	9666	APASS	10067	APASS	25.27	0	14	-414	31	-415	504 2100	504 2101
18:00:05.30 +30:24:26.48	8941	APASS	9856	APASS	27.18	0	15	30	-233	-191	603 1811	603 1812

Table 2 concludes on next page.

Searching for New Double Stars with a Computer

Table 2 (conclusion). Non-WDS Pairs

RA Dec	mv	mv src	mvb	mvb src	sep.	Dbl Flag	Pri PM in RA	Pri PM in Dec	Sec. PM in RA	Sec. PM in Dec	A UCAC4 id	B UCAC4 id
18:10:15.1 -27:20:02.61	9687	APASS	9778	APASS	7.79	0	-155	-913	11	115	314 2791	314 2792
18:13:51.30 -37:39:59.46	9650	APASS	10530	APASS	24.93	0	-51	-59	-17	-54	262 2954	262 2953
18:15:14.95 +19:21:30.64	9656	APASS	9885	APASS	27.66	0	0	-78	-45	-84	547 1912	547 1911
18:19:15.23 -28:45:40.20	9861	APASS	10355	APASS	15.12	0	-78	-309	-4	-20	307 3092	307 3091
18:19:24.93 -29:27:01.20	9819	APASS	10279	APASS	13.95	0	-384	1	-62	-24	303 3126	303 3125
18:21:16.74 +6:08:41.79	9877	APASS	10789	APASS	23.30	0	-52	-58	-33	-49	481 2346	481 2345
18:22:04.51 -22:17:52.10	7527	APASS	8497	APASS	20.58	6	50	-230	-80	-134	339 2709	339 2710
18:24:44.63 -21:57:21.64	9796	APASS	10005	APASS	6.76	0	-824	-728	-70	-174	341 2807	341 2808
18:38:19.0 -26:36:57.60	9575	APASS	9663	APASS	13.12	0	-190	-203	-13	-35	317 3134	317 3133
18:04:25.58 -40:01:20.90	9681	APASS	9960	APASS	25.68	2	-50	-40	11	-54	250 2697	250 2696
18:43:05.37 +22:47:01.66	9911	APASS	10774	APASS	24.38	35	-58	-95	-5	8	564 2101	564 2100
18:05:02.79 +74:47:25.17	9747	APASS	9955	APASS	10.30	25	-169	-94	98	-260	824 595	824 594
18:55:53.85 +12:13:13.69	9825	APASS	10039	APASS	8.49	0	0	0	-126	-67	512 2364	512 2363
18:07:24.98 -29:37:01.8	9531	APASS	9949	APASS	14.84	0	186	536	-313	-454	302 3073	302 3072
18:09:34.78 +16:41:42.60	9904	APASS	10609	APASS	25.51	0	-28	4	-17	-96	534 2048	534 2050
19:00:00.37 +13:42:29.58	9635	APASS	9726	APASS	17.64	35	47	28	-83	82	519 2287	519 2288
19:02:10.96 -24:34:40.26	9735	APASS	10609	APASS	26.18	0	-969	-724	79	-119	328 3055	328 3053
19:03:27.0 +18:22:49.93	9831	APASS	9965	APASS	29.38	0	-5	28	-65	-175	542 2286	542 2285
19:34:34.66 +31:07:26.22	9417	APASS	10066	APASS	28.98	0	-24	-103	-21	-107	606 2174	606 2173
19:55:57.77 +15:57:53.17	9343	APASS	9409	APASS	7.57	0	18	-89	-679	-501	530 2508	530 2507
19:56:52.49 +9:44:51.3	9357	APASS	10327	APASS	24.71	0	-95	-257	41	-12	499 2860	499 2862
19:09:11.17 +5:22:38.7	9674	APASS	10110	APASS	27.76	0	-114	-147	-8	-46	477 2641	477 2642
2:29:56.75 -3:19:07.36	9968	APASS	10725	APASS	24.25	0	-603	197	294	-388	434 197	434 196
20:15:07.67 +26:18:21.82	9965	APASS	10645	APASS	27.22	0	-53	-55	-32	-153	582 2445	582 2446
20:03:21.65 +15:44:39.84	9582	APASS	10053	APASS	11.47	35	22	-53	-696	-1078	529 2655	529 2654
20:05:10.32 +48:11:17.29	9562	APASS	9661	APASS	24.74	35	360	-228	360	-228	691 2132	691 2133
21:39:52.7 +11:06:33.56	9784	APASS	10666	APASS	17.30	0	-93	-266	59	28	506 3024	506 3025
21:46:16.77 +53:00:34.39	9774	APASS	10334	APASS	24.98	0	-26	-38	-118	-204	716 2181	716 2182
21:49:20.99 +56:33:32.89	9720	APASS	10308	APASS	29.20	0	-58	-61	-11	-33	733 1956	733 1955
22:38:54.26 -5:51:32.88	9943	APASS	10364	APASS	18.00	0	-3	13	-142	-188	421 3025	421 3024
23:38:05.81 +45:02:14.97	9280	APASS	10020	APASS	27.22	0	-113	-1111	90	-214	676 3198	676 3200