

Astronomical Association of Queensland Program of Measurements of Seven Southern Multiple Stars

Graeme Jenkinson

Astronomical Association of Queensland.
bluestars@iprimus.com.au

Abstract: This paper presents the results of a mid-2014 program of the Astronomical Association of Queensland of photographic measurements of seven southern multiple stars. The images were obtained using a Meade DSI CCD camera in conjunction with an equatorially mounted 150mm F8 refractor. For each target pair, either a 2x or 5x barlow lens was used as required. Image processing was carried out using Losse's REDUC software.

Introduction

These latest results are part of an ongoing program commenced in 2008 by the Double Star Section of the Astronomical Association of Queensland. The target stars were selected from the Washington Double Star Catalog (WDSC) and were observed in Queensland from a latitude of approximately 27° S.

Method

Once obtained with the equipment described above, the images were analyzed using the astrometric double star program REDUC (Losse, 2008). Approximately 10 stacked images of each target were taken per night for seven nights and the results averaged to obtain measures of separation and position angle with sufficient confidence.

Full details of the method are given in Napier-Munn and Jenkinson (2009). Some recent work on the errors inherent in the method is described in Napier-Munn and Jenkinson (2014). The images were obtained using a Meade DSI CCD camera in conjunction with an

equatorially mounted 150mm F8 refractor. For each target pair, either a 2x or 5x barlow lens was used as required. As proficiency has grown in the use of this equipment with the 150mm refractor, close doubles with considerable magnitude difference between the components have been successfully measured.

Results

For all of the systems the WDSC information is first reproduced, showing the epoch 2000 position, magnitudes, separation, PA, and the last recorded measurement. The new measurements are then given in tabular form (Tables 2 - 8), including the mean and standard deviation and 95% confidence limits. Any uncertainties between the images and the last recorded measurements are discussed. Finally a conclusion is given as to whether any movement of the component stars has occurred in PA or separation, based on the P-value for the t-test comparing the new mean values with the cataloged value ($P < 0.05$ is considered as evidence of change).

Table 1. Summary of Measurements of Seven Multiple Stars

System	Last listed measure			New measure			Comment
	PA °	Sep. "	Epoch	PA °	Sep. "	Epoch*	
B2350 Libra	202.0	9.3	1999	203.70	9.34	2014.335	Slow movement
HO554A-B Oph.	359.0	9.8	1904	355.89	9.59	2014.502	Definite change in PA
HO554A-C Oph	350.0	35.3	1999	350.08	35.94	2014.502	Possible increase in sep.
I 428 Circinus	315.0	11.0	2000	314.77	11.13	2014.330	No probable movement
I 1282 Scorpius	248.0	12.1	1998	251.39	12.70	2014.461	Definite change in PA
SEE114A-B Antlia	298.0	47.3	1999	298.57	52.58	2014.239	Changes since 1 st measure
SEE234 Lupus	38.0	13.0	1999	37.04	13.33	2014.384	Little change

* Epochs of new measures given in Besselian years as the average of the observations making up the measure.

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The mean 95% confidence intervals for the new measures were $\pm 0^{\circ}.305$ in PA and $\pm 0^{\circ}.082$ in separation. The results are presented in Table 1.

Acknowledgements

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

References

Losse F., Reduc software, V4.5.1. <http://www.astrosurf.com/hfosaf/uk/t/download.htm>

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Table 2. Measurements of B 2350

B2350 Libra	RA. 15 09.9	DEC. -23 59	Last Measure 1999
	MAG. 6.8 & 12.5	PA. 202.0°	SEP. 9.3"
Date	No. images	PA°	Sep"
19 Apr 2014	10	204.26	9.248
21 Apr 2014	10	203.13	9.352
23 Apr 2014	10	203.90	9.489
25 Apr 2014	10	203.80	9.376
03 May 2014	10	203.76	9.396
21 May 2014	10	203.75	9.340
24 May 2014	10	203.31	9.156
Mean		203.701	9.337
Standard dev.		0.376	0.107
95% CI +/-		0.347	0.099
P(t) movement		0.000	0.400
COMMENTS: Slow changes evident since the first measures in 1953 of 201° and 10.3"			

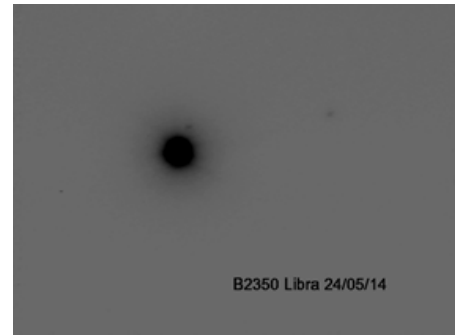
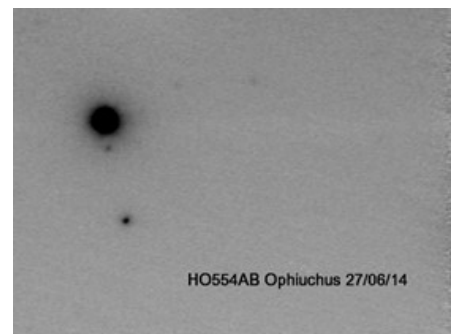


Table 3. Measurements of HO 554 AC

HO554A-C Ophiuchus	RA. 17 01.2	DEC. -29.41	Last Measure 1999
	MAG. 9.13 & 11.59	PA. 350.0°	SEP. 35.3"
Date	No. images	PA°	Sep"
27 June 2014	10	350.26	35.960
29 June 2014	10	350.20	35.893
30 June 2014	10	349.87	35.880
2 July 2014	10	349.73	36.003
3 July 2014	10	350.17	35.925
5 July 2014	10	350.12	35.972
8 July 2014	10	350.21	35.940
Mean		350.080	35.939
Standard dev.		0.200	0.044
95% CI +/-		0.185	0.040
P(t) movement		0.000	0.000
COMMENTS: A small increase in separation may have occurred in the last 15 years.			



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Table 4. Measurements of I 428

<u>I 428</u>	RA. 15 16.6	DEC. -60 54	Last Measure 2000
<u>Circinus</u>	MAG. 5.8 & 11.6	PA. 315.0°	SEP. 11.0"
<u>Date</u>	<u>No. images</u>	<u>PA°</u>	<u>Sep"</u>
18 Apr 2014	10	314.63	11.194
19 Apr 2014	10	314.60	11.097
21 Apr 2014	10	314.80	11.143
23 Apr 2014	10	314.86	11.041
25 Apr 2014	10	314.93	11.121
01 May 2014	10	314.43	11.071
17 May 2014	10	315.13	11.262
Mean		314.769	11.133
Standard dev.		0.234	0.076
95% CI +/-		0.216	0.070
P(t) movement		0.000	0.004
COMMENTS: No probable movement in the last 14 years.			

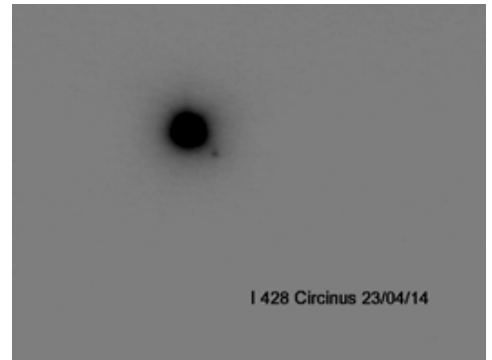
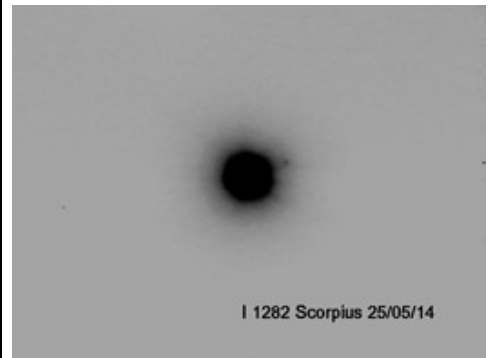


Table 5. Measurements of I 1282

<u>I 1282</u>	RA. 16 02.7	DEC. -29 08	Last Measure 1998
<u>Scorpius</u>	MAG. 6.03 & 13.0	PA. 248.0°	SEP. 12.1"
<u>Date</u>	<u>No. images</u>	<u>PA°</u>	<u>Sep"</u>
25 May 2014	10	251.51	12.966
18 June 2014	10	251.50	12.794
22 June 2014	10	251.35	12.592
25 June 2014	10	251.72	12.713
26 June 2014	10	251.82	12.728
27 June 2014	10	250.89	12.489
29 June 2014	10	250.96	12.611
Mean		251.393	12.699
Standard dev.		0.355	0.155
95% CI +/-		0.328	0.144
P(t) movement		0.000	0.000
COMMENTS: Definite movement in PA, small increase in separation possible.			



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Table 6. Measurements of SEE 114 AB

<u>SEE114 A-B</u>	RA. 09 31.6	DEC. -35 43	Last Measure 1999
<u>Antlia</u>	MAG. 6.0 & 12.8	PA. 298.0°	SEP. 47.3"
<u>Date</u>	<u>No. images</u>	<u>PA°</u>	<u>Sep"</u>
28 Feb 2014	10	298.67	52.616
7 Mar 2014	10	298.55	52.632
13 Mar 2014	10	298.51	52.682
29 Mar 2014	10	298.72	52.500
30 Mar 2014	10	298.52	52.610
31 Mar 2014	10	298.50	52.502
18 April 2014	10	298.51	52.543
Mean		298.569	52.584
Standard dev.		0.089	0.070
95% CI +/-		0.082	0.064
P(t) movement		0.000	0.000
<i>COMMENTS:</i> Considerable increase in separation since the first measure of 23.6" in 1897. Position angle has also increased from 283° at that time.			

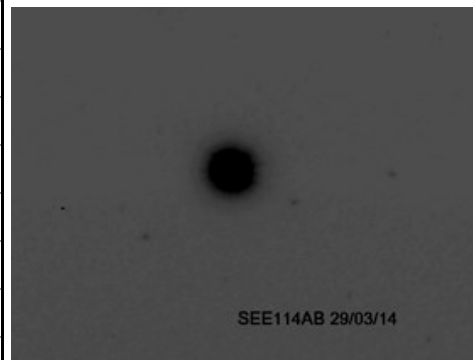
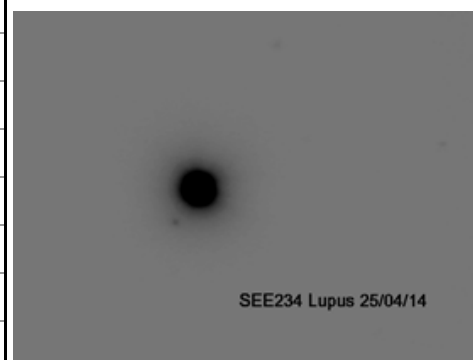


Table 7. Measurements of SEE 234

<u>SEE234</u>	RA. 15 28.5	DEC. -51 36	Last Measure 1999
<u>LUPUS</u>	MAG. 6.1 & 12.5	PA. 38.0°	SEP. 13.0"
<u>Date</u>	<u>No. images</u>	<u>PA°</u>	<u>Sep"</u>
25 Apr 2014	10	36.65	13.361
3 May 2014	10	37.90	13.319
21 May 2014	10	36.51	13.208
24 May 2014	10	36.87	13.463
25 May 2014	10	36.77	13.363
26 May 2014	10	37.55	13.251
7 June 2014	10	37.06	13.335
Mean		37.044	13.329
Standard deviation		0.506	0.083
95% CI +/-		0.468	0.076
P(t) movement		0.000	0.000
<i>COMMENTS:</i> Very slow changes since the first measure in 1897 of 31° and 14.0"			



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Table 8. Measurements of HO 554 AB

<u>HO554A-B</u>	RA. 17 01.2	DEC. -29 41	Last Measure 1904
<u>Ophiuchus</u>	MAG. 7.9 & 12.9	PA. 359.0°	SEP. 9.8"
<u>Date</u>	<u>No. images</u>	<u>PA°</u>	<u>Sep"</u>
27 June 2014	10	355.95	9.586
29 June 2014	10	356.39	9.545
30 June 2014	10	355.34	9.410
2 July 2014	10	355.43	9.648
3 July 2014	10	355.29	9.645
5 July 2014	10	356.67	9.634
8 July 2014	10	356.17	9.649
Mean		355.891	9.588
Standard deviation		0.550	0.088
95% CI +/-		0.509	0.081
P(t) movement		0.000	0.000
<i>COMMENTS:</i> Definite movement in PA and negligible change in separation in the last 110 years.			