Journal of Double Star Observations

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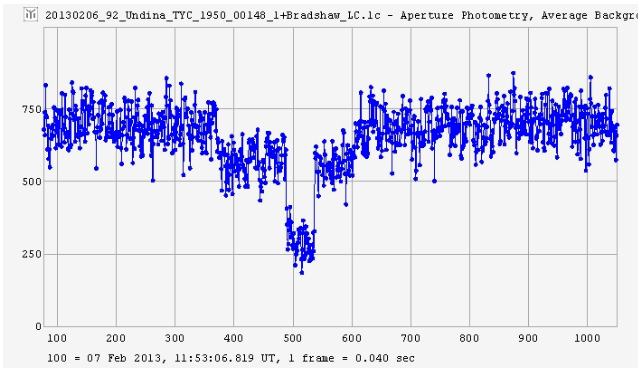

Occultation light curve of a new double star obtained by Jonathan Bradshaw in Australia. For more, see "A New Double Star from an Asteroidal Occultation: TYC 1950-00148-1" by Dave Herald, *et al.*

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A New Double Star from an Asteroidal Occultation: TYC 1950-00148-1

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Abstract: An occultation of TYC 1950-00148-1 by the asteroid (92) Undina on February 6, 2013 showed this star to be a double star with a separation of 28 mas.

Observation

On February 6, 2013, Bradshaw, Broughton, and Hanna observed the asteroid (92) Undina occult the star TYC 1950-00148-1 from four locations in Australia. Watson observed a miss from New Zealand. The observations were made with the equipment described in Table 1.

Six other observers (Gordon Hudson, John Talbot, Terry Butt, Ross Skilton, Dennis Lowe, and Rory O'Keefe) had registered in Occult Watcher for this event, but were clouded out. Had it been clear, at least 3 of these had a good chance of a positive recording.

Videos were analyzed and light curves produced by the observers using Tangra 1.4 software by Hristo Pavlov. Results were consolidated and analyzed by Talbot using Occult4 Software by Dave Herald.

The star is of magnitude 11.2(V), 11.6(R), and has a corresponding expected apparent diameter of less than 0.1 mas. The expected magnitude drop at occultation was 1.0 magnitudes (0.8 R).

Table 1. Equipment Used in Observing the Occultation.

Observer	Telescope	Camera	Timing
Watson, NZ	20 cm	Visual	Tape Recorder and Time signal
Bradshaw,AU	36 cm	CCD	GPS time inserted
Broughton Reedy Creek,AU	25 cm	WAT120N	GPS time inserted
Broughton Mobile Pimpama, AU	32 cm	WAT120N	GPS other linking
Hanna,AU	20 cm	StellaCam 3	GPS time inserted

The star is not listed in the Fourth Interferometric Catalog nor the Washington Double Star catalog.

Three of the light curves obtained from the occultation (Figures 1 - 4) show clear AB-BA step events,

A New Double Star from an Asteroidal Occultation: TYC 1950-00148-1

characteristic of a double star. Hanna's (Figure 1) shows only a single event, but Bradshaw's (Figure 2) shows the steps most clearly.

The observations were analyzed in the standard manner described by Herald [Herald, 2010]. With seven effective chords, there is no ambiguity in the solution.

The asteroid has a near elliptical profile (Figure 5) with dimensions approximately 180 x 155 km. It becomes clear in this figure why Hanna did not see a step

(Continued on page 229)

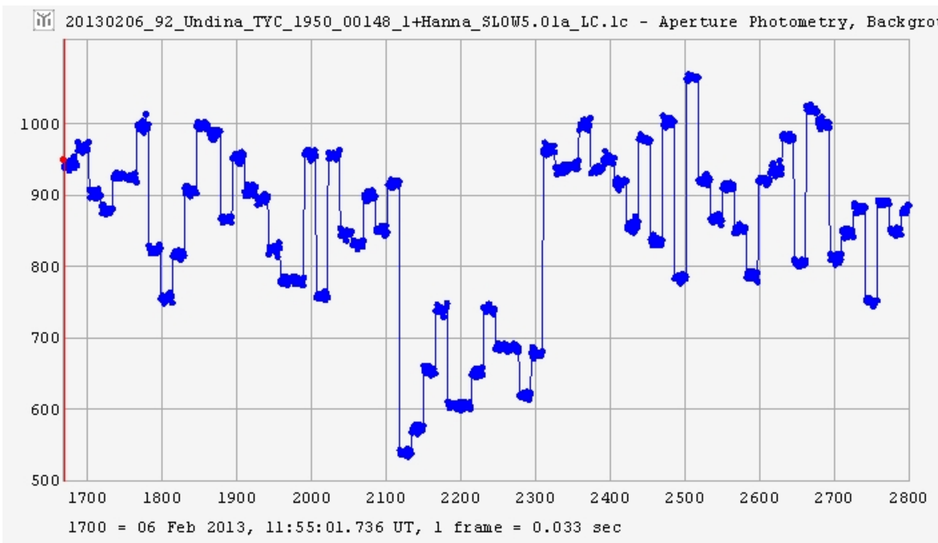

Figure 1: Occultation light curve obtained by Hanna.

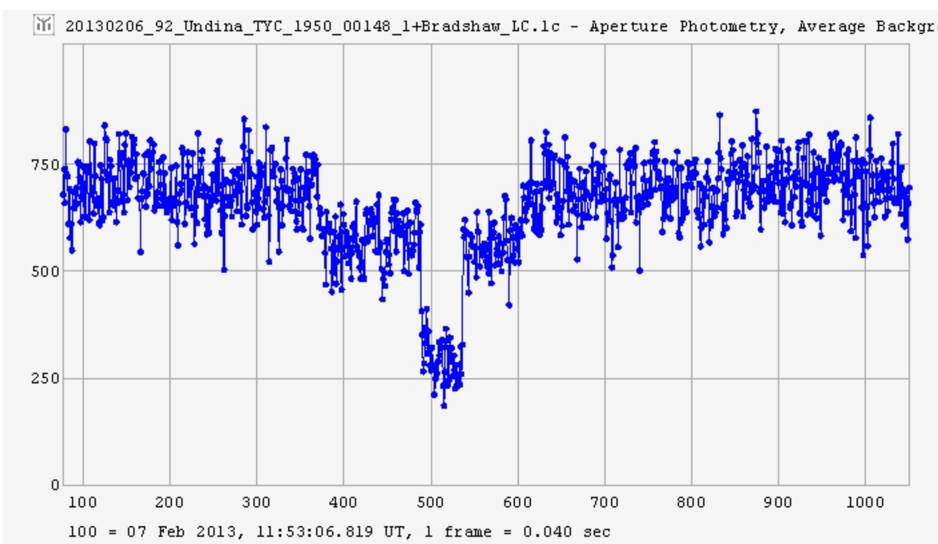

Figure 2: Occultation light curve obtained by Bradshaw.

A New Double Star from an Asteroidal Occultation: TYC 1950-00148-1

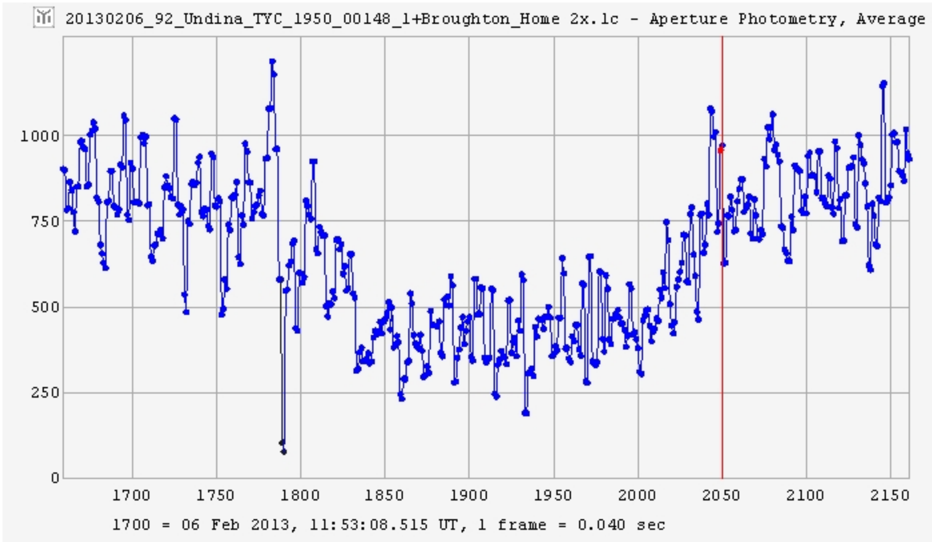

Figure 3: Occultation light curve obtained at Broughton Home, Reedy Creek.

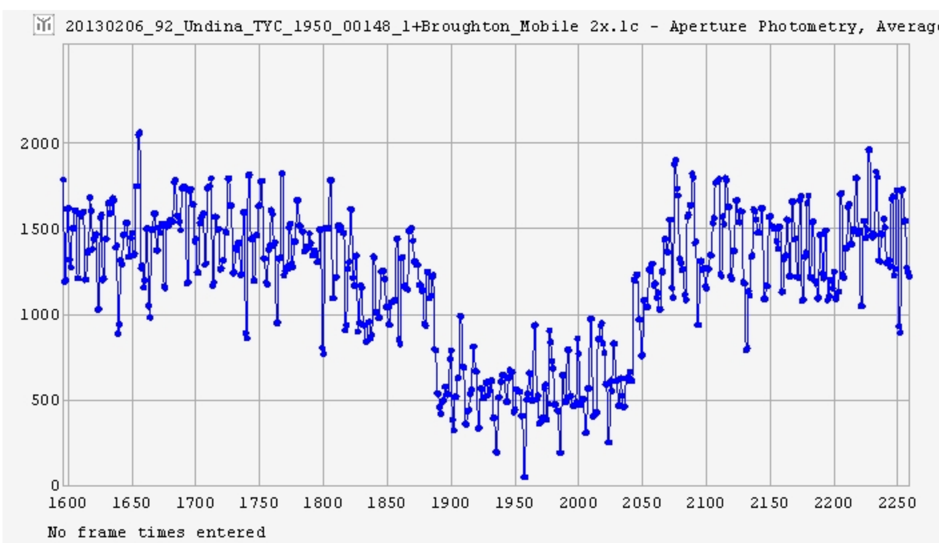

Figure 4: Occultation light curve obtained at Broughton Mobile, Pimpama.

A New Double Star from an Asteroidal Occultation: TYC 1950-00148-1

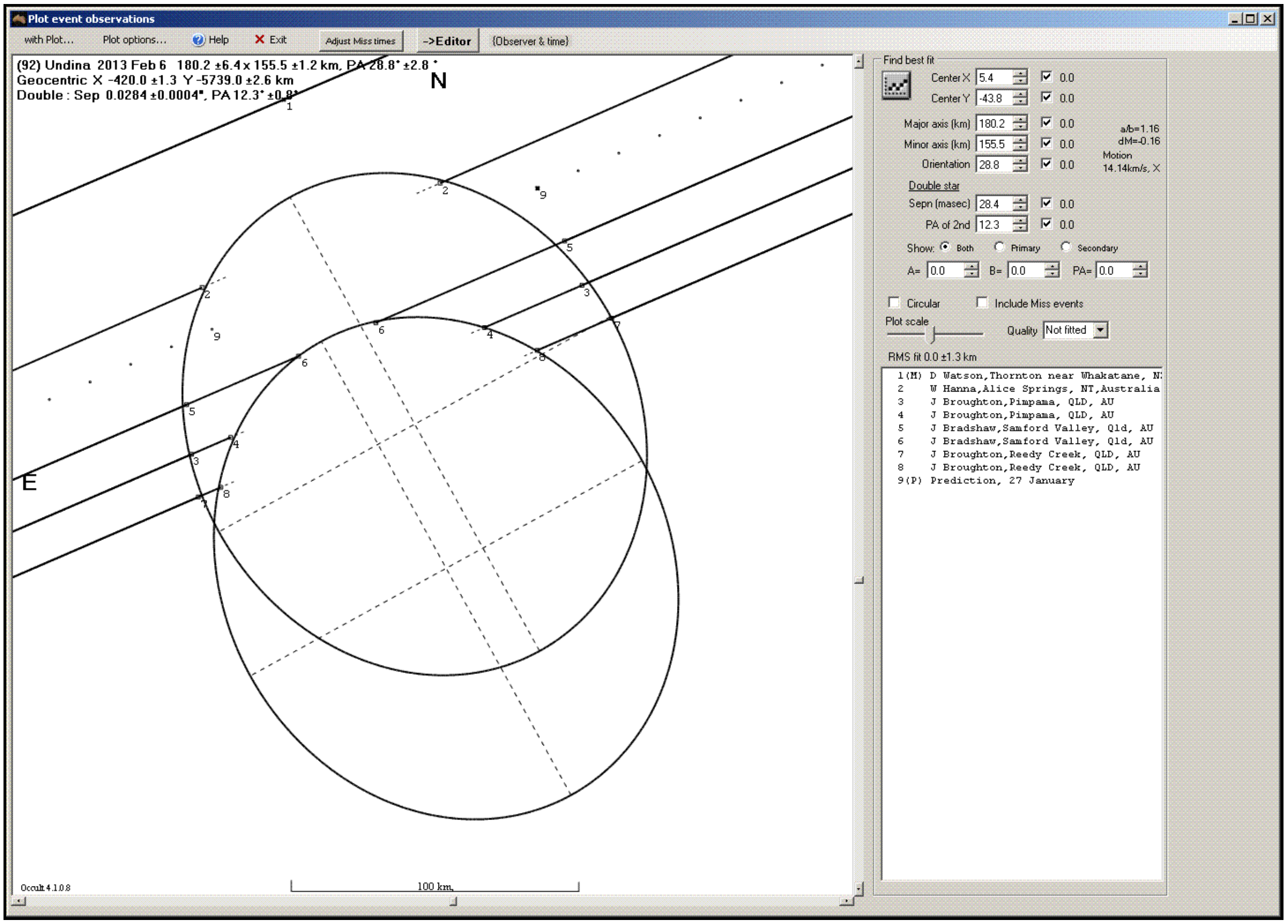

Figure 5. Outline of the asteroid from the shadows of the two stars. Hanna's observation is path 2, showing that he could observe the shadow of only one star.

(Continued from page 227)

as he saw the shadow of only one star.

The double star characteristics are:

Star	TYC 1950-00148-1 = UCAC4 573-045670
Coordinates(J2000)	09h01m30.65s, +24° 27' 27.95"
Spectral type	(none found)
Mag A	12.14 ± 0.2 (V)
Mag B	12.11 ± 0.2 (V)
Separation	28.4 ± 0.5 mas
Position Angle	12.3º ± 2º
Epoch	2013.1008 (Besselian)

References

Herald, D. , 2010, "New Double Stars from Asteroidal Occultations, 1971 – 2008", JDSO, **6**, 88-96.

Herald, D., *Occult 4 Software* http://www.lunar-occultations.com/iota/occult4.htm

Pavlov, H., *Tangra Software* http://www.hristopavlov.net/Tangra/Tangra.html

Double Star Measurements Using a Webcam, Annual Report of 2012

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Abstract: I report on the measurements of 355 double stars during 2012 using a standard webcam. The measured separations are in range between 1.3 and 493 arc seconds. The average separation in this report is about 76 arc seconds. Therefore, most measurements represent optical double stars or common proper motion stars. Only a small number are physical double stars. For some double stars I recommend companions which are not yet listed in the WDS catalog. I also give a short note about Christian Mayer's discovery of the structure of δ Bootis in 1776.

In January 2012 the 8 inch Newtonian telescope which was used for measurements from 2006 to 2011 (Schlimmer 2007a, Schlimmer 2012b) was replaced by a 12 inch Newtonian telescope. The primary focal length is 1500 mm, the aperture ratio is f/5. Because double star measurements in the past were also made with a focal length of 1500 mm (with help of a Barlow lens), the reproduction scale has not changed significantly. The 12 inch Newtonian telescope collects about 2.6 times more light than the replaced 8 inch telescope, so the sensitivity has increased by about 1 magnitude. For double stars with a distance less than 2 arc seconds, the focal length has to be enlarged. Therefore two Barlow lenses with a magnification of 2- and 5- times can be used.

The 12 inch Newtonian telescope is set on a Celestron CGEM-DX mount. This mount is designed for Schmidt-Cassegrain telescopes with short lens tube lengths with focus at the end of the lens tube. In case of a 12 inch Newtonian telescope, the focus is sited near the aperture and is often reachable only with a ladder. For better handling and also more stability, the tripod was replaced by a concrete column.

As a detector for measurements, a standard webcam described in a previous report (Schlimmer 2010), is used. The webcam and the Celestron GCEM-DX mount are connected with a computer. Windows XP (SP3) is used on the computer. Redshift 7 astronomy software is used for star alignment. The analysis of the webcam data was done using the REDUC software package. This software was specially developed for double star analysis by Florent Losse.

During my observations in 2012, I found components which are not yet listed in the WDS catalog. These observations are discussed below.

1. WDS00324+5820, BU 1227AD

Companions B, C, and D were discovered in 1891 and 1897 by Burnham. Near CD a further star can be found. Its separation is about 43 arc seconds from A, its brightness is about 12 magnitudes.

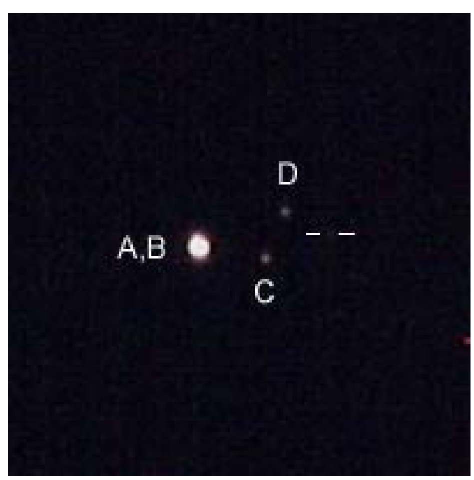

Figure 1: WDS00324+5820, companion marked with lines is not yet listed in WDS catalog

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2. WDS00365+5831, BU 1096AB,C

Companions B and C were discovered in 1889 by Burnham. During my own observations, I found two background stars at a distance of about 21 arc seconds and 39 arc seconds. Both background stars have a brightness of about 12 magnitudes.

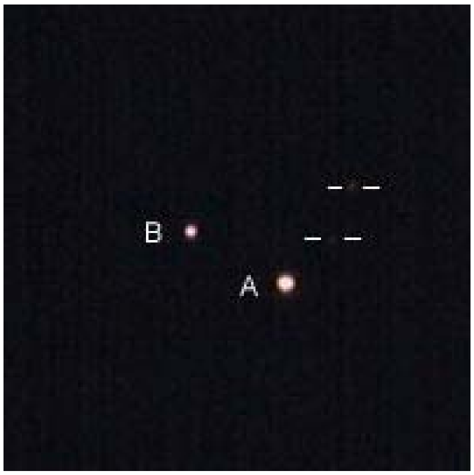

Figure 2: WDS00365+5831, companions marked with lines are not yet listed in WDS catalog.

3. WDS05020+434, BU 554AB, Epsilon Aurigae

Epsilon Aurigae is a variable star of Algol type with period of about 27 years. There are a lot of companions but only C and E are brighter than 12 magnitudes. During my own observations in 2012, I found further background stars at distances between 28 and 132 arc seconds. The large number of faint stars is caused by its position near Milky Way. With help of the background stars, the common proper motion of Epsilon Aurigae can be observed.

Figure 3: WDS05020+434, background stars with numbers are not yet listed in WDS catalog

4. WDS05167+4600, Capella

Companions C to E, with brightness between 12 and 15 magnitudes, were discovered in 1878/79 by Burnham. These companions are background stars; only companion H has about the same proper motion as Capella. During my own observations in 2012, I found two further background stars at a distance of 92 and 134 arc seconds.

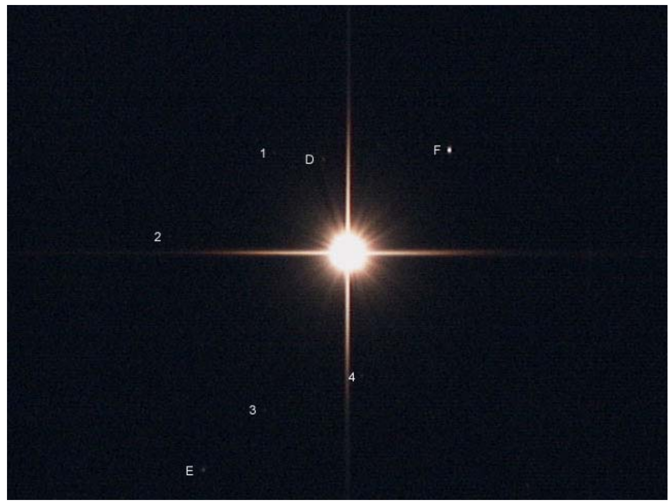

Figure 4: WDS05167+4600, Capella, background stars with numbers are not yet listed in WDS catalog

5. WDS05235+1602, STF 697AB

STF1254 was described in detail in my previous report (Schlimmer 2009b). Between components C and D a further background star can be found. Its brightness is about 12 magnitudes, distance from A is about 163 arc seconds.

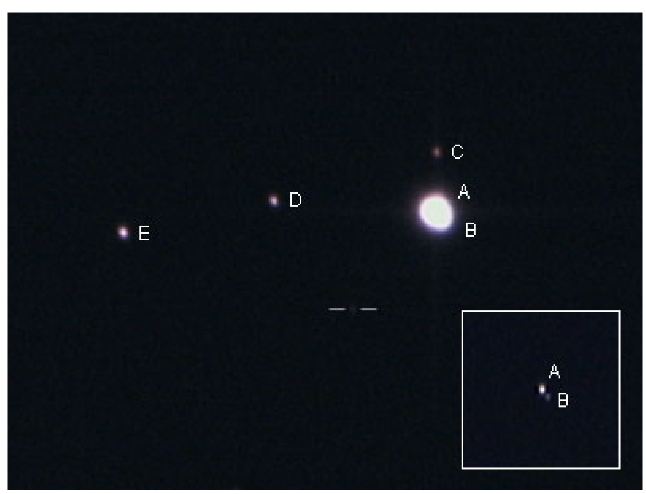

Figure 5: WDS05235+1602, background star with number is not yet listed in WDS catalog

6. WDS05351+0956, STF 738AB, Lambda Orionis

Lambda Orionis is the brightest star of the open star cluster Collinder 69 and has some companions with brightness between 9 and 11 magnitudes. At a distance of 62 arc seconds an additional companion can be found.

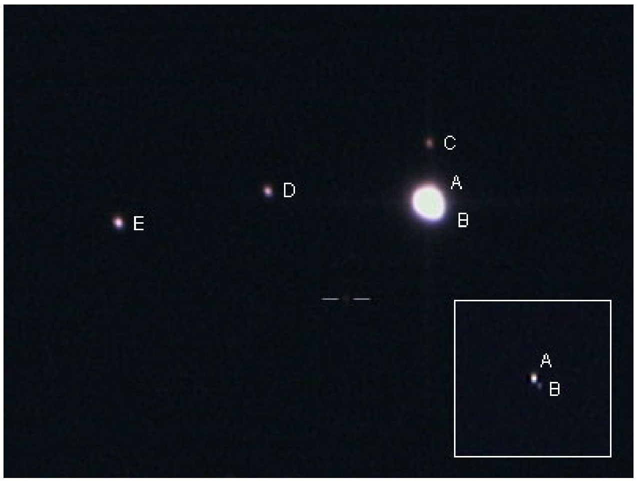

Figure 6: WDS05351+0956, background star marked with lines is not yet listed in WDS catalog

7. WDS05552+0724, H 6 39AB, Betelgeuse

Next to Betelgeuse are some background stars. The brightest one of them was discovered in 1786 by William Herschel. Currently the components A-H are listed in the WDS catalog. Companions B, C, and F to H were observed only one time before. In the same field there are two further components with a brightness of 13.5 magnitudes (like component D) which are not yet listed in the WDS catalog. The distances are 218 arc seconds and 190 arc seconds.

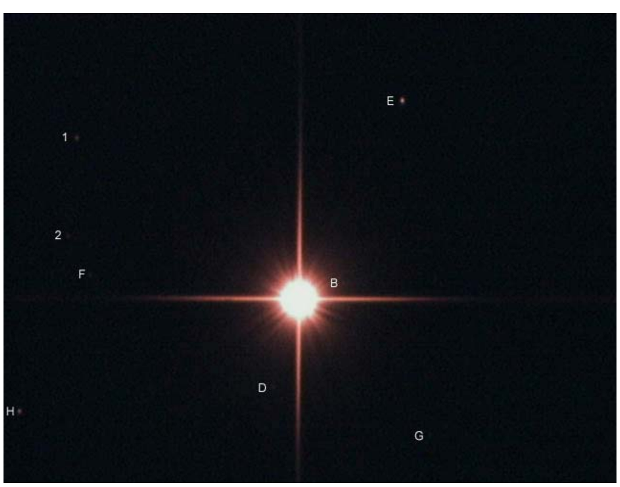

Figure 7: Betelgeuse with some background stars with brightness of 11.2 to 14.5 magnitude. Stars 1 and 2 are not yet listed in WDS catalog.

8. WDS06412+0928, STF 954AB

Around STF 954 some companions can be observed. Between companions A and G a further star can be found which is not yet listed in the WDS catalog. The distance is about 48 arc seconds, brightness is about 12 magnitudes.

Figure 8: WDS06412+0928, background star 1 is not yet listed in WDS catalog.

9. WDS07393+0514, LAM 6AC, Procyon

Procyon is one of the brightest stars in winter sky. Some bright background stars can be observed. During my own observations in 2012, I found a further companion next to G. The distance to G is about 34 arc seconds.

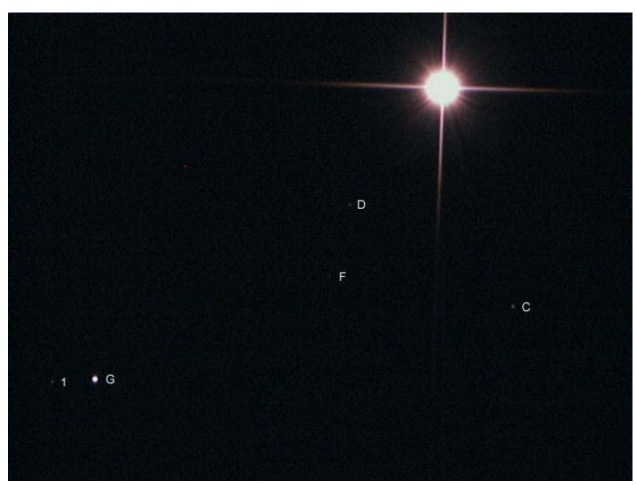

Figure 9: WDS07393+0514, Procyon, background star near component G is not yet listed in WDS catalog

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10. WDS08404+1940, STF1254 in Presepe, Messier 44

STF1254 is a multiple star in open star cluster Presepe (Messier 44). The B component was discovered in 1825, the C and D components were found in 1863. No motion between them has been observed since first observation. During my observations in 2012, I observed an additional component next to A, which is not yet listed in the WDS catalog. The distance is about 16 arc seconds, the angle is 154 degrees. Figure 10 shows a composite of two images which were made with a Canon EOS400D. The measurement was made with a stacked webcam picture. The brightness is estimated to be 12.5 magnitudes.

Figure 10: STF1254, the component near A is not yet listed in the WDS catalog. The figure shows a composite of two images which were made with a Canon EOS400D.

11. WDS15155+3319, STFA 27, Delta Bootis and G 167-29AB

STFA 27 has a companion at 105 arc seconds. Because of its brightness of 7.89 magnitudes, it was often observed. The German astronomer Christian Mayer observed the companion for the first time on June 10, 1776 from his new observatory at Mannheim. He described his observation in his book “Defense of New Observations of Fixed Star Satellites” which was published in 1778 (Mayer, 1778). Mayer found a distance of 102.0 arc seconds and an angle of 80 degrees. It is not known why Mayer did not add this observation to his double star catalog, *De novis in coelo sidereo phaenomenis in miris stellarum fixarum comitibus*, published one year later in 1779 (Chr. Mayer 1779). This was the first double star catalog in history (Schlimmer 2007b). However, William Herschel observed Delta Bootis on July 23, 1780 and published his observation in his double star catalog in 1782 (Herschel 1782). Only this component of δ Bootis is listed in the WDS. During my own observations, I found a further component at a distance of 91.6 arc seconds and a position angle of about 5 degrees.

G 167-29AB is a high proper motion star next to Delta Bootis and was described in detail in my previous report (Schlimmer 2012). The proper motion is about 350 mill arc seconds per year. The image was made with a Canon EOS400D.

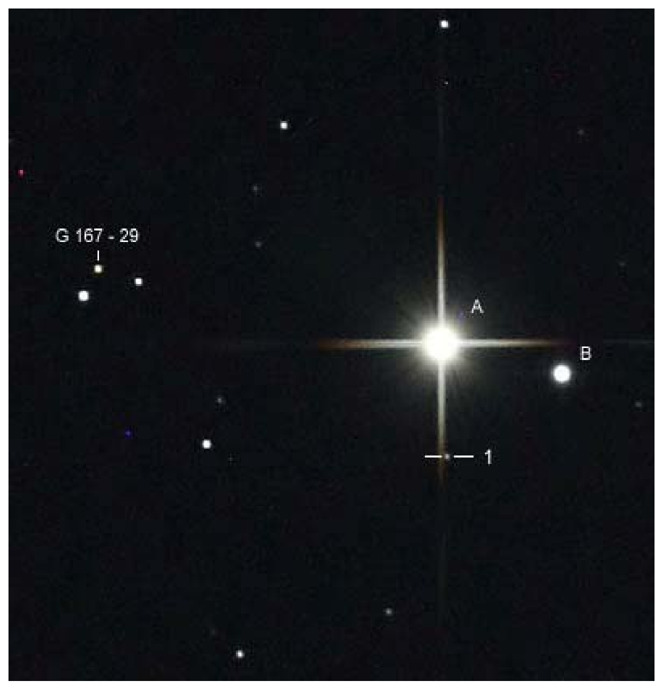

Figure 11: STFA 27, the component which is marked with lines is not yet listed in WDS catalog.

12. WDS18369+3846, H 5 39AB, Vega

Vega is the brightest star in the summer sky. Because of some brighter background stars with brightness between 9.5 to 11 magnitudes, the proper motion of Vega can be easily observed. In addition to the known background stars, I listed some fainter background stars with brightness of about 12 magnitudes in the table.

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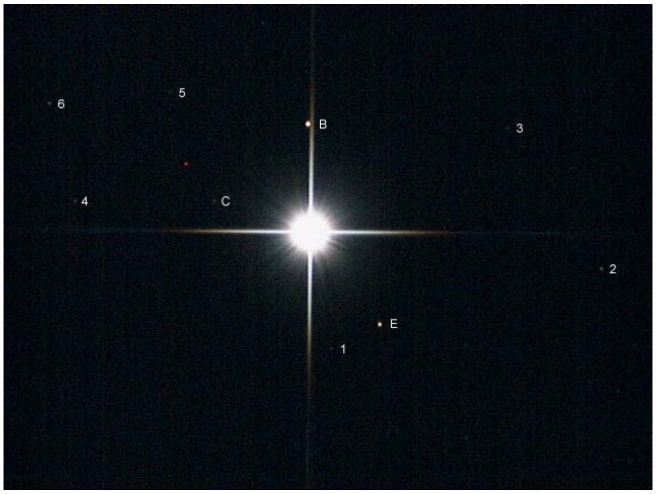

Figure 12: Vega, background stars which are marked with lines are not yet listed in WDS catalog.

13. WDS19307+2758, STFA 43, Albireo

Albireo is a very colorful double star. Because it is in the Milky Way a lot of background stars can be seen. I added known background stars to the list.

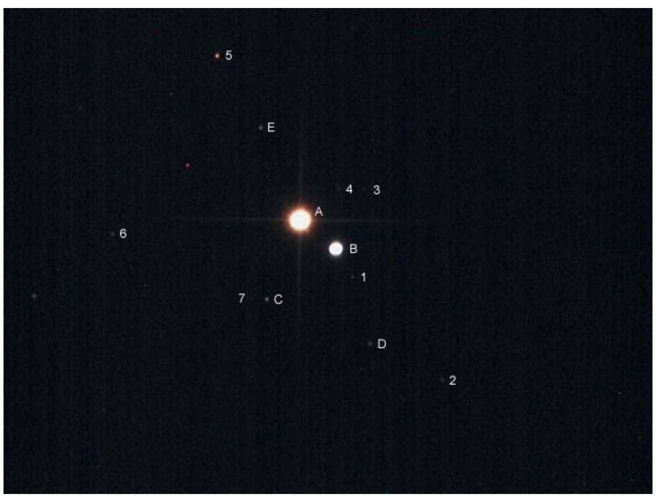

Figure 13: Albireo, background stars which are marked with lines are not yet listed in WDS catalog.

14. UNSO-B1.0 1006-0508835, near DS19411+1041, STF2558

At a distance of about 95 arc seconds from STF2558 (see table) a further double star can be found. The separation is 20 arc seconds, position angle is 330 degree. The brightness of both components is about 11 magnitudes. UNSO-B1.0 1006-0508835 is not yet listed as a double star in WDS catalog.

Figure 14: STF2558 and a possible optical pair in the neighborhood.

15. WDS19463+1037, 50 Aquarius

Companion B was discovered in 1836. Companions C and D were discovered in 1999 and 1907. The brightness of these companions is similar. Two further companions can be found.

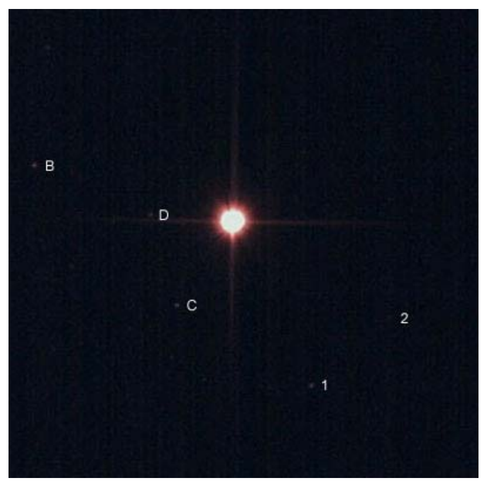

Figure 15: WDS19463+1037, background stars with numbers are not yet listed in WDS catalog.

16. WDS19508+0852, Altair

Altair is also a bright star in the summer sky. Companions were described in detail in my previous report (Schlimmer 2009). I found another companion next to the C companion.

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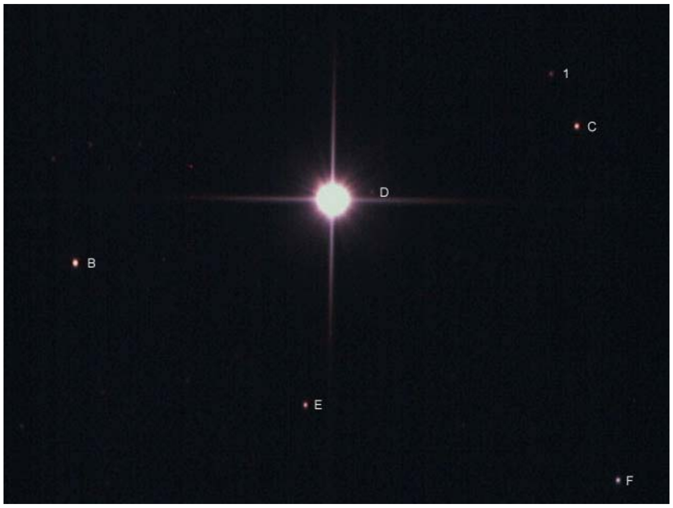

Figure 16: Altair, background d star with number is not yet listed in WDS catalog.

17. WDS19521+1138, BUP 200 and TYC1066-1390-1, 19524+1139

Only one companion at a distance of about 87 arc seconds was reported in the past. An additional companion of similar brightness can be found closer to component A at a distance of 26 arc seconds.

TYC1066-1390-1 can be seen in the same field of view as WDS19521+1138. It looks like a wide optical pair, but is not yet listed in the WDS catalog. The separation is about 33 arc seconds, position angle is 340 degrees.

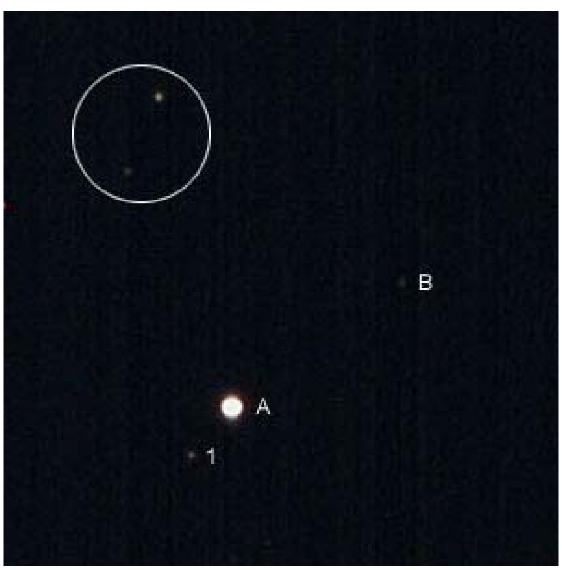

Figure 17: WDS19521+1138 and a possible optical pair in the neighborhood.

18. WDS20145+3648, 29 Cygni

29 Cygni is a multiple star. The distance between AB is about 215 arc seconds. Next to A companion E at a distance of about 35 arc seconds can be found. During my own observation in 2012, I found a further companion next to A, distance is about 32 arc seconds, position angle is about 36 degree. Together with A and E it forms an equilateral triangle.

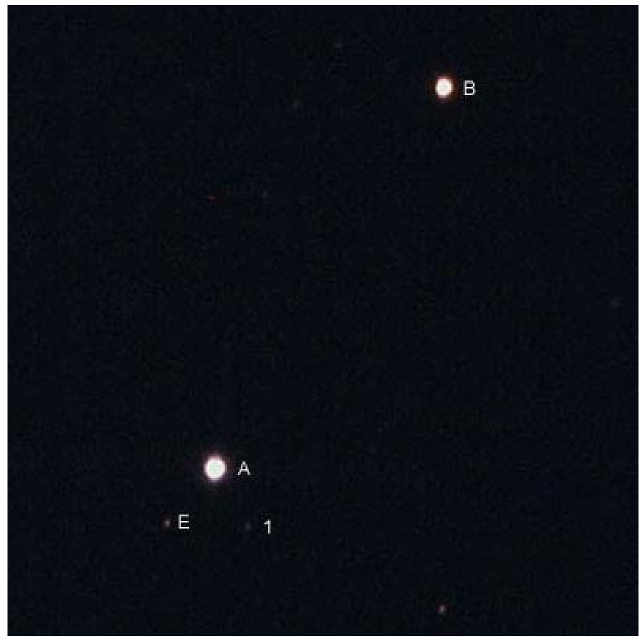

Figure 18: WDS20145+3648, background star with number is not yet listed in WDS catalog.

19. WDS21069+3845, 61 Cygni

61 Cygni is one of the famous binary stars and has been frequently observed. Around 61 Cygni there are a lot of background stars and its large proper motion can be easy observed. Some of these companions are described in my previous report of 61 Cygni (Schlimmer 2009a). Since 2005, I've observed other background stars near 61 Cygni which are not yet listed in one of my reports. The brightness of these stars is about magnitude 11.5, the separation is between 68 and 144 arc seconds.

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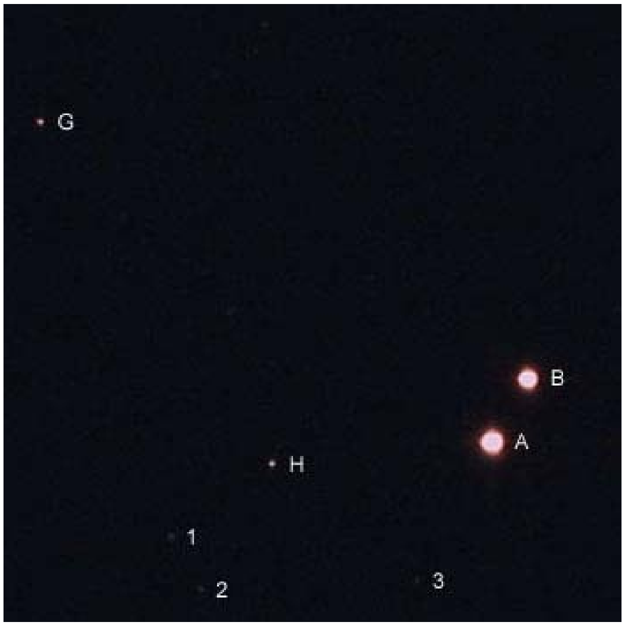

Figure 19: 61 Cygni, background stars with numbers are not yet listed in WDS catalog.

20. WDS22139+3943

With brightness between 10 and 13 magnitudes, not all companions are easy to observe. During my own observation, I found two further background stars around component A which form an equilateral triangle. Distances are about 38 arc seconds.

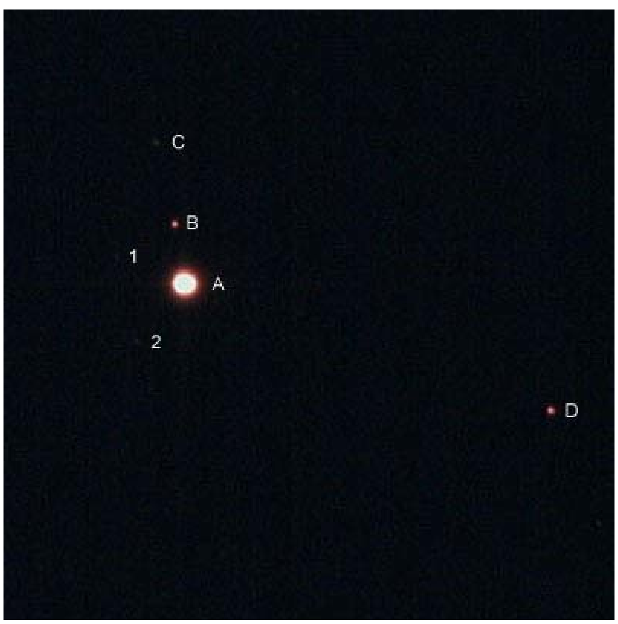

Figure 20: WDS22139+3943, background stars with numbers are not yet listed in WDS catalog.

21. WDS21435+5847, Herschel's Garnet star

Around Herschel's Garnet star some faint companions can be observed. Components B and C are listed in WDS catalog. Because of their brightness of 12.3 and 12.7 magnitudes they are not often observed. During my observation in 2012 I found further companions with brightness of magnitude 11 and 13.

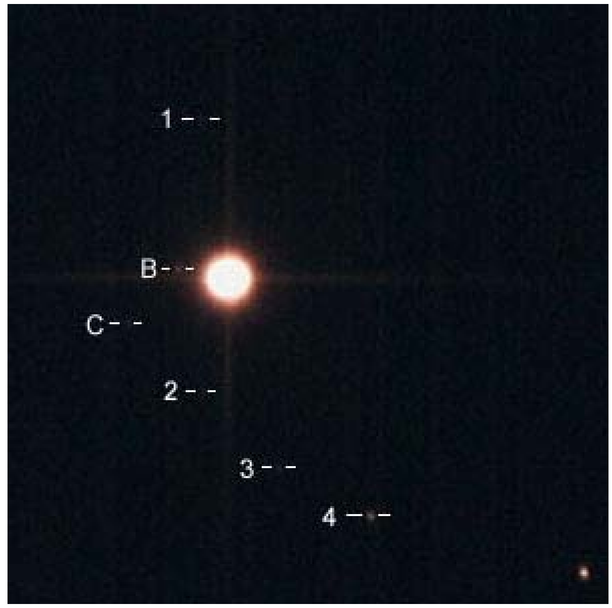

Figure 21: WDS21435+5847, background stars with numbers are not yet listed in WDS catalog.

The following table (next page) shows my measurements of 2012.

Acknowledgements

This research made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.

This research made use of the SIMBAD database, operated at CDS, Strasbourg, France

References

Schlimmer 2007A, "Double Star Measurement Using a Webcam", *Journal of Double Star Observations*, **3**, Pages 131-134.

Schlimmer 2007B, "Christian Mayer's Double Star Catalog of 1779", *JDSO*, **3**, 151-158.

Schlimmer 2008A, "The Proper Motion of HLD120AB (WDS14527+0746)", *JDSO*, **4**, 56-58.

(Continued on page 245)

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NAME	RA+DEC	MAGS	PA	SEP	DATE	N	NOTES
ES 2	00311+5648	8.97 9.5	112.1	5.93	2012.801	1	
BU 1227AC	00324+5820	7.21 11.2	79.6	22.53	2012.801	1	
BU 1227AD	00324+5820	7.21 11.7	111.6	30.96	2012.801	1	
A1	00324+5820	7.21 12	94.9	43.10	2012.801	1	1
ES 3	00350+5636	8.65 9.5	158.6	8.10	2012.801	1	
STF 38	00355+5841	8.66 8.97	144.4	16.89	2012.801	1	
BU 1096AB-C	00365+5831	8.79 9.74	240.8	35.50	2012.801	1	
A1	00365+5831	8.79 12	132.6	20.86	2012.801	1	2
A2	00365+5831	8.79 12	145.4	38.58	2012.801	1	3
BU 1349AB	00405+5632	2.35 14.0	280.8	24.01	2012.801	1	α Cas
BU 1349AC	00405+5632	2.35 13.0	103.2	30.98	2012.801	1	
H 518AD	00405+5632	2.35 8.98	282.0	70.49	2012.801	1	
ES 2214	04584+3844	8.4 12.3	26.1	6.46	2012.801	1	
STF 616AB	04593+3753	5.00 8.21	0.8	4.87	2012.801	1	
STI1427	00473+5651	8.96 11.6	252.9	15.23	2012.801	1	
STF 60AB	00491+5749	3.52 7.36	323.3	13.22	2012.801	1	η Cas
STF 0AE	00491+5749	3.52 10.15	124.5	77.97	2012.801	1	
SMR 2AI	00491+5749	3.5 11.6	72.6	90.28	2012.801	1	
SMR 2AJ	00491+5749	3.5 12.3	261.6	237.14	2012.801	1	
BU 1AC	00528+5638	8.58 8.89	136.1	3.90	2012.727	1	NGC281
BU 1AD	00528+5638	8.58 9.66	194.8	8.96	2012.727	1	
BU 1AE	00528+5638	8.58 12.1	332.0	16.39	2012.727	1	
ABH 5AB-F	00528+5638	8.32 11.00	229.2	53.09	2012.727	1	
ABH 5AB-G	00528+5638	8.32 11.00	240.3	56.08	2012.727	1	
ABH 5AB-H	00528+5638	8.32 12.30	145.9	74.26	2012.727	1	
ABH 5AB-I	00528+5638	8.32 13.34	160.3	45.43	2012.727	1	
BKO 139AN	00528+5638	8.58 13.9	46.1	32.10	2012.727	1	
BKO 139AO	00528+5638	8.58 14.0	295.9	34.39	2012.727	1	
BKO 139FG	00528+5638	11.00 11.00	309.3	10.98	2012.727	1	
ES 552	00531+5713	7.1 13.1	85.6	14.51	2012.727	1	
ES 44	00570+5729	7.98 10.0	265.7	9.60	2012.727	1	
HJ 1114	02191+5708	6.55 11.8	322.9	16.44	2012.727	1	NGC869
STT 64AB	03500+2351	6.81 10.15	235.9	3.21	2012.932	1	
STT 64AC	03500+2351	6.81 10.54	234.9	10.29	2012.932	1	
STT 64BC	03500+2351	10.15 10.54	235.6	6.76	2012.932	1	
STT 92AB	05003+3924	6.02 9.50	283.6	4.07	2012.932	1	
BU 554AB	05020+4349	2.99 14.0	225.6	28.93	2012.938	1	ε Aur
BU 554AC	05020+4349	2.99 11.26	275.9	42.75	2012.938	1	
BU 554AD	05020+4349	2.99 13.4	316.8	45.33	2012.938	1	
BU 554AE	05020+4349	2.99 9.60	47.9	206.93	2012.938	1	
STU 19AF	05020+4349	2.99 11.02	272.1	221.93	2012.938	1	
A1	05020+4349	2.99 14	14.8	101.01	2012.938	1	4
A2	05020+4349	2.99 13.5	22.1	123.50	2012.938	1	5
A3	05020+4349	2.99 13.5	140.1	110.88	2012.938	1	6
A4	05020+4349	2.99 13.5	159.1	132.01	2012.938	1	7
A5	05020+4349	2.99 14	301.1	28.81	2012.938	1	8

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NAME	RA+DEC	MAGS	PA	SEP	DATE	N	NOTES
STT 96	05091+4907	6.67 11.1	104.6	20.57	2012.938	1	
SMR 15	05122+1611	10.3 10.5	151.9	31.35	2012.138	1	
SMR 16AB	05123+1614	9.7 10.5	122.0	36.67	2012.138	1	
SMR 16AC	05123+1614	9.7 10.1	113.4	185.27	2012.138	1	
SMR 16AD	05123+1614	9.7 11.4	76.7	159.28	2012.138	1	
SMR 16AE	05123+1614	9.7 12.3	59.3	12.14	2012.138	1	
STT 101	05138+4658	7.59 10.64	183.3	5.71	2012.938	1	
BAR 25AB	05167+4600	0.08 17.1	5.8	91.89	2012.938	1	Capella
BU 1392AC	05167+4600	0.08 13	331.7	132.94	2012.938	1	
BU 1392AD	05167+4600	0.08 13.6	194.6	71.30	2012.938	1	
BU 1392AE	05167+4600	0.08 12.1	326.0	193.72	2012.938	1	
HJ 2256AF	05167+4600	0.08 10.21	135.0	106.51	2012.938	1	
A1	05167+4600	0.08 13	216.0	91.90	2012.938	1	9
A2	05167+4600	0.08 13	264.4	133.69	2012.938	1	10
STF 666	05172+3320	7.85 7.89	75.5	3.13	2012.938	1	
STF 681	05207+4658	6.61 9.21	181.8	23.14	2012.938	1	
STT 104	05232+4701	7.1 11.1	189.8	21.18	2012.938	1	
STF 697AB	05235+1602	7.27 8.10	285.6	26.05	2012.138	1	Ori
WAL 38AC	05235+1602	7.27 10.83	284.1	97.90	2012.138	1	Ori
SMR 3AD	05235+1602	7.3 10.1	284.6	249.27	2012.138	1	Ori
A1	05235+1602	7.3	288.9	163.00	2012.138	1	11
STFA 14AC	05320-0018	2.41 6.83	0.1	52.38	2012.086	1	Mintaka
STF 738AB	05351+0956	3.51 5.45	41.3	4.31	2012.086	1	l ori
STF 738AC	05351+0956	3.51 10.72	185.5	29.25	2012.086	1	l ori
STF 738AD	05351+0956	3.51 9.63	271.7	78.46	2012.086	1	l ori
GUI 9AE	05351+0956	3.51 9.22	279.4	151.14	2012.086	1	l ori
A1	05351+0956	3.51	325.0	61.61	2012.086	1	l ori
STF 761AB	05386-0233	7.86 8.39	202.6	68.08	2012.086	1	
STF 761AC	05386-0233	7.86 8.55	208.9	71.70	2012.086	1	
STF 761BC	05386-0233	8.39 8.55	268.0	8.56	2012.086	1	
STF 762AB-C	05387-0236	3.76 8.79	240.0	10.68	2012.086	1	s ori
STF 762AB-D	05387-0236	3.76 6.56	82.9	12.91	2012.086	1	s ori
STF 762AB-E	05387-0236	3.76 6.34	61.4	41.49	2012.086	1	s ori
STF 774AC	05407-0157	1.88 9.55	9.6	58.41	2012.086	1	z ori
H 6 39AB	05552+0724	0.9 14.5	112.7	36.81	2012.138	1	Betel.
H 6 39AD	05552+0724	0.9 13.5	345.3	70.99	2012.138	1	Betel.
H 6 39AE	05552+0724	0.9 11.0	154.3	175.20	2012.138	1	Betel.
SLE 31AF	05552+0724	0.9 12.1	265.7	168.34	2012.138	1	Betel.
SLE 831AG	05552+0724	0.9 12.8	46.8	147.93	2012.138	1	Betel.
SLE 831AH	05552+0724	0.9 11.2	293.7	239.79	2012.138	1	Betel.
A1	05552+0724	0.9 13.5	237.0	217.79	2012.138	1	12
A2	05552+0724	0.9 13.5	257.3	189.93	2012.138	1	13
STF 926AB	06317+0546	7.23 8.62	287.0	10.86	2012.138	1	14
SLE 291	06318+0529	10.0 10.2	282.2	12.80	2012.138	1	15
GAN 3AC	06319+0457	6.79 11.8	312.8	6.76	2012.138	1	
GAN 3AD	06319+0457	6.79 12.24	287.4	12.24	2012.138	1	
GAN 3AE	06319+0457	6.79 11.64	198.4	13.52	2012.138	1	

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SLE 293AF	06319+0457	6.79 11.63	352.3	45.03	2012.138	1	
SLE 293AG	06319+0457	6.79 11.75	246.7	48.94	2012.138	1	
SLE 293AH	06319+0457	6.79 12.77	254.3	65.83	2012.138	1	
SLE 293AI	06319+0457	6.79 9.39	234.9	64.17	2012.138	1	
SLE 293AJ	06319+0457	6.79 11.18	109.9	53.64	2012.138	1	
SLE 293AK	06319+0457	6.79 10.74	137.1	74.43	2012.138	1	
STF 927AB	06321+0458	8.86 9.3	83.5	5.01	2012.138	1	
A 2820	06365+0548	8.57 12.7	51.4	4.01	2012.138	1	
	06365+0548	8.57	312.1	19.31	2012.138	1	
STF 950AC	06410+0954	4.66 9.9	14.2	16.43	2012.138	1	s Mon
STF 950AD	06410+0954	4.66 9.7	308.4	40.66	2012.138	1	s Mon
STF 950AE	06410+0954	4.66 8.86	139.8	73.79	2012.138	1	s Mon
STF 950AF	06410+0954	4.66 9.0	222.4	155.48	2012.138	1	s Mon
STF 950AG	06410+0954	4.66 10.01	230.3	187.63	2012.138	1	s Mon
STF 950AH	06410+0954	4.66 9.81	166.9	89.00	2012.138	1	s Mon
STF 950AK	06410+0954	4.66 8.2	56.0	104.90	2012.138	1	s Mon
STF 950AM	06410+0954	4.66 9.75	104.0	177.90	2012.138	1	s Mon
STF 950AO	06410+0954	4.66 9.7	260.9	136.17	2012.138	1	s Mon
D 11EP	06410+0954	8.86 10.4	42.6	3.52	2012.138	1	s Mon
STF 952MN	06410+0954	9.75 10.05	115.5	13.94	2012.138	1	s Mon
SMR 9AQ	06410+0954	9.75 11.5	6.2	95.30	2012.138	1	
SMR 9AR	06410+0954	9.75 11.5	143.7	142.53	2012.138	1	
SMR 9AS	06410+0954	9.75 11.5	155.3	124.04	2012.138	1	
STF 954AB	06412+0928	7.18 10.23	153.2	12.98	2012.138	1	x-mas
SLE 558AC	06412+0928	7.15 10.93	117.1	56.89	2012.138	1	
ARN 40AD	06412+0928	7.18 9.09	251.1	104.74	2012.138	1	
SMR 10AF	06412+0928	7.18	277.5	119.57	2012.138	1	
SMR 10AG	06412+0928	7.18	237.8	48.21	2012.138	1	16
STF1110AB	07346+3153	1.93 2.97	56.7	4.82	2012.215	1	Castor
STF1110AC	07346+3153	1.93-9.83	165.4	70.52	2012.095	1	Castor
STF1110AD	07346+3153	1.93-10.07	222.0	181.85	2012.095	1	Castor
LAM 6AC	07393+0514	0.38-11.7	21.7	180.21	2012.237	1	Procyon
DIC 1AD	07393+0514	0.38-	325.5	116.68	2012.237	1	Procyon
SLE 439AF	07393+0514	0.38-	332.7	172.34	2012.237	1	Procyon
SMR 11AG	07393+0514	0.38-8.8	313.8	355.65	2012.237	1	Procyon
G1	07393+0514	8.8-12	277.4	33.51	2012.237	1	17
STF1196AB-C	08122+1739	5.30-6.20	67.5	6.25	2012.222	2	ζ Cnc
STF1196AB-D	08122+1739	5.31-8.89	107.0	275.60	2012.222	2	ζ Cnc
STF1254AB	08404+1940	6.44-10.37	54.2	20.34	2012.207	1	
STF1254AC	08404+1940	6.52-7.61	342.7	63.20	2012.207	1	
STF1254AD	08404+1940	6.52-9.20	43.8	82.39	2012.207	1	
AE	08404+1940	6.52-	153.9	16.19	2012.207	1	18
S 571AC	08399+1933	7.31-7.47	156.5	45.15	2012.207	1	
S 571AD	08399+1933	7.31-6.67	241.7	92.45	2012.207	1	
BKO 34DE	08399+1933	6.67-11.0	2.8	34.97	2012.207	1	
HJ 110	08585+1151	4.25-11.8	323.7	10.48	2012.207	1	

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HJ 110	08585+1151	4.25	11.8	323.7	10.48	2012.207	1	
STF1300AB	09013+1516	9.47	9.73	180.6	4.98	2012.207	1	
ENG9001AC	09013+1516	9.47	9.8	13.4	201.42	2012.207	1	
ENG9001AD	09013+1516	9.47	10.2	61.6	197.22	2012.207	1	
STFB 6AB	10084+1158	1.40	8.24	307.9	174.65	2012.207	1	Regulus
STF1424AB	10200+1950	2.37	3.64	127.0	4.73	2012.207	1	Algieba
STF1424AC	10200+1950	2.37	9.64	288.4	337.78	2012.207	1	AD Leo
STF1424AD	10200+1950	2.60	10.0	302.0	369.56	2012.207	1	
STF1523AB	11182+3132	4.33	4.80	191.1	1.68	2012.284	1	ξ UMa
SHJ 143AB	12225+2551	4.86	11.8	57.1	36.73	2012.396	1	12 Com
SHJ 143AC	12225+2551	4.86	8.90	167.0	65.02	2012.396	1	
ARN 6AD	12225+2551	4.86	10.10	132.0	213.08	2012.396	1	
STF1643AB	12272+2701	9.03	9.45	5.0	2.30	2012.396	1	
STFA 21AB	12289+2555	5.23	6.64	250.1	144.86	2012.396	1	17 Com
STF1651	12317+2701	8.65	10.07	214.1	6.99	2012.396	1	
STF1670AB	12417-0127	3.48	3.53	13.2	1.76	2012.284	1	
STF1744AB	13239+5456	2.23	3.88	154.1	14.47	2012.221	1	Mizar
SMR 4AD	13239+5456	2.23	7.6	99.8	492.47	2012.221	1	
STF1835A-BC	14234+0827	5.03	6.78	195.1	6.32	2012.462	1	ξ Boo
STF1877AB	14450+2704	2.58	4.81	345.7	2.76	2012.396	1	e Boo
STF1888AB	14514+1906	4.76	6.95	305.7	5.91	2012.462	1	
HLD 120AB	14527+0746	8.05	10.84	225.0	15.83	2012.396	1	
STF1909	15038+4739	5.20	6.10	62.1	1.31	2012.456	1	44 Boo
STF1919	15127+1917	6.71	7.38	10.4	23.37	2012.462	1	
STFA 27	15155+3319	3.56	7.89	77.9	104.56	2012.426	2	d Boo
A1	15155+3319	3.56		4.7	91.64	2012.396	1	19
G 167-29AB	15151+3318	12.7		331.9	25.41	2012.426	2	20
G 167-29AC	15151+3318	12.7		74.5	35.24	2012.426	2	
ENG 52AB	15073+2452	4.97	10.8	40.4	103.46	2012.462	1	
STF2055AB-C	16309+0159	3.82	11.0	170.4	118.49	2012.560	1	7 Her
STFA 31AB	16406+0413	5.76	6.92	230.2	69.45	2012.560	1	36/37 Her
STF2074BC	16406+0413	6.92	11.4	316.0	25.74	2012.560	1	
BAL2421	16409+0338	8.51	11.1	226.0	8.91	2012.560	1	
STF2081AB	16430+0327	7.8	10.5	322.0	20.04	2012.560	1	
BU 9015AC	16430+0327	7.8	12.0	174.8	42.88	2012.560	1	
STF2086	16443-0033	7.43	10.22	156.7	14.00	2012.560	1	
STF2088AB	16447+0220	8.0	12.0	331.6	21.21	2012.560	1	
STF2088AC	16447+0220	8.0	13.4	354.0	16.08	2012.560	1	
STF2088BC	16447+0220	12.0	13.4	104.8	8.58	2012.560	1	
ENG 58AB	16469+0215	6.75	8.83	218.0	148.84	2012.560	1	
STF2096AB	16472+0204	6.09	9.68	89.4	23.59	2012.560	1	
ENG 59AB	17011-0413	4.99	9.71	67.6	99.94	2012.560	1	
ARN 16AC	17011-0413	4.99	8.75	85.2	221.10	2012.560	1	
STF2130AB	17053+5428	5.66	5.6	4.5	2.42	2012.568	1	μ Dra
STF2140AB	17146+1423	3.48	5.40	101.2	4.99	2012.675	1	α Her
STF2166	17279+1123	7.15	8.58	282.3	27.19	2012.555	1	

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STF2170AB	17287+1029	9.38 10.01	58.1	3.30	2012.555	1	
GUI 18AC	17287+1029	9.38 7.08	18.7	189.44	2012.555	1	
STF2176AB	17311+1027	9.53 10.32	17.0	16.72	2012.555	1	
GUI 19AC	17311+1027	9.53 9.46	71.6	89.50	2012.555	1	
STFA 35	17322+5511	4.87 4.90	310.9	61.85	2012.568	1	
STF2184AB	17344+1310	6.7 11.6	64.9	22.82	2012.555	1	
STF2184AC	17344+1310	6.7 12.6	293.5	127.79	2012.555	1	
STFA 34AB	17346+0935	5.80 7.50	190.3	41.11	2012.555	1	
STFA 34AC	17346+0935	5.80 11.90	343.7	96.83	2012.555	1	
STFA 34AD	17346+0935	5.80 10.5	213.3	126.92	2012.555	1	
STF2212	17464+0542	9.51 9.60	341.2	3.09	2012.555	1	
STF2216	17470+0542	8.01 10.09	26.9	27.22	2012.555	1	
STF2223	17490+0458	7.56 9.66	211.2	18.40	2012.555	1	
BU 633AB	17566+5129	2.23 13.4	152.0	20.95	2012.568	1	
BU 633AC	17566+5129	2.23 12.9	234.1	41.20	2012.568	1	
BU 633AD	17566+5129	2.23 12.9	11.3	57.88	2012.568	1	
BU 633AE	17566+5129	2.23 11.9	234.4	94.88	2012.568	1	
BU 633AF	17566+5129	2.23 11.2	114.1	124.83	2012.568	1	
BU 633AG	17566+5129	2.23 11.9	27.2	141.80	2012.568	1	
STF2271AB	18003+5251	8.17 9.24	267.5	3.36	2012.568	1	
H 6 2AC	18006+0256	3.96 8.06	142.3	54.18	2012.555	1	
BU 634AE	18006+0256	3.96 11.0	180.2	45.25	2012.555	1	
BU 634CD	18006+0256	8.06 12.5	123.0	7.21	2012.555	1	
BU 634CE	18006+0256	8.06 11.0	266.0	33.26	2012.555	1	
STF2272AB	18055+0230	4.22 6.17	129.7	6.15	2012.555	1	
STF2272AC	18055+0230	4.22 12.05	325.4	94.02	2012.555	1	
STF2272AR	18055+0230	4.22 12.87	26.1	164.83	2012.555	1	
STF2272AT	18055+0230	4.22 12.25	44.5	127.69	2012.555	1	
STF2272AV	18055+0230	4.22 10.83	275.5	145.38	2012.555	1	
STF2272VX	18055+0230	10.83 15.	252.1	17.35	2012.555	1	
STF2323AB	18239+5848	5.06 8.07	345.2	3.64	2012.612	1	39 Dra
STF2323AC	18239+5848	5.06 7.95	19.7	88.64	2012.612	1	
H 5 39AB	18369+3846	0.09 9.5	183.8	81.63	2012.612	1	Vega
STFB 9AC	18369+3846	0.09 11.0	254.5	76.04	2012.612	1	
STFB 9AE	18369+3846	0.09 9.5	39.4	87.24	2012.612	1	
A1	18369+3846	0.09 12	12.8	89.50	2012.612	1	21
A2	18369+3846	0.09 11	85.3	221.48	2012.612	1	22
A3	18369+3846	0.09 12	120.4	167.83	2012.612	1	23
A4	18369+3846	0.09 12	265.0	179.15	2012.612	1	24
A5	18369+3846	0.09 12	227.6	149.96	2012.612	1	25
A6	18369+3846	0.09 12	246.2	219.36	2012.612	1	26
HJ 2836AB	18384+6043	6.7 9.9	316.4	32.41	2012.612	1	
HJ 2836AC	18384+6043	6.7 9.9	252.1	56.08	2012.612	1	
SLE 235AD	18384+6043	6.7 8.9	313.2	154.35	2012.612	1	
STF2382AB	18443+3940	5.15 6.10	347.1	2.16	2012.631	1	ε Lyr
STF2383CD	18443+3940	5.25 5.38	77.7	2.38	2012.659	2	

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STFA 37AD	18443+3940	5.15	5.38	172.2	208.71	2012.622	2	ε Lyr
STFA 37AI	18443+3940	5.15	10.43	137.7	150.04	2012.622	2	
STF2383CE	18443+3940	5.25	11.71	332.9	63.07	2012.622	2	
STFA 37CI	18443+3940	5.25	10.43	37.1	120.35	2012.622	2	
SHJ 277EF	18443+3940	11.71	11.2	37.4	45.29	2012.622	2	
SHJ 277GH	18443+3940	13.83	13.22	358.4	35.58	2012.612	1	
CD-F	18443+3940	5.25	11.2	359.5	92.18	2012.622	2	
CD-G	18443+3940	5.25	13.83	292.4	75.60	2012.612	1	
CD-H	18443+3940	5.25	13.22	312.2	95.78	2012.612	1	
STF2420AB	18512+5923	4.77	8.26	319.0	37.29	2012.612	1	
BU 137AC	18540+3723	8.69	12.0	146.8	24.38	2012.631	1	
ES 2028AB	18545+3654	4.30	11.2	349.8	86.49	2012.631	1	d Lyr2
SMR 13AD	18545+3654	4.30	8.8	210.2	193.02	2012.631	1	
SMR 13AE	18545+3654	4.30	10.3	238.4	400.15	2012.631	1	
SMR 13AF	18545+3654	4.30		245.5	368.72	2012.631	1	
SM 13AG	18545+3654	4.30		261.4	335.27	2012.631	1	
SMR 13AH	18545+3654	4.30		284.6	229.03	2012.631	1	
SMR 13AJ	18545+3654	4.30		249.7	278.99	2012.631	1	
SMR 13AK	18545+3654	4.30		236.8	303.75	2012.631	1	
SMR 13HI	18545+3654	4.30		251.8	25.85	2012.631	1	
HO 90	18545+3719	8.72	12.7	222.5	3.57	2012.631	1	
STF2427AB	18581+3813	9.61	9.93	59.4	55.05	2012.631	1	
STF2427AC	18581+3813	9.61	10.20	61.7	61.69	2012.631	1	
CTT 11AD	18581+3813	9.61	11.8	290.5	56.44	2012.631	1	
SP 2AE	18581+3813	9.61	5.87	350.4	160.50	2012.631	1	
STF2427BC	18581+3813	9.93	10.20	78.9	7.13	2012.631	1	
SMR 14EF	18581+3813	5.9	11.2	332.8	83.30	2012.631	1	
STF2487AB	19138+3909	4.38	8.58	80.5	28.28	2012.713	1	20 Lyr
STT 366AB	19142+3413	7.67	10.55	229.9	21.80	2012.713	1	
ES 2675AC	19142+3413	7.67	11.7	139.4	26.49	2012.713	1	
WAL 106AD	19142+3413	7.67	13.16	116.6	21.79	2012.713	1	
STT 367A-BC	19145+3434	7.31	10.26	227.0	33.40	2012.713	1	
HO 648AD	19145+3434	7.31	12.9	92.9	15.58	2012.713	1	
SEI 585	19148+3820	8.91	11.7	120.5	14.58	2012.713	1	
SHJ 292AB	19164+3808	4.48	10.14	70.3	99.16	2012.713	1	21 Lyr
SHJ 292AC	19164+3808	4.48	11.1	128.5	101.60	2012.713	1	
STFA 43AB	19307+2758	3.19	4.68	53.8	34.62	2012.686	1	Albireo
WAL 114AC	19307+2758	3.19	10.99	339.9	64.80	2012.686	1	
CTT 17AD	19307+2758	3.2	11.	32.1	107.22	2012.686	1	
CTT 18AE	19307+2758	3.2	11.	205.8	75.79	2012.686	1	
A1	19307+2758	3.2	12	45.3	58.29	2012.686	1	27
A2	19307+2758	3.2	12.5	44.4	161.44	2012.686	1	28
A3	19307+2758	3.2	12.5	118.2	53.96	2012.686	1	29
A4	19307+2758	3.2	12.5	131.9	37.56	2012.686	1	30
A5	19307+2758	3.2	10	209.5	138.95	2012.686	1	31
A6	19307+2758	3.2	11.5	276.9	142.22	2012.686	1	32

Table continues on next page.

Double Star Measurements Using a Webcam, Annual Report of 2012

NAME	RA+DEC	MAGS	PA	SEP	DATE	N	NOTES
C7	19307+2758	3.2 11.5	269.3	11.96	2012.686	1	33
STF2558	19411+1041	8.0 10.5	308.0	27.77	2012.686	1	
New	19424+1041	11.4 11.4	330.3	20.11	2012.686	1	34
STF2567AB	19441+1222	7.93 9.96	310.7	17.92	2012.686	1	
STF2570AB-C	19449+1047	7.62 9.81	279.7	4.47	2012.686	1	
BUP 198AB	19463+1037	2.72 10.8	256.7	134.06	2012.686	1	50 Aqu
DAL 44AC	19463+1037	2.7 10.9	329.0	65.72	2012.686	1	
DAL 44AD	19463+1037	2.7 11.4	267.9	53.47	2012.686	1	
A1	19463+1037	2.7 11.5	28.2	118.95	2012.686	1	35
A2	19463+1037	2.7 12	60.7	119.65	2012.686	1	36
STF2583AC	19487+1149	6.34 12.9	297.6	36.15	2012.686	1	
STFB 10AB	19508+0852	0.95 9.82	284.8	194.99	2012.686	1	Altair
STFB 10AC	19508+0852	0.95 10.3	107.6	187.95	2012.686	1	Altair
DAL 27AD	19508+0852	0.95 11.9	101.0	29.22	2012.686	1	Altair
SMR 5AE	19508+0852	0.95 11.0	353.4	152.39	2012.686	1	Altair
SMR 5AF	19508+0852	0.95 10.3	46.6	294.68	2012.686	1	Altair
A1	19508+0852	0.95	120.9	185.08	2012.686	1	37
J 124AB	19510+1025	5.11 13.5	251.3	19.46	2012.686	1	54 Aqu
J 124AC	19510+1025	5.11 13.7	220.0	21.69	2012.686	1	
POP1228AD	19510+1025	5.11 13.2	121.2	49.61	2012.686	1	
POP1228AE	19510+1025	5.11 13.0	148.0	81.61	2012.686	1	
BUP 200AB	19521+1138	6.13 11.7	128.8	87.23	2012.686	1	
A1	19521+1138	6.13 11.0	322.1	25.97	2012.686	1	38
New	19524+1139	11.08 11.5	339.8	33.28	2012.686	1	39
STF2593AB	19533+1150	8.7 10.1	342.1	12.03	2012.686	1	
STF2593AC	19533+1150	8.7 11.4	256.5	13.94	2012.686	1	
STF2593BC	19533+1150	10.1 11.4	307.0	3.67	2012.686	1	
SMR 7	20000+1736	10.1 11.4	264.3	4.17	2012.622	2	
S 730AB	20001+1737	7.16 8.45	14.5	112.79	2012.622	2	
S 730AC	20001+1737	7.16 10.21	337.8	78.58	2012.622	2	
S 730AD	20001+1737	7.16 9.9	198.4	41.04	2012.622	2	
ES 25AB	20060+3546	7.89 12.0	119.2	8.83	2012.713	1	
ES 25AC	20060+3546	7.89 14.8	296.5	11.76	2012.713	1	
SHJ 315AD	20060+3546	7.89 8.73	235.9	20.16	2012.713	1	
WAL 127AE	20060+3546	7.89 11.71	94.3	33.86	2012.713	1	
BU 440AB	20060+3547	6.78 12.0	64.6	6.77	2012.713	1	
BU 429AC	20060+3547	6.78 11.0	28.6	12.59	2012.713	1	
SHJ 314AD	20060+3547	6.78 9.49	300.2	11.15	2012.713	1	
BU 429AE	20060+3547	6.78 11.42	107.4	27.91	2012.713	1	
DOO 78AH	20060+3547	6.78 13.8	57.4	29.61	2012.713	1	
SHJ 314AF	20060+3547	6.78 7.30	28.3	35.82	2012.713	1	
BU 429FG	20060+3547	7.30 13.8	111.2	10.19	2012.713	1	
SEI 858AB	20060+3545	11.2 11.4	28.5	19.79	2012.713	1	
SEI 857AC	20060+3545	11.2 12.96	323.1	27.62	2012.713	1	
SEI 865	20061+3546	11.5 11.5	17.4	14.45	2012.713	1	
SEI 867AB	20062+3544	11.0 13.0	243.2	12.81	2012.713	1	

Table concludes on next page.

Double Star Measurements Using a Webcam, Annual Report of 2012

NAME	RA+DEC	MAGS	PA	SEP	DATE	N	NOTES
BKO 82AC	20062+3544	11.0 15.0	34.6	6.59	2012.713	1	
ENG 72AB	20145+3648	4.96 6.71	155.1	215.54	2012.713	1	29 Cyg
BUP 207AE	20145+3648	4.96 12.2	324.8	35.20	2012.713	1	
A1	20145+3648	4.96 12.5	35.5	32.42	2012.713	1	40
STF2758AB	21069+3845	5.35 6.10	151.8	31.29	2012.612	1	61 Cyg
STF2758AG	21069+3845	5.35 10.84	237.3	239.73	2012.670	2	
STF2758AH	21069+3845	5.35 10.89	278.4	95.86	2012.670	2	
A1	21069+3845	5.35 11.5	289.2	144.96	2012.670	2	41
A2	21069+3845	5.35 11.5	299.6	141.30	2012.670	2	42
A3	21069+3845	5.35 11.5	332.7	68.85	2012.612	1	43
HJ 1746AB	22139+3943	4.65 10.6	189.5	30.34	2012.691	1	
HJ 1746AC	22139+3943	4.65 12.14	191.5	72.34	2012.691	1	
WAL 141AD	22139+3943	4.65 13.07	71.0	193.87	2012.691	1	
A1	22139+3943	4.65 13	248.4	36.33	2012.691	1	44
A2	22139+3943	4.65 13	321.0	37.81	2012.691	1	45
STF2922AB	22359+3938	5.66 6.29	185.5	22.27	2012.691	1	8 Lac
A 1469AC	22359+3938	5.66 10.38	167.8	48.51	2012.691	1	
A 1469AD	22359+3938	5.66 9.08	143.9	81.64	2012.691	1	
COM 8BF	22359+3938	6.29 10.97	175.3	127.60	2012.691	1	
A 1469DI	22359+3938	9.08 11	227.2	10.14	2012.691	1	
S 813AB	22393+3903	4.84 10.30	49.2	62.42	2012.691	1	
S 815	22415+4014	5.21 10.80	14.7	67.91	2012.691	1	
BU 690AB	21435+5847	4.2 12.3	258.7	19.31	2012.801	1	
BU 690AC	21435+5847	4.2 12.7	293.8	41.86	2012.801	1	
A1	21435+5847	4.2 13	189.0	61.73	2012.801	1	46
A2	21435+5847	4.2 13	347.1	44.46	2012.801	1	47
A3	21435+5847	4.2 13	14.7	75.07	2012.801	1	48
A4	21435+5847	4.2 11	30.4	105.94	2012.801	1	49
STT 479	22441+4149	5.21 10.90	130.4	14.36	2012.691	1	
BU 451AB	22520+4319	4.94 11.9	158.6	23.53	2012.691	1	
BU 451AC	22520+4319	4.94 12.1	305.2	105.98	2012.691	1	
BU 451AD	22520+4319	4.94 12.5	230.2	140.12	2012.691	1	
STF3050AB	23595+3343	6.46 6.72	338.3	2.35	2012.801	1	Mayer 80

Notes:

1. Not yet listed in WDS catalog, brightness about 12.0 magnitudes
2. Not yet listed in WDS catalog, brightness about 12.0 magnitudes
3. Not yet listed in WDS catalog, brightness about 12.0 magnitudes
4. Background star near Epsilon Aurigae, not yet listed in WDS catalog
5. Background star near Epsilon Aurigae, not yet listed in WDS catalog
6. Background star near Epsilon Aurigae, not yet listed in WDS catalog
7. Background star near Epsilon Aurigae, not yet listed in WDS catalog
8. Background star near Epsilon Aurigae, not yet listed in WDS catalog
9. Background star near Capella, not yet listed in WDS catalog
10. Background star near Capella, not yet listed in WDS catalog
11. Not yet listed in WDS catalog, brightness about 12.0 magnitudes
12. Next to Betelgeuse, not yet listed in WDS catalog, brightness about 13.5 magnitudes
13. Also next to Betelgeuse, not yet listed in WDS

Double Star Measurements Using a Webcam, Annual Report of 2012

catalog, brightness about 13.5 magnitudes

14. Inside open star cluster Collinder 97
15. Inside open star cluster Collinder 97
16. Not yet listed in WDS catalog, brightness about 12.0 magnitudes
17. Next to SMR 11AG, brightness about 12.0 magnitudes
18. Not yet listed in WDS catalog, brightness about 12.5 magnitudes
19. Not yet listed in WDS catalog
20. See article (Schlimmer 2012)
21. Background star near Vega, brightness about 12 magnitudes
22. Background star near Vega, brightness about 11 magnitudes
23. Background star near Vega, brightness about 12 magnitudes
24. Background star near Vega, brightness about 12 magnitudes
25. Background star near Vega, brightness about 12 magnitudes
26. Background star near Vega, brightness about 12 magnitudes
27. Background star near Albireo, not yet listed in the WDS catalog
28. Background star near Albireo, not yet listed in the WDS catalog
29. Background star near Albireo, not yet listed in the WDS catalog
30. Background star near Albireo, not yet listed in the WDS catalog
31. Background star near Albireo, not yet listed in the WDS catalog
32. Background star near Albireo, not yet listed in the WDS catalog
33. Background star near Albireo, not yet listed in the WDS catalog
34. UNSO-B1.0 1006-0508835, not yet listed in WDS catalog, can be found in a distance of only 94.5 arc seconds and 88 degree from STF2558 not listed as double star in SIMBAD astronomical database
35. Not yet listed in WDS catalog
36. Not yet listed in WDS catalog
37. Not yet listed in WDS catalog
38. Bright companion, Not yet listed in WDS catalog
39. TYC1066-1390-1, not yet listed in WDS catalog
40. 29 Cyg, not yet listed in WDS catalog, brightness about 12.5 magnitudes
41. Background star near 61 Cygni
42. Background star near 61 Cygni
43. Background star near 61 Cygni
44. Not yet listed in WDS catalog, brightness about 13.0 magnitudes
45. Not yet listed in WDS catalog, brightness about 13.0 magnitudes
46. Near Herschel's Garnet Star, not yet listed in WDS catalog
47. Near Herschel's Garnet Star, not yet listed in WDS catalog
48. Near Herschel's Garnet Star, not yet listed in WDS catalog
49. Near Herschel's Garnet Star, not yet listed in WDS catalog

(Continued from page 236)

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A New Visual Binary Star in Scorpius

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Abstract: Presented in this paper is a new visual binary star in the constellation of Scorpius that is not in the current edition of the WDS catalog, the components of which share similar proper motions. Given their tight angular separation and near-identical photometric and proper motion characteristics, it seems likely that this is a physically related pair.

Introduction

I first identified this pair in January 2012 in DSS images, though it wasn't until four months later that I was able to obtain my own discovery image using the remotely operable 61-centimeter Cassegrain telescope of the Sierra Stars Observatory Network (SSON) in California [1] (Figure 1). A low resolution image was obtained on May 14th 2012 at 08:37 UTC. I was moderately happy with this image at the time even though it lacked the processing precisions I would have liked, ending with only a partial resolution of the components.

This Scorpius double star resides at ICRS coordinates: 16 03 22.2, -14 53 35 (Epoch 2000.0). Much to my surprise, I found that neither component appears to have formal designations in the catalogs. Using the PPMXL Catalog's 'r1 mag' as a guide, I have estimated the apparent visual brightness of the pair at V mags ~11.0, ~11.1, with the southernmost of the two stars appearing marginally the brighter one in the pair. I have hence assigned it as the 'A' component.

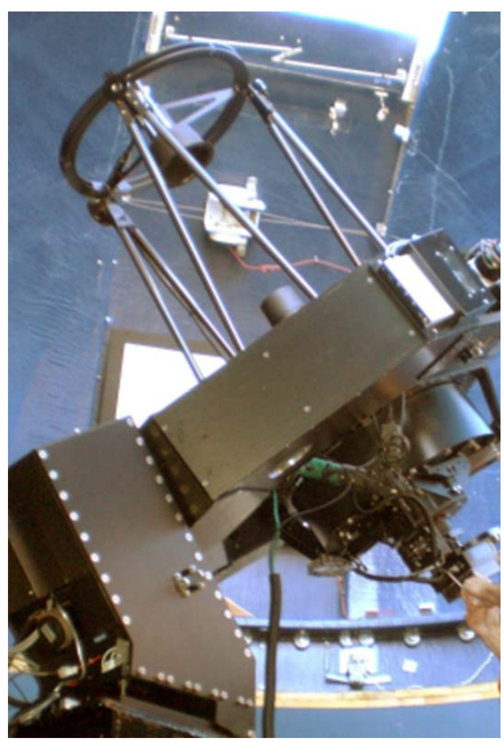

Figure 1: The 61-centimeter Cassegrain telescope of the SSON in California, housed within its observatory dome.

Latest Measurements

My preliminary discovery image of this pair, de-

A New Visual Binary Star in Scorpius

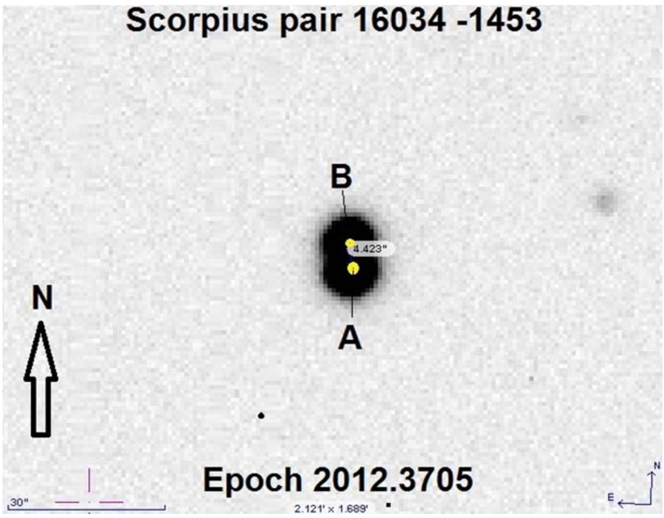

Figure 2: Image of the new CPM pair

scribed earlier, is shown in Figure 2. Measurements from the above image yield:

Position Angle (θ): 5.8^o (Epoch 2012.3705)
Separation (ρ): 4.42" (Epoch 2012.3705)

Even though the two stars were only partially resolved, with their Airy discs overlapping, the center of disc of each star could be isolated by eye in the FITS image in the Aladin viewer, enabling approximate measurements to be taken. Due to the tight separation and partial resolution of the components, the margins of error were thus expected to be quite high. Following several sets of measurements, it was found that the Position Angle was oscillating by up to ±2.5^o and the Separation by up to ±1.5" around the stated mean values.

Proper Motion, Photometry and Distance

The PPMXL Catalog [2] indicates that the two stars share similar proper motions in both RA and Dec, in both magnitude and in sign. These are given in Table 1.

The pair as a whole has a total proper motion of: $\{ [(12.5)^2 + (-10.0)^2]^{½} + [(13.9)^2 + (-8.1)^2]^{½} \} / 2 =$ ~16.0 milliarcseconds per year.

A total proper motion of 16.0 mas/year implies a distance for the pair in the region of something like 650 light-years, though this figure will be hugely dependent upon the quality of the proper motion measures themselves.

The 2MASS catalog [3] gives the J and K-band magnitudes for this Scorpius double star shown in Table

Table 1: Proper motion of the components

Scorpius Double Star	Proper Motion in RA	Proper Motion in Dec
A-component	+12.5 mas/year	-10.0 mas/year
B-component	+13.9 mas/year	-8.1 mas/year

Table 2: J and K magnitudes of the components

	J-magnitude	K-magnitude
A-component	9.895	9.486
B-component	9.927	9.445

2.

From these we derive color indices of (J – K) = +0.41 for the primary and (J – K) = +0.48 for the secondary component. However, these values appear way too high (i.e. making the stars seem way too red) when we compare them with the actual visual appearance of the two stars in color DSS images.

At a galactic latitude of +27^o on the celestial sphere, this double star is located in a dense region of the summer Milky Way not far from the direction looking toward the center of our galaxy, which lies in Sagittarius (Figure 3). The pair is therefore subjected to high levels of interstellar reddening, which is more pronounced in the infrared end of the spectrum. Indeed, long exposure deep sky survey images show the pair to be visibly eclipsed by a dark and tenuous cloud of intervening gas and dust, giving rise to both increased reddening and some measure of interstellar extinction in their visual brightness as well.

The derived (J - K) color indices from 2MASS stated earlier, therefore, need to be reduced by a factor of some ~0.1-magnitude each, which would take the spectral types of the pair to an early-G on the Hertzsprung-Russell diagram. That is to say, the revised color indices would be (J – K) = +0.31 for the primary and (J – K) = +0.38 for the secondary component. I made the decision to do this and found this classification, based on the corrected (J - K) color indices, to be certainly in closer agreement with the creamy-yellow hues of the two stars we see visually in DSS color images. This then suggests an absolute magnitude (M) of around +4.5 for each star in the pair, fitting the apparent magnitudes (m) of +11 and distance modulus of a pair of G0 V-type main sequence stars placed at 650 light-years

Figure 3: Position in the night sky relative to the Milky Way. [Image courtesy: Stellarium]

away from the Earth.

On the assumption that both stars in this pair are in fact at this same distance of 650 light-years away, if their orbit was projected in the plane of the sky, the two stars would be physically separated by:

Tan (4.42") x 650 x 63240 = 881 A.U.

They would thus be well within the distance threshold from each other to form an orbital binary pair.

Conclusion

In the various methods of fitting the observed photometric values to physical properties, distances and proper motions of this pair discussed in this paper, it seems that this is a good candidate for being a true binary star.

References

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[2] PPMXL Catalog (Roeser+ 2010).

[3] 2MASS All-Sky Catalog of Point Sources (Cutri+ 2003).

New Suspected Common Proper Motion Pairs

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Abstract: This article describes the identification of 11 new suspected pairs and one new suspected trio of stars with suspected common proper motion. We provide position measurements and proper motion values using data from UCAC4 catalog (Zacharias, et al. 2013).

Introduction

During the analysis of CCD images taken for the purpose of photometry of variable light sources and of astrometry of minor planets of our solar system, we have identified, serendipitously, 11 new suspected pairs and 1 new suspected trio of common proper motion stars not previously reported by observers and not included in the last edition of the Washington Visual Double Star Catalog (Mason, et al. 2001).

Analysis

In order to search for new pairs of common proper motion stars we analyzed images collected during 2012 with the instruments of the "Stazione Astronomica Betelgeuse (SAB)" located in Magnago, Italy (a Schmidt-Cassegrain 0.25m-f/10.0 telescope equipped with a KAF261E CCD camera). For each suspected pair identified, we checked the UCAC4 catalog in order to establish a similarity in the proper motion of the components.

In Table 1, for each pair of stars with suspected common proper motion, we report the provisional designation, epoch, position (R.A. and Dec.), and unfiltered magnitude as measured with the software Astrometrica (Raab, 2011); proper motion in right ascension (pm RA) and proper motion in declination (pm DE) for components as derived from the UCAC4 catalog; separation and position angle derived as described by Buchheim (2008).

Table 2 shows the images of fields containing the suspected common proper motion pairs; the orientation is north up and east left.

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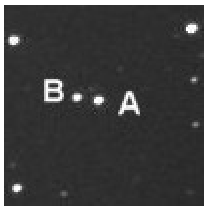
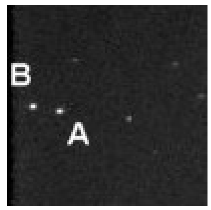
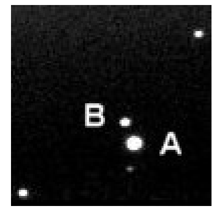
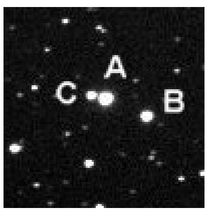
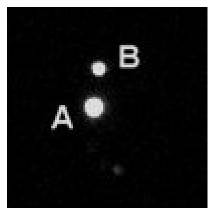
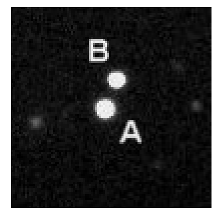
New Suspected Common Proper Motion Pairs

Table 1: Analysis Results

Name	Epoch	R.A.			Decl.			Mag.	UCAC4 pmRA mas/yr	UCAC4 pmDE mas/yr	Sep (ρ) "	P.A. (θ) °
		h	m	s	°	'	"					
MMA031 A	2012.03	5	5	27.6	25	46	58.3	13.2	-4.0	5.0	17.32	277.96
MMA031 B		5	5	26.4	25	47	0.7	13.7	-9.0	7.0		
MMA032 A	2012.04	1	19	15.0	9	15	4.5	16	-5.0	-27.0	21.62	279.58
MMA032 B		1	19	13.6	9	15	8.1	16.1	-12.0	-30.0		
MMA033 A	2012.04	2	54	59.6	-0	29	28.3	11.7	14.0	-5.0	18.22	202.76
MMA033 B		2	54	59.1	-0	29	11.5	14.3	9.0	-4.0		
MMA034 A	2012.04	22	55	42.1	51	23	50.0	10.8	-7.0	-9.0	35.29	113.02
MMA034 B		22	55	45.5	51	23	36.2	11.5	-8.0	-6.0		
MMA034 A	2012.04	22	55	42.1	51	23	50.0	10.8	-7.0	-9.0	11.62	282.93
MMA034 C		22	55	40.8	51	23	52.6	12.5	-10.0	-6.0		
MMA035 A	2012.23	15	41	35.1	53	50	33.4	9.7	21.0	-21.0	30.87	7.58
MMA035 B		15	41	35.5	53	51	4.0	11.7	20.0	-19.0		
MMA036 A	2012.23	13	57	43.5	22	50	56.9	10.7	-25.0	-7.0	24.56	21.81
MMA036 B		13	57	44.1	22	51	19.7	11.3	-24.0	-7.0		
MMA037 A	2012.36	9	12	42.6	64	41	46.3	15.5	-10.0	-5.0	13.44	155.18
MMA037 B		9	12	43.5	64	41	34.1	15.9	-6.0	-10.0		
MMA038 A	2012.51	17	47	57.6	52	23	57.2	14.7	-3.0	-8.0	35.70	180.00
MMA038 B		17	47	57.6	52	23	21.5	15.4	-3.0	-14.0		
MMA039 A	2012.55	17	8	1.6	13	21	49.2	13.5	-8.0	18.0	15.33	271.50
MMA039 B		17	8	0.5	13	21	49.6	15.3	-17.0	22.0		
MMA040 A	2012.70	23	27	39.9	8	50	37.0	14.9	20.0	3.0	15.43	267.40
MMA040 B		23	27	38.9	8	50	36.3	16.3	22.0	4.0		
MMA041 A	2012.71	0	42	40.9	41	22	16.1	12.9	12.0	1.0	13.51	54.74
MMA041 B		0	42	41.9	41	22	23.9	14.4	14.0	-1.0		
MMA042 A	2012.73	23	10	46.9	30	38	25.3	12.5	-20.0	-14.0	5.80	358.73
MMA042 B		23	10	46.9	30	38	31.1	12.6	-18.0	-10.0		

New Suspected Common Proper Motion Pairs

Table 2: Identification Charts

		
MMA031	MMA032	MMA033
		
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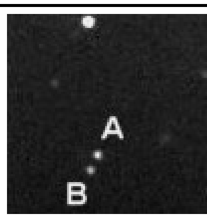
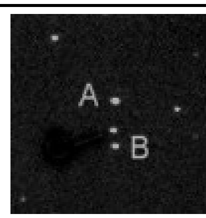
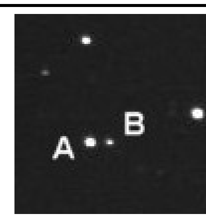
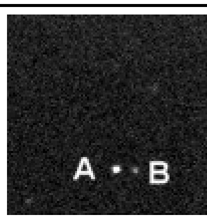
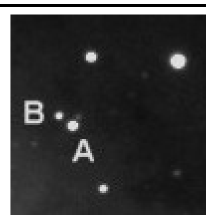
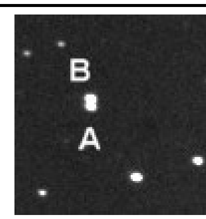
		
MMA037	MMA038	MMA039
		
MMA040	MMA041	MMA042

Observations of Double Stars at "Stazione Astronomica Betelgeuse"

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Abstract: This report contains measurements of 49 different double star systems. Data were obtained at the "Stazione Astronomica Betelgeuse" in Magnago, Italy as data mining activity on CCD images taken with different projects from the position measurement of double stars.

Introduction

During the analysis of CCD images taken during the period spanning from 2003 to 2012, with the purpose of photometry of variable star and of astrometry of minor planets, we have identified on our images a lot of already known double stars previously included in the last edition of the Washington Visual Double Star Catalog (Mason, et al. 2001).

Analysis

In order to perform astrometry on double stars, we analyzed images collected with the instruments of the "Stazione Astronomica Betelgeuse (SAB)" located in Magnago, Italy (a Schmidt-Cassegrain 0.20m-f/10.0 telescope equipped with a KAF401E CCD camera from 2003 to 2011 and a Schmidt-Cassegrain 0.25m-f/10.0 telescope with a KAF261E CCD camera since 2012).

In Table 1, for each pair of double stars we report designation, epoch, position (R.A. and Decl.) unfiltered magnitude as measured with the software Astrometrica (Raab, 2011), separation and position angle derived as described by Buchheim (2008), and the number of measurements of the pair.

References

Buchheim R.K., 2008, "CCD Double-Star Measurements at Altimira Observatory in 2007", *JDSO*, **4**, 27.

Mason B.D., et al., 2001, "The Washington Visual Double Star Catalog (WDS), Version 2010-07-03", *A.J.*, **122**, 3466.

Raab H., 2011, Astrometrica (Version 4.6.6.391), http://www.astrometrica.at.

Observations of Double Stars at "Stazione Astronomica Betelgeuse"

Name	Epoch	R.A.			Decl.			Mag.	Sep. (ρ) "	P.A. (θ) °	Num.
		h	m	s	°	'	"				
ABL 88A	2008.00	2	54	26.7	0	29	41.7	10.4	19.12	235.06	2
ABL 88B		2	54	25.7	0	29	30.8	12.6			
ALI 606A	2008.52	17	38	58.3	37	51	59.8	10.5	10.89	98.45	1
ALI 606B		17	38	59.2	37	51	58.2	12.3			
BAL1103A	2012.06	7	31	51.2	0	18	7.6	12.5	17.94	203.14	1
BAL1103B		7	31	50.7	0	17	51.1	13.4			
BKO 35A	2010.21	8	51	7.2	11	53	1.6	12.4	10.64	141.37	3
BKO 35B		8	51	7.7	11	52	53.9	13.3			
BKO 36A	2009.07	8	51	7.8	11	48	9.3	11.2	32.61	29.32	5
BKO 36B		8	51	8.9	11	48	37.8	13.4			
BKO 37A	2009.16	8	51	17.0	11	50	46.3	10.7	8.68	203.95	4
BKO 37B		8	51	16.8	11	50	38.2	11.6			
BKO 38A	2009.07	8	51	18.5	11	49	21.5	12.3	9.64	74.30	5
BKO 38B		8	51	19.2	11	49	24.2	13.2			
BKO 39A	2009.07	8	51	15.4	11	47	31.4	12.3	12.43	233.46	5
BKO 39B		8	51	14.8	11	47	24.0	12.4			
BKO 40A	2009.07	8	51	17.5	11	45	22.6	8.9	21.15	332.50	5
BKO 40B		8	51	16.8	11	45	41.4	13.6			
BKO 41A	2009.15	8	51	23.9	11	47	15.0	12.0	8.64	145.68	4
BKO 41B		8	51	24.2	11	47	7.9	12.5			
BKO 42A	2009.07	8	51	27.0	11	51	52.6	10.7	13.85	116.97	5
BKO 42B		8	51	27.8	11	51	46.3	13.8			
BKO 43A	2009.16	8	51	32.6	11	48	52.0	10.7	10.39	94.97	4
BKO 43B		8	51	33.3	11	48	51.3	11.7			
BKO 45A	2009.07	8	51	32.4	11	47	52.7	12.5	8.31	356.09	5
BKO 45B		8	51	32.4	11	48	0.8	12.5			
BKO 46A	2008.58	8	51	34.3	11	51	10.5	10.7	15.87	182.65	4
BKO 46B		8	51	34.3	11	50	54.7	13.3			
BKO 47A	2008.58	8	51	42.7	11	46	36.5	12.0	31.71	72.56	4
BKO 47B		8	51	44.7	11	46	46.0	12.7			
CHE 118A	2009.07	8	51	7.8	11	48	9.3	11.2	23.84	61.71	5
CHE 118B		8	51	9.2	11	48	20.6	13.0			
CHE 119A	2008.10	8	51	17.5	11	45	22.6	8.9	12.92	300.22	3
CHE 119B		8	51	16.7	11	45	29.1	12.0			
CHE 119A	2008.58	8	51	17.5	11	45	22.6	9.1	32.48	13.31	4
CHE 119C		8	51	18.0	11	45	54.3	12.3			
CHE 120A	2009.64	8	51	26.2	11	53	52.0	9.9	31.21	144.38	4
CHE 120B		8	51	27.4	11	53	26.6	12.3			
CHE 121A	2009.07	8	51	27.0	11	51	52.6	10.7	31.28	37.25	5

Table continues on next page.

Observations of Double Stars at "Stazione Astronomica Betelgeuse"

Name	Epoch	R.A.				Decl.		Mag.	Sep. (ρ) "	P.A. (θ) °	Num.
		h	m	s	°	'	"				
CHE 121C		8	51	28.8	11	51	59.8	12.2			
CHE 123A	2008.58	8	51	34.3	11	51	10.5	10.7	39.20	220.47	4
CHE 123B		8	51	32.6	11	50	40.6	12.1			
CHE 124A	2009.64	8	51	39.2	11	50	3.8	11.9	26.83	273.00	4
CHE 124B		8	51	37.4	11	50	5.3	12.2			
CHE 125A	2009.07	8	51	42.3	11	50	7.6	11.1	15.78	174.09	5
CHE 125B		8	51	42.5	11	49	52.0	12.2			
CHE 126A	2008.58	8	51	42.7	11	46	36.5	12.0	22.92	121.57	4
CHE 126B		8	51	44.0	11	46	24.5	12.3			
CHE 127A	2010.21	8	51	48.6	11	49	15.6	10.7	24.70	50.95	3
CHE 127B		8	51	50.0	11	49	31.1	12.2			
CHE 127A	2010.21	8	51	48.6	11	49	15.6	10.7	28.85	14.74	3
CHE 127C		8	51	49.1	11	49	43.5	12.3			
ES 962A	2009.19	14	43	51.2	47	43	2.3	9.1	9.50	257.84	1
ES 962B		14	43	50.3	47	43	0.3	10.4			
HJ 3253A	2009.87	3	52	10.5	26	13	53.1	9.3	30.61	72.51	1
HJ 3253B		3	52	12.7	26	14	2.3	9.6			
HO 120A	2003.71	20	11	58.7	34	35	39.7	8.3	24.67	199.90	1
HO 120B		20	11	58.0	34	35	16.5	11.8			
HO 236A	2012.95	6	41	3.4	20	38	44.1	18.3	18.26	203.08	1
HO 236B		6	41	2.8	20	38	27.3	12.9			
HO 400A	2012.51	16	0	23.6	15	40	3.5	9.4	11.46	137.12	1
HO 400B		16	0	24.1	15	39	55.1	12.3			
J 389A	2010.31	9	50	49.2	11	50	32.9	7.8	29.09	145.24	3
J 389B		9	50	50.3	11	50	9.1	12.6			
JEF 3A	2009.60	20	7	36.5	17	42	14.7	14.8	11.32	280.17	1
JEF 3B		20	7	35.8	17	42	16.7	13.4			
LDS2632A	2012.38	12	9	28.1	62	58	41.9	9.2	24.99	8.78	1
LDS2632B		12	9	28.7	62	59	6.6	16.1			
MLB 521A	2009.12	6	47	41.5	28	7	49.9	11.5	6.20	1.22	1
MLB 521B		6	47	41.5	28	7	56.1	12.1			
MMA 024A	2012.94	6	7	26.2	51	3	43.2	14.6	22.76	333.69	1
MMA 024B		6	7	25.1	51	4	3.6	14.5			
POU2145A	2010.31	6	56	22.4	24	45	30.2	13.2	12.85	40.29	1
POU2145B		6	56	23.0	24	45	40.0	13.8			
POU3250A	2009.56	16	52	5.4	23	49	13.8	11.2	16.36	53.63	1
POU3250B		16	52	6.4	23	49	23.5	13.7			
POU3845A	2005.67	19	28	15.2	24	24	6.7	13.0	15.50	106.11	1
POU3845B		19	28	16.3	24	24	2.4	13.4			
POU5258A	2012.53	21	13	3.6	24	23	29.0	9.8	29.96	65.76	2

Table concludes on next page.

Observations of Double Stars at "Stazione Astronomica Betelgeuse"

Name	Epoch	R.A.			Decl.			Mag.	Sep. (ρ) "	P.A. (θ) °	Num.
		h	m	s	°	'	"				
POU5258B		21	13	5.6	24	23	41.3	13.4			
POU5268A	2012.53	21	13	27.0	24	25	36.0	13.2	8.55	358.17	2
POU5268B		21	13	27.0	24	25	44.6	13.5			
POU 656A	2008.89	5	18	58.0	23	8	15.6	10.6	10.93	94.72	1
POU 656B		5	18	58.8	23	8	14.7	12.7			
SLE 73A	2011.11	5	24	44.9	40	16	33.9	11.4	10.86	315.92	1
SLE 73B		5	24	44.2	40	16	41.7	12.8			
STI1283A	2006.84	0	8	48.0	54	39	36.3	10.3	12.99	124.74	1
STI1283B		0	8	49.3	54	39	28.9	11.9			
STI1627A	2011.07	1	33	13.1	56	10	46.7	10.6	15.47	126.49	1
STI1627B		1	33	14.6	56	10	37.5	12.5			
STI2875A	2012.55	22	50	53.8	56	58	53.2	13.6	11.48	36.73	1
STI2875B		22	50	54.7	56	59	2.4	13.5			
STT 356A	2007.58	18	33	12.4	40	9	50.7	9.1	28.88	121.87	2
STT 356B		18	33	14.6	40	9	35.5	7.0			
STT 356A	2007.58	18	33	12.4	40	9	50.7	9.1	45.50	44.86	2
STT 356C		18	33	15.2	40	10	23.0	10.2			

Double Star Measures of Neglected Systems Using the Video Drift Method

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Abstract: Position angles and separations are given for 64 neglected multiple star systems measured using the video drift method. Most of these systems have lacked measurements since the late 1800's and early to mid 1900's as shown in the WDS Catalog version from early 2012. Most had multiple drifts, resulting in thousands of video frames analyzed per system. The video drift method provides high systematic accuracy.

Introduction

In the first and subsequent papers describing a new video method to measure double stars (Nugent and Iverson, 2011, Nugent and Iverson, 2013), 1,000's of Cartesian (*x*,*y*) positions of the double star components weere obtained from a short video clip of the multiple star system drifting across the field of view. The freeware program *Limovie* (Miyashita, 2006), originally intended for analysis of occultation videos, was used to automatically convert the raw video into a table of Cartesian (*x*,*y*) positions for the component stars being measured. An Excel program written by this author reads the (*x*,*y*) coordinate data and computes a simultaneous solution for the position angle, separation and other statistical quantities from the entire data set per system. Typical probable errors for the data presented here in the Tables is 0.75° for PA and 0.28″ for separation.

Methodology

The telescope used and scale factor are summarized in Table 1. The systems targeted in this research in Table 2 lacked measurements from the late 1800's to the early to mid 1900's. Unknown to this author, some systems were updated in the WDS catalog during the course of this research by other investigators. For most systems, a Collins I^3 image intensifier (Collins 1998) was used to aid in reaching fainter doubles. This device is attached between the telescope and the video camera and adds approximately three (3) magnitudes to the faint limit of the video system. The faintest system measured from Table 2 had a secondary with a published magnitude of +14.0 (WDS 14284+0520/LDS 961). Table 2 presents results for 64 double star systems along with standard deviations, number of video

Table 1: Telescope used and scale factor.

TELESCOPE	APERTURE	FOCAL LENGTH	SCALE FACTOR
Meade LX-200	14" (35cm)	3550 mm f/10	0.6"/pixel

Double Star Measures of Neglected Systems Using the Video Drift Method

frames, number of drift runs, and other data.

Table 3 has the result for the unconfirmed system WDS 13109+2114 SIN 79AC whose only entry is from epoch 1989.

Discussion of Individual Systems

06072-2216/ARA 1638BC

See Figure 1. The Palomar Sky Survey (DSS) IR image shows only two stars at nearly 180° PA. The WDS catalog value for the AB component for year 1999 shows a PA=179°, sep=13.4". This is very close to the Table 2 values of PA= 182.1° and Sep=12.4". A “BC” component is listed from a 1920 entry at PA=147°, sep=8.8" however no such star is visible in any of the images at or near the reported magnitude of +10.9. Ignoring a flare star possibility in 1920, it is suggested that the C component doesn’t exist and the BC entry should

(Continued on page 260)

Table 2. Results of 64 neglected double stars using the video drift method.

WDS	Discoverer	PA	PA-σ	Sep	Sep-σ	Date	# video frames	mag pri	mag sec	N
02414+0426	A 2337AD	214	0.8	20.1	0.28	2013.044	1903	6.9	11.7	3
02578-2317	ARA1971	92.8	1.9	16.7	0.65	2013.036	759	9.89	12.7	1
02595+3753	HO 219AD	188.3	0.7	47.3	0.42	2013.044	822	8.2	11.6	1
03195-2145	JC 1AC	119.8	0.8	38.6	0.67	2013.036	623	3.91	10.8	1
04286+1911	BUP 61AB	268.8	0.2	191	0.55	2013.036	592	3.53	10.6	2
04467-0042	BAL 663	200.7	3.1	16.9	0.9	2013.036	683	10.82	11.2	1
04507-1713	ARA 155	24.3	4.7	10.8	0.88	2013.036	443	12.53	12.7	1
04514+0706	LDS3621	176.9	1.4	53.1	1.22	2013.036	717	11.92	12.0	1
04564+1331	BU 553AC	71.3	0.2	106	0.44	2013.197	1331	4.07	11.6	3
06072-2216	ARA1638AB	182.1	1.1	12.4	0.33	2013.255	2446	10.36	10.9	3
06089-1954	ARA 540	184.8	2.0	9.8	0.46	2013.255	2375	12.81	12.9	3
06136-1527	GAL 396AB	256.9	1.0	15.2	0.27	2013.255	2171	8.5	10.5	3
06290+0335	BAL2172	262.3	1.7	14.6	0.52	2013.255	2192	11.32	11.9	3
06312+2253	POU1390	322.1	2.2	13.2	0.44	2013.255	2377	11.43	12.2	3
06360-0047	BAL 701BC	200.3	2.3	15.7	0.58	2013.255	1473	11.2	11.4	3
06549-0224	BAL 95	21.2	1.3	17.2	0.38	2013.2	2161	12.14	12.1	3
07147+2453	HO 343	279.5	0.2	30.9	0.35	2013.2	759	6.0	12.7	1
07175-2239	ARA1683	145	2.6	14.8	0.68	2013.255	1608	11.74	11.8	2
07366-1429	STF1121AC	131.5	1.1	17.7	0.36	2013.255	1942	6.92	13.0	3
07535+0428	BAL2794	283.2	0.7	28.6	0.39	2013.2	2085	10.8	11.0	3
07550+0036	BAL1123	48.7	3.4	14.4	0.77	2013.255	2141	11.96	12.2	3
07585-0217	BAL 191	121.2	1.4	11.6	0.33	2013.197	2180	8.90	11.1	3
08000-0050	BAL 842	93	1.2	13.1	0.4	2013.197	2188	11.44	11.5	3
08022-0058	HJ 77AB	359.2	0.5	30.8	0.3	2013.197	2241	9.68	11.7	3
08022-0058	HJ 77AC	13.9	0.5	34.5	0.33	2013.197	2168	9.68	12.0	3
08022-0058	HJ 77BC	73.3	1.7	9.9	0.32	2013.197	2182	11.7	12.0	3
08029-0242	BAL 194	143.9	1.6	10.7	0.34	2013.197	2190	10.6	11.0	3
08165-1619	FOX 157AC	32.4	0.4	74.3	0.41	2013.197	2052	7.7	10.8	3
08236+2509	BUP 116	171.4	0.2	116	0.45	2013.252	1496	10.04	12.0	2
08468-0004	BAL1142	105.2	1.3	12.7	0.37	2013.2	2176	10.28	10.4	3

Table continues on next page.

Double Star Measures of Neglected Systems Using the Video Drift Method

Table 2 (conclusion). Results of 64 neglected double stars using the video drift method.

WDS	Discoverer	PA	PA-σ	Sep	Sep-σ	Date	#video frames	mag pri	mag sec	N
08491-1244	J 2064AB	29.4	0.4	68	0.45	2012.227	1799	8.40	10.8	3
08504+1123	HJ 2470	215	2.2	7	0.31	2013.197	2216	11.75	11.82	3
09006+4147	BUP 122AB-D	104.3	0.2	173	0.4	2013.258	853	4.03	10.8	2
09012+0245	STF1302AC	255.4	0.6	24	0.31	2013.252	1371	9.31	12.6	2
09047-0806	J 2895	5.1	2.1	7.5	0.3	2013.26	1522	12.02	12.0	2
09090-1411	HU 227AC	323.9	0.2	26.2	0.15	2013.197	2155	7.74	11.0	3
09142-2036	ARA1066	330.5	1.1	13.9	0.28	2013.2	2354	10.17	12.3	3
09168-2121	ARA1067	85.8	1.7	12	0.69	2013.26	1588	12.43	12.9	2
09230-2843	B 2680	314	0.7	15.7	0.23	2013.26	1568	8.87	13.0	2
09308-1623	LDS 272	6.5	1.0	23.8	0.35	2013.26	1561	10.65	12.9	2
09347-2509	B 2220	82.6	0.4	20.2	0.13	2013.26	1549	8.28	11.1	2
09357-2230	ARA1768	53.1	0.7	14.9	0.21	2013.2	2094	9.44	11.9	3
09419-3011	J 1556	21.5	2.7	9.2	0.35	2013.255	1706	10.5	11.0	2
10008-1809	ARA 220	5.8	1.9	7.7	0.36	2013.197	2317	11.8	11.9	3
10160+3034	BEW 6	21.5	1.8	10.3	0.3	2013.255	2586	13.6	13.4	3
10294+0346	SLE 494	38.8	1.6	21.7	0.55	2013.197	2141	11.8	12.5	3
10319+3223	HJ 482	248.4	0.4	56.8	0.29	2013.26	1453	5.90	11.8	2
10459-2025	ARA 672	269	1.3	7.6	0.27	2013.252	2341	11.83	12.2	3
10470-1241	GWP 1454	212.6	2.6	13.7	0.55	2013.26	1491	12.9	13.8	2
10522-2248	ARA1785	140.4	2.0	7.2	0.32	2011.107	3179	12.48	12.5	4
11330-3151	HJ 4449AB	133.9	0.4	73	0.53	2013.258	1307	3.54	10.7	2
11423-1544	LDS 357	256.7	0.2	66.5	0.3	2013.2	1919	9.11	11.5	3
11536-1607	A 2381AC	319.3	0.2	71.5	0.35	2013.2	2651	7.57	11.1	4
12301-1324	LV 19AC	302.8	0.2	71.3	0.27	2013.351	1904	6.49	10.6	3
12301-1324	LV 19AD	165.5	0.6	71.2	0.58	2013.351	724	6.49	11.6	1
12400+2955	LDS4243	44.3	0.2	87.7	0.32	2013.351	1431	11.54	12.6	2
13085+3106	LDS1363	288.2	0.1	198	0.34	2013.351	399	11.52	12.24	3
13343-0019	STF1757AD	75.7	0.2	144	0.51	2013.351	890	7.82	11.9	2
14158+1018	STF1823AB,D	253.3	0.3	65.4	0.46	2013.351	1247	9.19	12.4	2
14257+2338	BU 1442AF	283.1	0.1	246	0.37	2013.351	868	9.87	12.5	3
14284+0520	LDS 961	256.1	0.3	60.7	0.4	2013.351	1265	13.2	14.0	2
14313-1538	BU 117AC	330.8	0.3	142	0.62	2013.351	627	8.44	12.5	1
14336+3535	STF1858AC	322.1	0.1	36.6	0.1	2013.351	1650	8.13	13.9	2
14463+0939	STF1879AB,C	232.6	0.2	38.1	0.11	2013.351	1366	7.32	12.1	2

Table 2 Notes:

All magnitudes were taken from the WDS catalog.

All positions are for Equator and Equinox of date.

Column titled "# **video frames**" is the total combined no. of video frames from all drift runs. All video frames were used in the solution, none were discarded.

The last column "**N**" is the number of separate drift runs made for that system.

Double Star Measures of Neglected Systems Using the Video Drift Method

Table 3. Measures of Unconfirmed Double Star system using Video Drift Method

WDS	Discoverer	PA	PA-σ	Sep	Sep-σ	Date	#video frames	mag pri	mag sec	N
13109+2114	SIN 79AC	25	0.25	94.9	0.79	2012.307	750	6.82	12.2	1

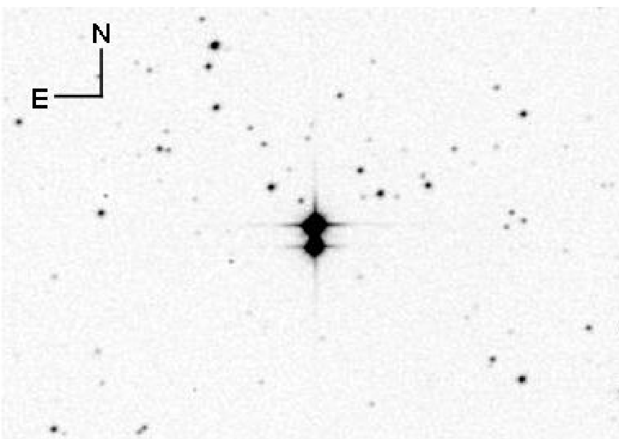

Figure 1. WDS 06072-2216, epoch 1991.

(Continued from page 258)

be removed.

07535+0428/BAL 2794

Primary and secondary have nearly similar magnitudes. A recent addition to WDS using 2000 data shows PA at 284°. The value derived by the video method was 103.2°, 180.8° different from the WDS catalog value. Hence 180° was added to get 283.2° to make the value consistent with the catalog measure. Misidentification of the primary star occurs occasionally with video due to the spectral sensitivity of the chip in the video camera.

09047-0806/J 2895

See Figure 2. POSS images from 1953 and 1991 plus a single video frame from 2013 show the PA change of approximately 15°, indicating possible orbital motion. WDS has only two entries for years 1945 and 1955 showing only a 1° PA change. The video method derived a value of PA = 5.1° for epoch 2013 confirming relative motion of the pair.

14257+2338/BU 1442AF:

See Figure 3. The AB components of this system have a common proper motion of 1.4"/yr. in PA = 144° and as of 2013 they have moved a distance of 116" since the WDS catalog's 1930 entry. This physical pair's large proper motion is clearly responsible for the large change in PA and separation values for the AF components over the 83 year interval since last measured.

Unconfirmed Individual Systems

WDS 13109+2114 SIN 79AC

See Figure 4 and Table 3. Identification of the single observation from the WDS in 1989 of this pair is not

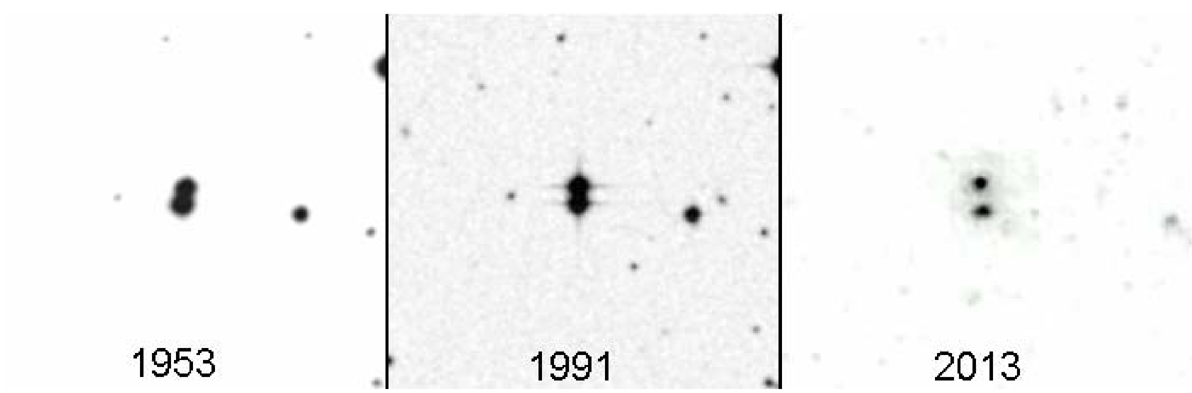

Figure 2. WDS 09047-0806. POSS images left to right epochs 1953, 1991 plus enlarged single video frame from 2013. From the images, the PA change over 60 years is approximately 15°, hence possible orbital motion is detected.

Double Star Measures of Neglected Systems Using the Video Drift Method

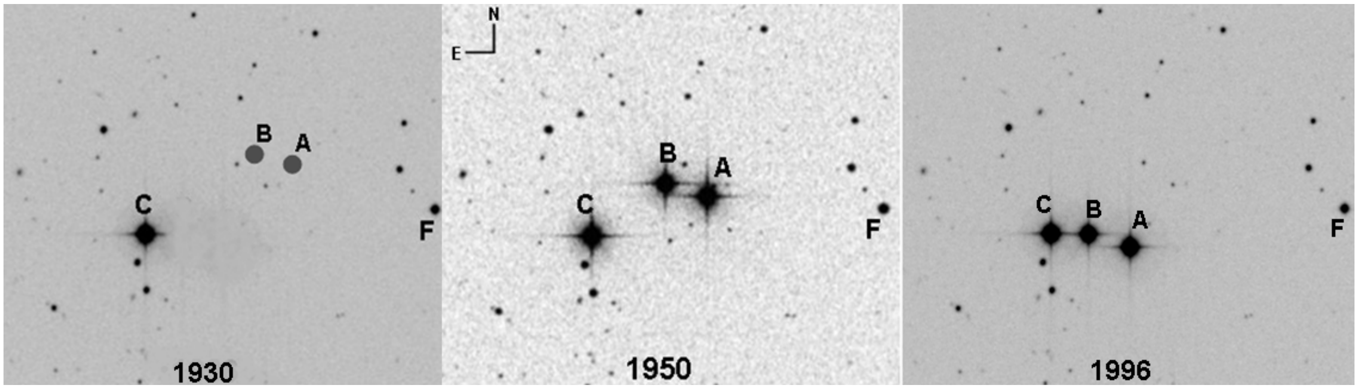

Figure 3. WDS 14257+2338. Left: calculated position of AB component in 1930 from proper motions. Center, right: POSS images from 1950, 1996. AB system has moved 92" in 66 years.

confirmed. The suspected C component is marked in Figure 4 at PA=25°, sep=95". Proper motion data does not support the 19° PA and 10" separation differences over the 23 year interval since the WDS 1989 entry. The B component is well known as 13109+2114 COU 96 AB.

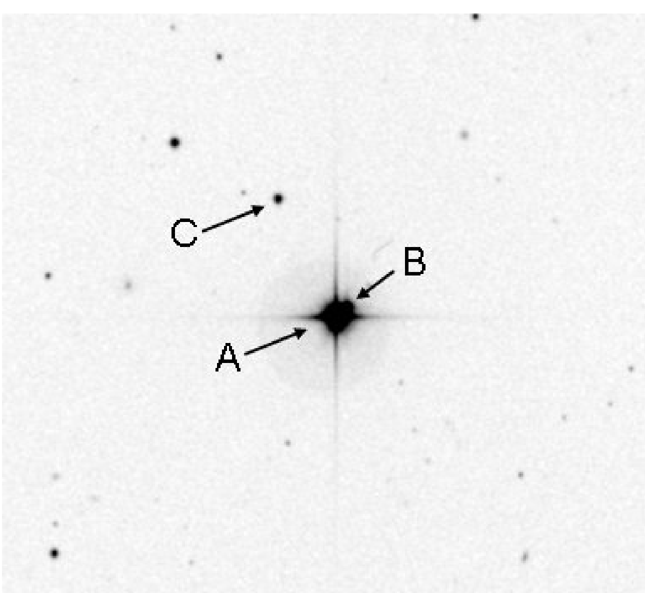

Figure 4. WDS 13109+2114 SIN 79. Arrows indicate components measured. POSS image epoch April 19, 1996. The AB components are known as 13109+2114 COU 96 AB.

Acknowledgements

This research makes use of the following catalogs/surveys: Washington Double Star Catalog maintained at the US Naval Observatory. The National Geographic Society - Palomar Observatory Sky Atlas (POSS), made by the California Institute of Technology with grants from the National Geographic Society. Dr. Brian Mason of the USNO made helpful comments.

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Study of 17 New Stellar Pairs in the Constellation Aurigae with Three Possible New Common Proper Motion Pairs

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Abstract: During observation in the constellation Auriga, 17 new stellar pairs were found by the author. The separations are between 3 and 10 arc seconds, the brightness's are between 10 and 14 magnitudes. The difference in brightness of the components of each pair is less than or equal to 1 magnitude. Except for USNO-B1.0 1257-0104496 and USNO-B1.0 1257-0104504, all other stars are listed as single stars. With Halbwachs' third criterion, possible new common proper motion pairs were found.

Report

A 12-inch Newtonian telescope with focal length of 1500 mm was used for the observations. Images of sky fields were taken with a Canon 1100 D Digital Single Lens Reflex Camera (DSLR). The camera was sited at the primary focus of the telescope. The field of view was about 0.9 x 0.6 degrees. To make the camera more sensitive to red light, the blocking filter for red light was removed. Therefore, stars with K and M spectra and also HII regions could be better imaged. The scale of the optical setup was about 0.77 arc seconds per pixel. The telescope was connected to a laptop. The software package Redshift 7 was used to aim the telescope. The DSLR camera was also connected to the laptop and could be controlled remotely.

For these observations in the constellation Auriga, single shots of 4 interesting star fields were taken on 2013.168. Exposure time was 30 seconds. The minimum brightness of the stars is about 16 magnitudes. The four interesting fields are around the star clusters M36, M37, M38, and around ε Aurigae.

During the analysis of the images, 17 new double stars were found. These double stars are located outside the star clusters, and are not listed in the WDS catalog.

These double stars are listed in Table 1. The first column lists the catalog name of the star, second and third columns are coordinates for R.A. and declination, fourth column gives the brightness, fifth and sixth columns give the proper motion if known, seventh column is the estimated difference in brightness, eighth column gives a short note about the color if the component has a K or M spectra, ninth and tenth columns give the calculated individual magnitudes, column eleven and twelve give the position angle in degrees and separation between the components in arc seconds, the thirteenth column shows the calculated Aitken limit p max in arc seconds, the fourteenth column gives the time in years for the pair to move the distance of its own separation if the proper motion is known, the fifteenth column gives a short note about the image field in the neighborhood. Except for USNO-B1.0 1257-0104496 and USNO-B1.0 1257-0104504, all other stars are listed as single stars in the Redshift database.

The difference in brightness of the components of each pair is less than or equal to one magnitude. The given value can be interpreted as a combined magnitude (except USNO-B1.0 1257-0104496 and USNO-B1.0 1257-0104504). For each component a new individual brightness and also the Aitken criteria ρ max can be calculated. For calculation the formula in Francisco

Table 1: 17 new stellar pairs in constellation Aurigae, observing date: 2013,168

Name	RA (h m s)	Dek (deg)	Mag	PM R.A. (mas/yr)	PM Dec. (mas/yr)	Est. Mag	spectra note	Mag A	Mag B	θ (deg)	ρ (as)	Aitken limit ρ max (as)	T= ρ/PM (yr)	Notes
TYC 2907-00308-1	05 00 01.4	43 42 11.1	12.45	0	0	0		13.20	13.20	304.0	5.90	2.04		ε Aur
USNO-B1.0 1340-0125220	05 00 35.4	44 02 03.3	11.50	0	0	1	A red	11.86	12.86	61.6	6.20	3.17		ε Aur
USNO-B1.0 1341-0125973	05 01 01.7	44 06 07.0	13.30	-6	-4	0.5		13.83	14.33	122.3	4.20	1.38	582	ε Aur
USNO-B1.0 1258-0101998	05 27 54.6	35 51 48.1	12.5	0	0	0.5		13.03	13.53	91.9	3.28	2.00		near M38
USNO-B1.0 1259-0104506	05 28 26.0	35 57 46.8	12.10	0	0	0		12.85	12.85	224.4	5.95	2.40		near M38
USNO-B1.0 1260-0103923	05 28 31.8	36 02 11.9	13.10	0	0	1		13.46	14.46	302.7	5.66	1.52		near M38
USNO-B1.0 1260-0104160	05 28 52.7	36 02 15.8	12.40	0	0	0		13.15	13.15	151.9	4.90	2.09		near M38
USNO-B1.0 1257-0104337	05 30 25.6	35 43 47.1	12.50	0	0	1		12.86	13.86	75.6	5.70	2.0		near M38
USNO-B1.0 1257-0104496	05 30 37.1	35 44 38.0	11.20	106	-312	0.1	A red	11.10	11.20	129.2	6.26	5.26	19	near M38
USNO-B1.0 1257-0104504	05 30 37.5	35 44 36.5	11.10	0	0									
USNO-B1.0 1259-0106575	05 30 44.9	35 57 19.2	12.60	0	0	0		13.35	13.35	217.0	5.18	1.91		near M38
USNO-B1.0 1244-0101791	05 35 12.5	34 26 19.4	13.0	0	0	1		13.36	14.36	97.8	5.28	1.59		near M36
USNO-B1.0 1243-0101852	05 35 31.0	34 19 32.2	13.1	0	0	0.5		13.63	14.13	179.0	5.84	1.51		near M36
USNO-B1.0 1243-0102624	05 36 45.1	34 18 23.0	13.5	0	0	0		14.25	14.25	267.1	5.57	1.26		near M36
USNO-B1.0 1243-0102678	05 36 49.2	34 20 15.4	11.10	0	0	0	A red	11.85	11.85	128.0	6.25	3.81		near M36
USNO-B1.0 1243-0102718	05 36 53.0	34 20 12.1	13.30	0	0	0.5		13.83	14.33	321.6	6.04	1.38		near M36
USNO-B1.0 1244-0102740	05 36 56.7	34 25 09.1	12.8	0	0	0.5	B red	13.33	13.83	115.6	5.17	1.74		near M36
USNO-B1.0 1240-0105442	05 38 25.0	34 01 28.2	11.30	-66	8	0	A red	12.05	12.05	4.5	9.80	3.47	27	near M36

Rica Romero's paper was used (Romero, 2006). In all cases the measured separation ρ is greater than the calculated Aitken criteria ρ max (see Table 1). As result of these calculations, it can be expected that these 17 analyzed pairs are not physical double stars.

For 3 stars, the proper motion is given in the USNO -B1.0 catalog. With Halbwachs' criteria (Halbwachs, 1986) it can be determined if these stars are possible common proper motion pairs. If time T is less than 1000 years, the probability for a common proper motion pair is nearly 99% (Halbwachs, 1986). T is the ratio of separation and proper motion (T = ρ/PM).

USNO-B1.0 1341-0125973 has the smallest proper motion of these 3 stars. Proper motion is -6 mas per year in R.A. and 4 mas per year in declination. The given error for proper motion in USNO-B1.0 catalog is for R.A. 1 mas per year and 5 mas per year in declination. Separation is 4.2 arc seconds, T = 582 years.

USNO-B1.0 1257-0104496 and USNO-B1.0 1257-0104504 are both single stars but the separation is only 6.26 arc seconds. The proper motion for USNO-B1.0 1257-0104496 is about 330 mas per year. The proper motion for USNO-B1.0 1257-0104504 is not known. Relative position between both stars has not significantly changed since the POSS-1 survey. Therefore it can be expected that both stars have same proper motion and are common proper motion stars. T = 19 years.

USNO-B1.0 1240-0105442 is the widest pair in this study of 17 new stellar pairs. The separation is 9.8 arc seconds. T = 27 years.

Because USNO-B1.0 1341-0125973, USNO-B1.0 1257-0104496/USNO-B1.0 1257-0104504 and USNO-B1.0 1240-0105442 satisfy Halbwachs' criteria these 3 pairs could be possible new common proper motion pairs.

(Continued on page 266)

Study of 17 New Stellar Pairs in the Constellation Aurigae with Three Possible New ...

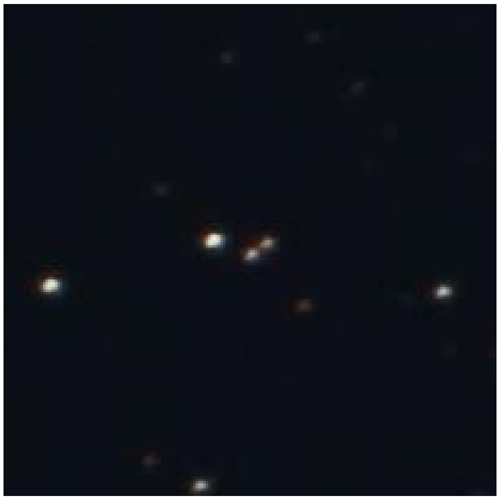

Figure 1: TYC 2907-00308-1

Figure 2: USNO-B1.0 1340-0125220

Figure 3: USNO-B1.0 1341-0125973 could be a possible common proper motion pair

Figure 4: USNO-B1.0 1258-0101998

Figure 5: USNO-B1.0 1259-0104506

Figure 6: USNO-B1.0 1260-0103923

Figure 7: USNO-B1.0 1260-0104160

Figure 8: USNO-B1.0 1257-0104337, USNO-B1.0 1257-0104496 and USNO-B1.0 1257-0104504 could be a possible common proper motion pair

Figure 9: USNO-B1.0 1259-0106575

Figure 10: USNO-B1.0 1244-0101791

Figure 11: USNO-B1.0 1243-0101852

Figure 12: USNO-B1.0 1243-0102624

Figure 13: USNO-B1.0 1243-0102678 on left hand side, USNO-B1.0 1243-0102718 on right hand side

Figure 14: USNO-B1.0 1244-0102740

(Continued from page 263)

Acknowlegements

This research has made use of the USNO Image and Catalogue Archive operated by the United States Naval Observatory, Flagstaff Station (http://www.nofs.navy.mil/data/fchpix/).

This research made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.

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Figure 15: USNO-B1.0 1240-0105442 could be a possible common proper motion pair

Romero, Francisco Rica, 2006, "R.G. Aitken's Criterion to Detect Physical Pairs", *Journal of Double Star Observations*, **2,** 36-41.

Halbwachs, J.L., 1986, "Common Proper Motion stars in the AGK 3", *Astronomy & Astrophysics Supplement Series* 66

Micro-Metric Measurements of 31 Aquilae

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Abstract: This paper discusses our discovery that the 2009 and 2010 position angle measurements of 31 Aquilae (the most current available in the WDS) are notably at variance with visual observations made in the summer and fall of 2012, along with a short history of prior observations. Also discussed are our efforts to measure both the position angles and separations in the summer and fall of 2012.

In early August of 2012, I happened across an eye-catching photograph (Figure 1) of 31 Aquilae, a stunning triple star with a neglected fourth member that hasn't been measured since 1914.

After admiring the configuration of the four stars, I turned my attention to the Washington Double Star Catalog to look at the measurements (shown below in Table 1) and could see immediately that the photograph and the data didn't match up well.

As can be seen in Table 1, the position angles for both AB and AC are listed at 281 degrees. But in the photograph, it's very obvious that AB and AC are not at identical position angles. Unable to determine the date of the photograph, I decided to take a hard look at 31 Aquilae as soon as the first opportunity presented itself — and when I did, I found the current position angles of AB and AC matched up well with the photo, as shown in my Figure 2 sketch.

And that led to this project.

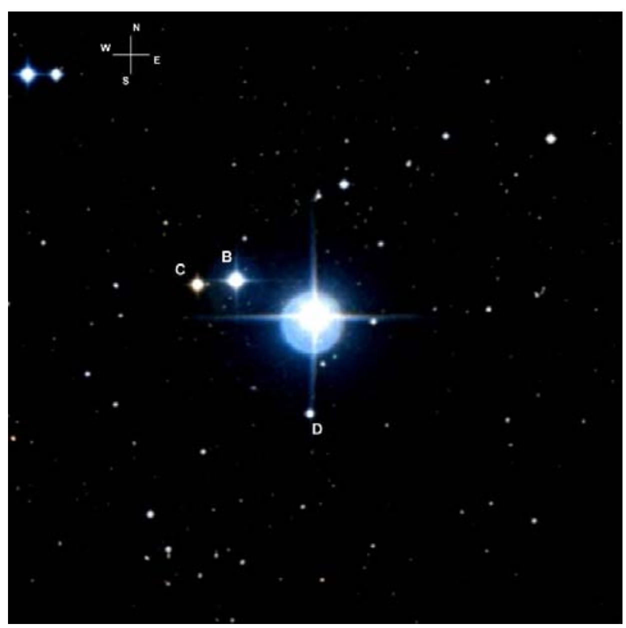

Figure 1. 31 Aquilae and its three companions. East and west reversed to match the refractor view. (Aladin photo)

Micro-Metric Measurements of 31 Aquilae

Table 1: Current WDS Measurements of 31 Aquilae

NAME	RA DEC	MAGS	PA	SEP	DATE
STT 588 AB	19250+1157	5.2 8.7	281	105.4	2010
STT 588 AC	19250+1157	5.2 10.3	281	145.2	2009
COM 7 AD	19250+1157	5.2 10.3	140	78.8	1914
STT 588 BC	19250+1157	8.7 10.3	266	44.2	2010

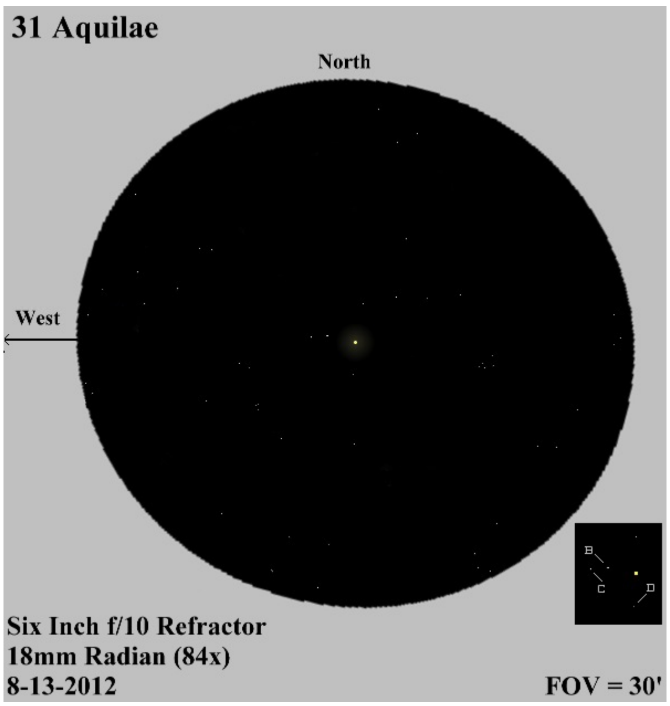

Figure 2. East and west reversed once again to match the view in the Aladin photo.

Proper Motion of 31 Aquilae

First, let's take a look at the earliest observations of 31 Aquilae.

The WDS shows the first recorded observation took place in 1852, which is credited to Otto Struve. The data from those observations is shown in Table 2, along with the first observations of the "D" component by Comstock in 1887.

When you compare the position angles and separations of AB and AC, it's clear that considerable change has taken place in the 157 and 158 years intervening between the first and last dates of measurement. As it turns out, most of that change is attributable to the rapid movement of the primary, which is shown below (Figure 3) in Simbad's plot of 31 Aquilae.

The long red line leading up and to the left is the primary of 31 Aquilae, and the shorter line to the right of it, pointing down and to the left, is the secondary, "B".

The WDS data confirms the rapid motion of the primary, showing it at +721 in RA and +643 in Declination, and it lists the proper motion of the secondary as at +032 in RA and -087 in Declination.

Previous Configurations of 31 Aquilae

I was somewhat perplexed by the fact that none of the early very active double star observers prior to Otto Struve - especially William Herschel, John Herschel, and James South - had recorded an observation of 31 Aquilae, but I suspected the reason for that was related to the rapid proper motion of the primary.

Armed with the 1852 data from Otto Struve's observations, I plotted the position angles and separations and came up with the chart shown below in Figure 4.

If you look at it closely, it's obviously not what you would call an eye-catching configuration of stars, although it certainly was enough to prompt Otto Struve to

Table 2: WDS First Dates of Observation of 31 Aquilae

NAME	RA DEC	MAGS	PA	SEP	DATE
STT 588 AB	19250+1157	5.2 8.7	4	142.5	1852
STT 588 AC	19250+1157	5.2 10.3	332	117.1	1852
COM 7 AD	19250+1157	5.2 10.3	122	82.2	1887
STT 588 BC	19250+1157	8.7 10.3	247	42.6	1852

Micro-Metric Measurements of 31 Aquilae

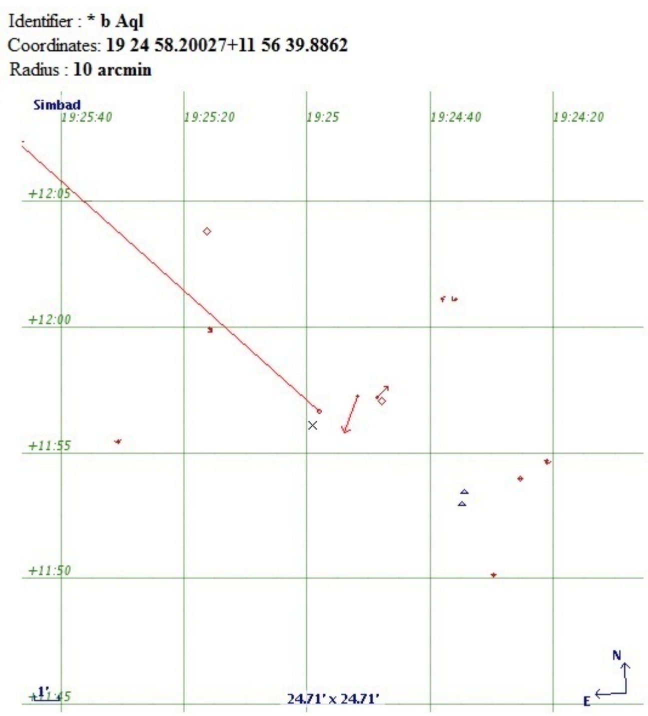

Figure 3. Plot of proper motions of 31 Aquilae "A" and "B". (From Simbad plot of "b", or 31, Aquilae).

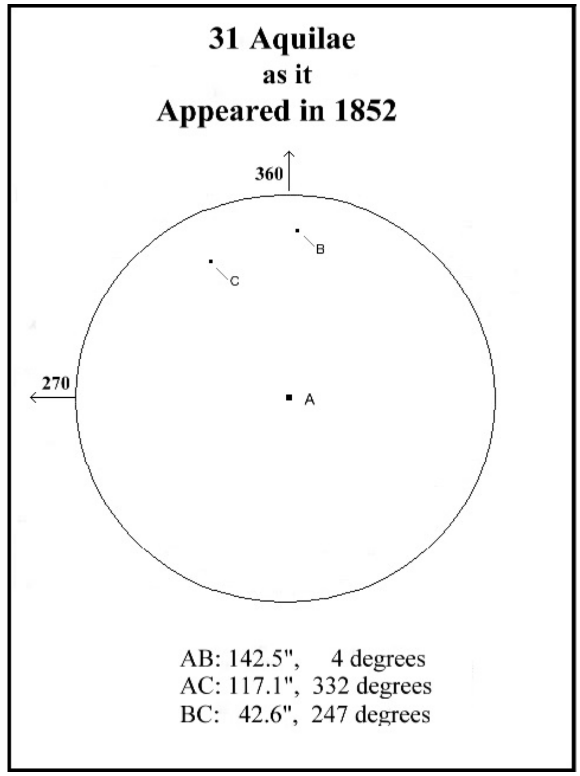

Figure 4. Plot of 31 Aquilae as it appeared to Otto Struve in 1852.

record the first measurements of 31 Aquilae.

Using the proper motions of the primary and the secondary shown in the WDS, and leaving "C" in place since its proper motion is relatively minor compared to that of the other two stars (+003 RA, +001 Dec), I plotted the positions of "A" and "B" backward in time to 1781. On July 25th of that year, William Herschel recorded an observation of nearby 28 Aquilae, located about one degree to the northwest of 31 Aquilae. Based on my results, if he had caught 31 Aquilae at that time, he would have seen something very close to the view shown in Figure 5. (See the references for a link to a discussion of both 28 and 31 Aquilae).

The circular field represents about a six arc minute eyepiece field of view, which is roughly equivalent to what William Herschel would have seen at 460x in the 160mm reflector he was using in 1781. Once again, hardly an eye-catching sight, and chances are he might have missed "B" altogether since it was probably well outside the field of view.

Back to the Present

So that takes us back to August and September of 2012. After mulling over all of the above information,

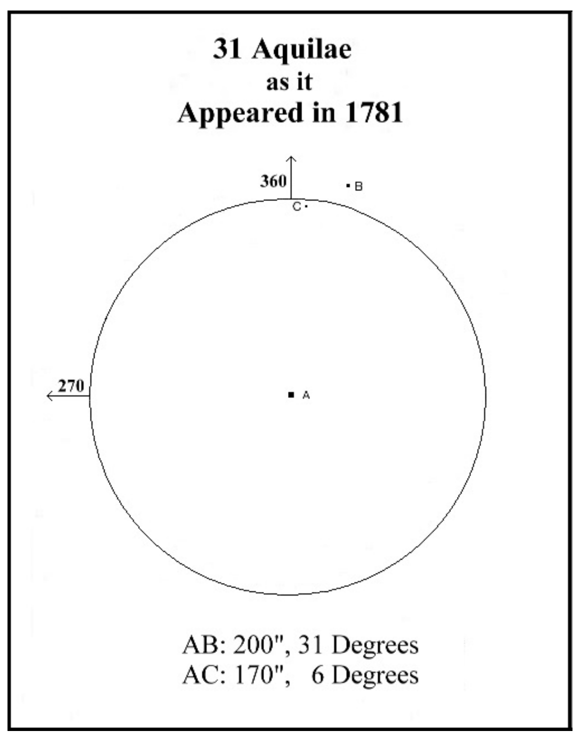

Figure 5. Plot of 31 Aquilae as it would have appeared in 1781 when Sir William Herschel was recording an observation of 28 Aquilae, one degree to the northwest.

Micro-Metric Measurements of 31 Aquilae

Table 3: My Measurements of 31 Aquilae

NAME	RA DEC	MAGS	PA	SEP	DATE	N
STT 588 AB	19250+1157	5.2 8.7	285.33	105.68	2012.748	1
STT 588 AC	19250+1157	5.2 10.3	279.30	145.31	2012.770	2
COM 7 AD	19250+1157	5.2 10.3	188.33	125.50	2012.773	3
STT 588 BC	19250+1157	8.7 10.3	268.01	46.24	2012.776	3

Notes:

1. Twenty readings using 2x Barlow (192x)
2. Twenty readings using 2.4x Barlow (230x)
3. Forty readings using 2.4x Barlow (230x)

Equipment used for all measurements: Celestron six inch f/8 refractor on a Losmandy G8 mount, Celestron 12.5mm Astrometric Eyepiece, Celestron 2x Barlow, 2.4x Dakin Barlow

I could see a real need for a tool to measure position angles and separations, and being a visual observer, my first thought was a bifilar micrometer. Unfortunately, those precision pieces of equipment are both rare and expensive, so I took a harder look at an astrometric eyepiece - a much more affordable choice, although one I had lost patience with in the past due to the difficulty of keeping the outer edges of the reticle in focus. My first choice was the Celestron eyepiece, which apparently is no longer offered in the U.S. under their name. Eventually I came across a Baader version of that eyepiece (an improvement over the original Celstron model), which I purchased and put to work immediately on 31 Aquilae.

I had become acquainted with Steve McGaughey after he had commented on a few of my columns written for the "Star Splitter" blog I co-write with Greg Stone, and thus was aware Steve had done some work with an astrometric eyepiece. Between his help and the chapter on astrometric eyepieces in Bob Argyle's *Observing and Measuring Visual Double Stars*, the Celestron instructions, and a tutorial I found on the web site of the Italian double star publication *Il Bollettine delle Stelle Doppie*, I had enough information to get started. There were some initial frustrations with the drift method (I ended up using information from the *Stelle Doppie* tutorial to resolve that), and also with establishing a scale constant for the linear scale (I highly recommend against using the stop watch feature on a cell phone for the timings). After twenty timings of ε Cassiopeiae to establish a scale constant using the equipment described in the notes below for Table 3, and some practice on a few stars, I was ready for 31 Aquilae.

Micro-metric Astrometric Results

Table 3 shows the measurements I obtained in September and October of 2012.

The big question in my mind, since this was my first concerted attempt to measure both position angles and separations, was how accurate my measurements were. Steve has worked in the past with Dr. J.D. Armstrong of the Faulkes Telescope Project (FTN), so the plan was to use the Two Meter Faulkes Telescope North to image and measure 31 Aquilae.

That particular telescope is located on the 10,000 foot summit of Mt. Haleakala, a dormant volcano on Maui, which is a site blessed with abundant clear dark skies and excellent seeing. The FTN is one of the telescopes in the Las Cumbres Observatory Global Telescope (LCOGT) network. In addition to the FTN, there is a matching 2-meter telescope, Faulkes Telescope South (FTS), which is located at Siding Springs Observatory, Australia.

(More than a dozen 1-meter telescopes and approximately two dozen 0.4-meter telescopes are being designed, built, and installed by LCOGT at diverse longitude and latitude locations around the globe to conduct research in "time-domain" astrophysics. Objects can be kept under constant surveillance around the clock as they are automatically passed from one identical telescope to another as the Earth turns. All of the telescopes in the network will be fully robotic and well instrumented including high speed, low noise EMCCD cameras that can be used for lucky imaging or speckle

Table 4: Measurements of J.D. Armstrong

NAME	RA DEC	MAGS	PA	SEP	DATE	N
STT 588 AB	19250+1157	5.2 8.7	283.94	104.92	2012.844	1
STT 588 AC	19250+1157	5.2 10.3	278.63	147.65	2012.844	1
COM 7 AD	19250+1157	5.2 10.3	189.01	124.64	2012.844	1

Notes

1. Photometric observations made with the Two Meter Faulkes Telescope North.

interferometry of double stars as well as spectrographs on the 1- and 2-meter telescopes).

The measurements with the FTN were accomplished on November 3, 2012 and yielded the following data shown in Table 4.

In comparing my figures with the photometric results obtained with the Faulkes Telescope North, I was rather pleased, especially with the position angles, which showed an improvement in accuracy after my initial efforts with the AB pair. The separation of the AC pair stands out as the one figure most in need of a second look, so I have plans to measure the separation once again in the summer of 2013. In fact, considering the changes in AB and AC in the three and four years between the WDS figures and the Faulkes measurements, it could be interesting to measure them again in August of 2013 to see how much change has taken place over the course of a year. The rapid proper motion of the primary appears to make a significant difference in the visual alignment of 31 Aquilae's components in a relatively brief period of time.

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(Tutorial for Celestron astrometric eyepiece): https://sites.google.com/site/ilbollettinodellestelledoppie/tutorial

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Nanson, John., 2012, "A Radiant Study in Stellar Contrasts: 28 and 31 Aquilae", Bestdoubles.wordpress.com

Part 1: http://wp.me/pVYaT-178

Part 2: http://wp.me/pVYaT-17j

Observing and Measuring Visual Double Stars, Bob Argyle (editor), Springer Verlag, New York 2004.

Web Sites

Faulkes Telescope Project: http://www.faulkes-telescope.com/

Simbad and Aladin web site: http://cds.u-strasbg.fr/

Link to Aladin plot of 31 Aquilae: http://simbad.u-strasbg.fr/simbad/sim-plot?target=_BLANK&ident=*+b+Aql&coo=19+24+58.20027%2B11+56+39.8862&radius.unit=arcmin&x=58&y=90&radius=10

Star Splitters: http://bestdoubles.wordpress.com/

Two New Double Stars from Lunar Occultations: SAO 117948 and TYC 1310-16-1

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Abstract: Lunar occultation observations by the author in March 2013 detected two new double stars SAO 117948 and TYC 1310-16-1.

SAO 117948

On March 24, 2013 a lunar occultation of SAO 117948 was video-recorded at 25 frames/sec using a 40 cm telescope. The moon was 90% illuminated, resulting in significant background noise in the video recording. Figure one shows the recorded light curve.

Given the noise levels in the measured light curve, the video was carefully inspected on a frame-by-frame basis to confirm that the step event at around frame 110 was ‘real’. The duration of the step event was 0.36 secs. With the radial velocity of the moon at the location of the occultation (at position angle 69.7 degrees) being 0.2457”/second, the separation of the components of this star is at least 0.09”. The magnitudes of SAO 117948 are 10.66 (BT) and 9.78 (VT), and from the heights of the three portions of the light curve the V magnitudes of the components are derived as 10.3 and 10.9 – with the fainter component being occulted first.

The Lunar Occultation Archive (VizieR Catalogue number VI/132A) was reviewed to ascertain whether there were any earlier occultation observations of this star that indicated the star was double. There are only 8 prior lunar occultation observations – four on 1975 June 14, two on 1993 April 3, and one each on 1995 May 8 and June 5. All observations were observed visually, and involved disappearance events at position angles between 59 and 161 deg. There is no indication of double star phenomena in any of the reports, which is not surprising since the disappearance of the fainter

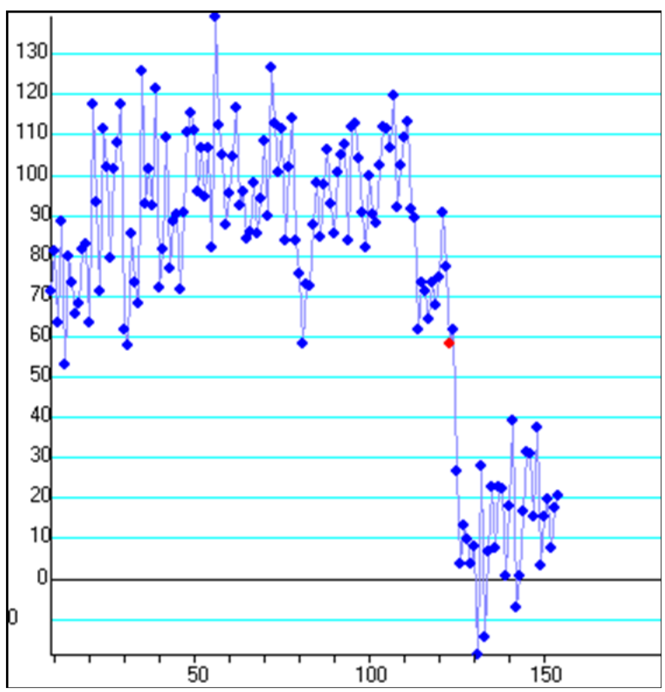

Figure 1. Light curve of SAO 117948 recorded during a lunar occultation.

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star before the brighter star would not have been readily seen by a visual observer.

Star SAO 117948 = TYC 828-1185-1 = PPM 156256 = 4UCAC 493-55268

Coordinates(J2000)	9h51m27.43s, +8º30'03.2"
Spectral type	G5
Mag A	10.3 ±0.1 (V)
Mag B	10.9 ±0.1 (V)
Epoch	2013.23
Separation	>0.09"
PA at epoch	between 160 and 340 deg

TYC 1310-16-1

On March 9, 2013, a lunar occultation of TYC 1310-16-1 was video-recorded at 25 frames/sec using a 40 cm telescope. This is the first time this star has been observed in lunar occultation. The moon was 47% illuminated. Despite the moon's altitude being a relatively low 13 degrees, a good recording was obtained. The resulting light curve is shown in Figure 2.

The intermediate step duration lasted 0.64 secs. With the radial velocity of the moon at the location of the occultation (at position angle 79.8 degrees) being 0.363"/second, the separation of the components of this star is at least 0.23". The magnitudes of TYC 1310-16-1 are 10.50 (BT) and 9.58 (VT), and from the heights of the three portions of the light curve the V magnitudes of the components are derived as 10.0 and 10.5 – with the fainter component being occulted first.

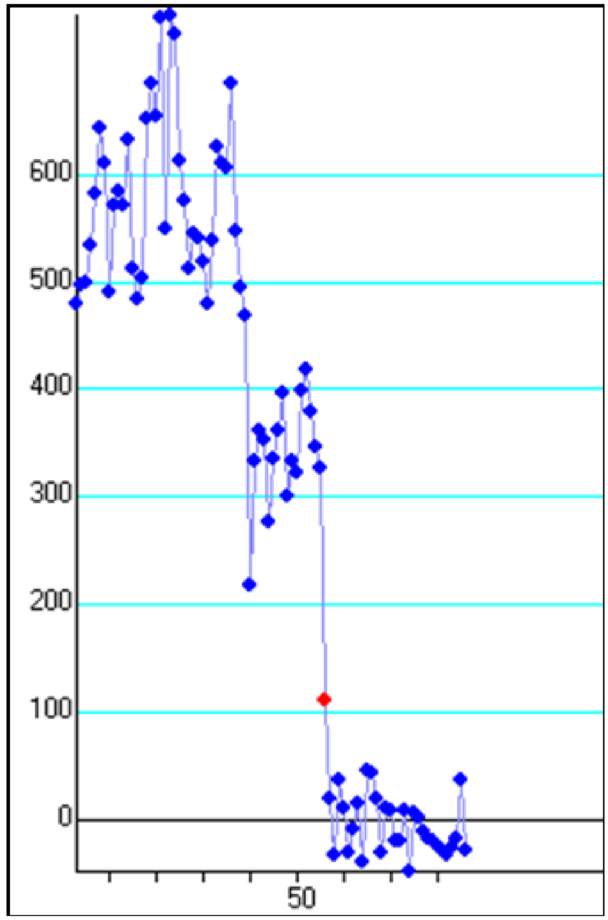

Figure 2. Light curve of TYC 1310-16-1 during a lunar occultation.

Star TYC 1310-16-1 = XZ 76885 = 4UCAC 555-18614

Coordinates (J2000)	5h 42m 25.69s, +20º 51' 19.0"
Spectral type	unknown
Mag A	10.0 ±0.1 (V)
Mag B	10.5 ±0.1 (V)
Epoch	2013.21
Separation	>0.23"
PA at epoch	between 170 and 350 deg

A New Visual Binary System in Orion

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Abstract: Presented in this paper is a brand new visual binary system in Orion that is not in the current WDS catalog, the components of which show orbital motion. From three sets of historical measurements, V, J and K-band photometry, and a calibrated distance of the system based on common proper motions, a provisional orbit is determined that appears to fit the observations remarkably well.

The system was first identified in June 2013 on image plates taken during the Palomar Observatory Sky Surveys (POSS) and then assessed against various methods adopted by the author in recent papers in order to determine binarity. The components bear no formal designations in major catalogs, being of obscure brightness of approximate V mags 11.8 and 13.0 [1]. The pair resides in the northern part of Constellation Orion, at 2000.0 ICRS: 05 30 01.66, +12 07 26.5.

Individual FITS images were obtained from each of three POSS surveys for epochs 1954-11-03, 1989-11-30 and 1997-11-07, as shown in Figures 1 (a), (b) through (c) below. From these images, three pairs of positional measures (θ° , ρ″) were found, as shown in Table 1.

Table 1 – Historical astrometry

Epoch:	θ	ρ
1954.841	45°.2	11″.23
1989.914	46°.3	11″.58
1997.851	47°.9	11″.95

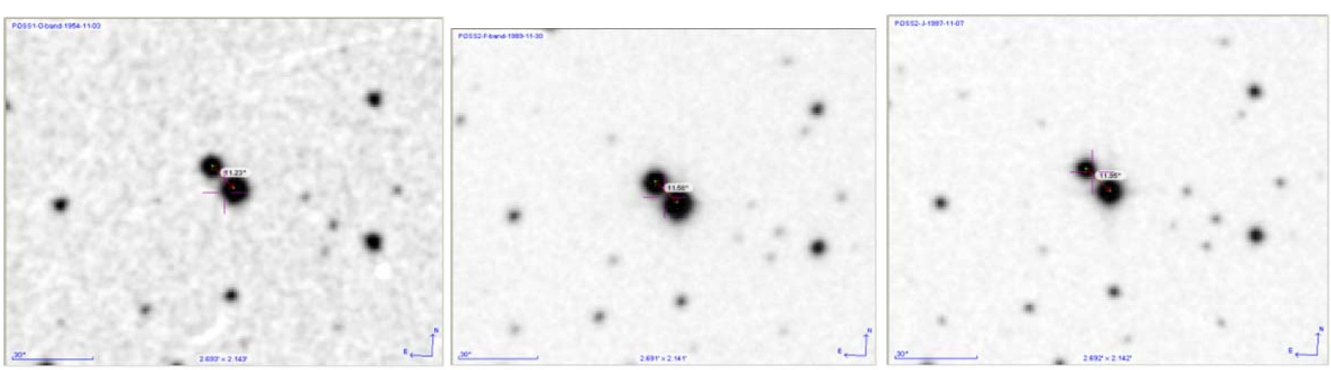

Figure 1 (a), (b), (c) – Images from POSS I & POSS II surveys.

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Table 2: Proper motion of the components

	μ_α	μ_δ
A-component	+54.8 mas/yr	-72.3 mas/yr
B-component	+56.2 mas/yr	-69.8 mas/yr

Table 3: J and K band photometry and Color Indices

	J	K	Color Index (J - K)
A-component	+9.653	+8.924	+0.73
B-component	+10.253	+9.406	+0.85

Derivation of Astrophysical Properties

From the UCAC4 Catalog [2], we find the two stars share similar proper motions in both RA and Dec as shown in Table 2.

The system, as a whole, therefore has a total proper motion of: $\{ [(54.8)^2 + (-72.3)^2]^{½} + [(56.2)^2 + (-69.8)^2]^{½} \} / 2 = 90.2$ milliarcseconds per year. This suggests a distance in the region of something like 100 light-years, which may be taken as a reasonable baseline assumption for determining astrophysical properties.

From the 2MASS Catalog [3], we find J and K-band magnitudes for the two components shown in Table 3.

As illustrated in previous papers [4], these 2MASS color indices (J – K) would categorize the components of this system into a pair of red dwarves of fractional solar masses each, of likely spectral types of ~M0V and ~M2V, respectively. From a combination of their distance moduli, observed apparent visual brightnesses, and the colors determined from 2MASS J and K magnitudes as shown above, we can infer estimates for masses of the two stars in the region of approximately 0.6 and 0.4 solar masses, respectively. By way of comparisons to stellar yardsticks that have been better studied, the secondary red dwarf component of the 61 Cygni binary system (61 Cygni B) and the singular red dwarf Lalande 21185 are stars of comparable mass and luminosity to the components of this Orion binary, which are located much nearer to us in the Solar neighborhood, and they are of equivalent masses of about 0.6 and 0.4 solar masses, respectively. If both 61 Cygni B and Lalande 21185 were projected out to a distance of some 100 to 150 light-years and placed next to each other, they would broadly be expected to shine at similar brightnesses as the two component stars of this Orion binary. We can therefore approximate a total system mass for this Orion binary at circa 1.0 solar mass overall.

Projection of the Apparent Orbit

Since the pair is proven to be moving across the sky in tandem, with common proper motions, the resultant changes in (θ^o , ρ") can only be properly attributed to orbital motion.

From the stated positional measures at each of the three epochs of t_1=1954.841, t_2=1989.914 and t_3=1997.851 stated in Table 1, a preliminary outline of the apparent orbit may be projected as in Figure 2.

From the diagram, it can be seen that the semi-major axis of the apparent orbit, a, is certain to lie close to the ρ" values and it may be taken as a = 10" as an approximation for the purposes of a preliminary orbit. At a projected distance of this binary of circa 100 light-years, the linear value of the length of the semi-major axis of the orbit ellipse would be: Tan 10" x 63240 x 100, which comes to ~306 Astronomical Units. Since we have already made a baseline deduction as to the sum of the masses of the two stars in this system, we are then in a position to obtain a provisional estimate of the orbital period, P, from the expression:

$$P = \frac{4\pi a^{3/2}}{\sqrt{GM}}$$

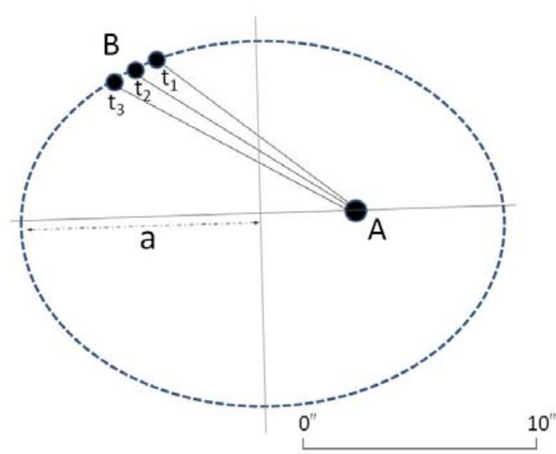

Figure 2 – Projection of the apparent orbit ellipse

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Substituting a = 306 AUs and a value for the gravitational constant, G, of 158.0, yields an orbital period of revolution, P, of 5,351 years. We have thus determined two out of the seven orbital elements required to completely specify the apparent orbit of this binary system in the sky. We do not have values for the orbital eccentricity, e, nor do we have any value for the angular inclination, i, to the line of sight. However, if we assume a circular orbit (e = 0) projected at 90^o to the line of sight (i = 90^o), the full orbit circumference of the apparent projected orbit would be 2 x π x 10" = 62".8. Thus in the 43-year interval between the first POSS survey (t1) and the last POSS survey (t3), we expect the B-component to have travelled by: (43/5351) x 62".8 = 0".50 along the length of its orbit about the primary. This is in close agreement with the observed difference of the separations: $\rho_3 - \rho_1$ = 11".95 – 11".23 = 0".72. Similarly, the projected change in the position angle, θ, between t_1 and t_3 ought to be: (43/5351) x 360^o = $2^o.9$. This again is in close agreement with the actual observed changes in θ: $\theta_3 - \theta_1 = 47^o.9 - 45^o.2 = 2^o.7$.

Conclusions

The apparent orbit, determined from just three pairs of measures in the limited timescale of this study in relation to the five-millennia long orbital period, is a reasonably good fit to the observations of this system at the current time. Further observations will help to refine the apparent orbit, lead to a better approximation of the masses of the system and enable a full determination of the true orbit in 3D space.

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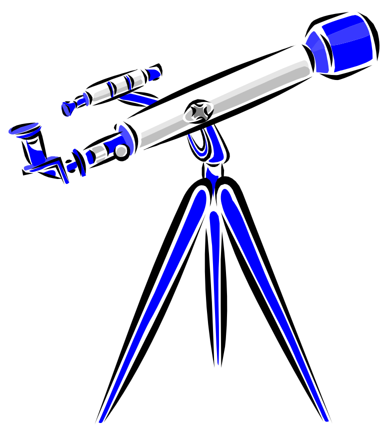

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