Measurements of 208 Aitken Visual Binary Stars with a 280 mm Reflector

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Abstract: This paper presents the measurements of 208 visual binary stars discovered by R.G. Aitken and listed in the WDS catalog. These measurements were obtained between November 2016 and January 2017 with an 11" reflector telescope and an ASI 290MM CMOS-based camera. Binaries with a secondary component up to magnitude 15 and separation between 0.6 and 5 arcsec have been measured. Measurements were carried out on auto-correlograms computed on sequences of a thousand images. This approach allowed us to obtain reliable measurements for pairs with very large difference of magnitude (up to 6). A significant part of the observed pairs had not been observed in the previous decades and show significant movement compared to their last measurement. We also report the discovery of a yet unobserved component for the star A 2455 (WDS 06426+1937).

1. Introduction

Observing – and *a fortiori* measuring – Aitken double stars is notoriously difficult. These stars, listed with the "A" discoverer code in the Washington Double Star Catalog (WDS, [7]), often exhibit very small separation, faint companions and/or large delta mag. For example, among the 3494 Aitken pairs listed in the WDS, 1455 have a separation $\rho < 1$ arcsec and 796 a separation $\rho < 0.5$ arcsec; 1016 have a companion with mag > 12 and 1009 exhibit a delta mag > 3. As a result, these pairs are not frequently observed. As reported in the WDS[1], 2301 pairs (66%) have not been observed in the last decade and 1286 in the last two decades (37%). In the same catalog, 1878 pairs (54%) are listed with less than 10 observations in total. A consequence of this lack of observational data is the fact that only 56 Aitken pairs have a known orbit (as reported in the Nov 2016 edition of the Sixth Catalog of Orbits [9]). Aitken stars therefore make very interesting - but challenging - targets for the double star observer. Their distinctive features also provide an interesting testbed for the assessment of the most recent cameras with CMOS back-illuminated high-sensitivity sensors, such as the ASI 290MM model evaluated in our previous JDSO paper [4]. We devoted 10 nights, between November 2016 and January 2017 to this task. The result of this short observing campaign are reported in this paper.

2. Instrumental setup

The instrumental setup is the same as that described in [4]. The telescope is a 280 mm Schmidt-Cassegrain reflector (Celestron C11) and the camera an ASI 290MM from ZWO [3]. In the previous paper we showed that with this setup we could obtain reliable measurements down to $\rho = 0.5$ arcsec and $m_2 = 12$, with individual exposure times in the range 10-50 ms.

The main motivation for the work described here was to assess the extent to which the limit in magnitude could be pushed. The optical train - wheel filter + 2x barlow + ADC - is unchanged compared to that described in [4], giving a resulting plate scale of 0.095"/pixel. An L-band (400-700 nm) filter is systematically used in order to reach the faintest magnitudes possible. With this configuration, the use of an atmospheric dispersion corrector (ADC) is mandatory, especially for stars with a zenithal distance > 20°. Our ADC configuration allows a full correction up to $z = 45°$.

3. Image acquisition and reduction

As in [1,2,4], acquisition is carried out with the Genika Astro software [5]. The gain of the camera is set at 550 (range is 0 - 600). Exposure time for individual images range from 10 to 100 ms typically. For faintest stars ($mag > 14.5$), this time has been pushed to 150 ms

Only for the closest pairs (typically $\rho < 1$ arcsec) did we make several acquisitions and hence did compute an estimation of standard errors[2] on the measured

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separation and position angle. The corresponding measures are reported with these errors indicated after the ± symbol in Table 1.

A small number of pairs were observed more than two nights. The values reported in Table 1 are then obtained by averaging those obtained on each night (the observation dates never differed by more than 15 days). In this case, the total number of measurements reported in Table 1 is the sum of the numbers for each date (with the number of nights indicated between brackets.

Calibration is, as reported in [4], carried out by analyzing timed star drifts thanks to D. Rowe's Speckle Toolbox [6]. Precise timing of each frame is performed by the Genika software.

Image reduction is carried out with the Reduc software [8] using the pixel autocorrelation technique described in [1,2,4]. A master dark frame is first computed by averaging 50 dark frames taken with a fixed 40 ms exposure. We did experiments with separate dark frames for each distinct exposure time but did not notice a significant improvement. This can be explained by the fact that the exposure times are here sufficiently small so that thermal noise (the one that depends on integration time) is negligible compared to the other sources of noise (and in particular the photon shot noise). Dark subtraction is therefore essentially used here to remove permanent hot pixels (which do show at this very high gain setting). Pragmatically, using a single master dark also allows us to use Reduc in batch mode, which significantly reduces the burden of processing the acquired data. The master dark is then subtracted from all acquired frames and the autocorrelogram (AC) is computed on each sequence of 1000 frames. Each acquisition sequence is also sorted by quality so that a manual selection can be further performed in order to compute a direct image. All of these operations are carried out automatically using the Reduc *batch* mode. User intervention is only required for i) selecting the best frames from the quality sorted sequence and stack them in order to obtain the direct image ii) perform the post-processing filtering step[3] on the computed auto-correlogram and make the actual measurement by adjusting the size of the peak-matching area and registering its position.

Using an AC-based technique for measuring pairs with separation above the seeing limit may appear unnecessary. In fact, in many cases the companion is clearly visible on the image obtained by selection, shift and addition of a few dozen of best frames. But measuring on this direct image is often problematic for two reasons. First, in the case of faint companions, the image of the companion is often "spread out", which makes estimation of its relative position imprecise. This is illustrated, for example, with the images of A 1802 reproduced on Plate 1. Here, the auto-correlation peaks (right image), exhibit a much more regular and symetrical aspect than the direct image of the companion (left image). Second, in case of pairs with a large delta mag, the image of the primary component quickly gets overexposed which in turn can cause two problems: i) estimating the position of this primary becomes itself difficult because classical profile matching techniques do not work well with flattened overexposed profiles ii) the image of the companion can be hidden in the halo of the primary. In all these cases, we have found that the AC images were much more amenable to precise measurement either because the position of the primary does not depend on its luminosity (it is always centered on the middle of the frame, by construction) and/or the correlation peaks corresponding to the companion show a much more regular and smooth profile. This is for example illustrated with the images of A 1821 or A 918 on Plate 1.

4. Results

The reported measurements were obtained over 10 nights, between 2016-11-01 and 2017-01-06. The total number is 283 measures, concerning 208 binaries. Only one (A 1813AB,C) has a published orbit.

Figures 1, 2, 3, and 4 show the distribution of all measurements according to the magnitude of the primary and secondary component, their separation, and their difference in magnitude. Comparing these results with those reported in [4] (obtained with the same instrumental setup and camera) immediately shows that our previous estimation of the magnitude limits - at least for pairs with a separation greater than 1 arcsec - was greatly underestimated. The histogram of Figure 4 also shows that many pairs with so-called "large" delta mag (≥ 3, typically), which are often neglected because viewed as "too difficult", are indeed accessible.

The measures themselves are listed in Table 1. As indicated in Section 3, the values for the position angle (PA) and separation (SEP) are given with their corresponding standard errors when the latter can be computed. These errors were derived, as described in Section 3, from n distinct measures, where n is given in column 9 ("N"). A selection of reduced images from which the measures were obtained in given in Plate 1.

(Text continues on page 443)

2. Standard errors are computed, classically, by dividing the standard deviations by the square root of the total number of measurements.

3. Practically, this means selecting the size of the 2D mean-rejection filter which is used by Reduc to remove the "halo" around the center of the auto-correlogram and improve peak detection.

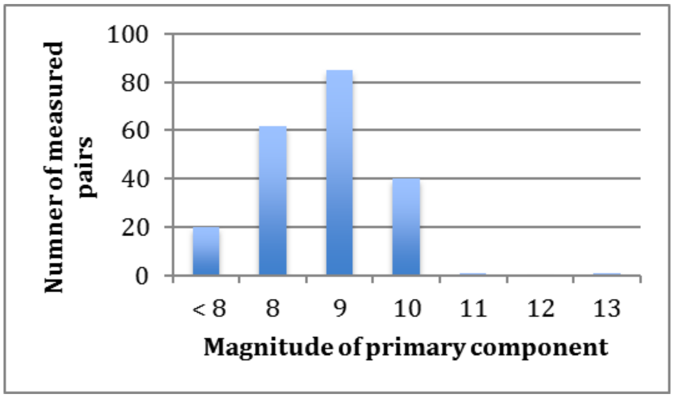


Figure 1. Distribution of measurements according to the magnitude of the primary component.

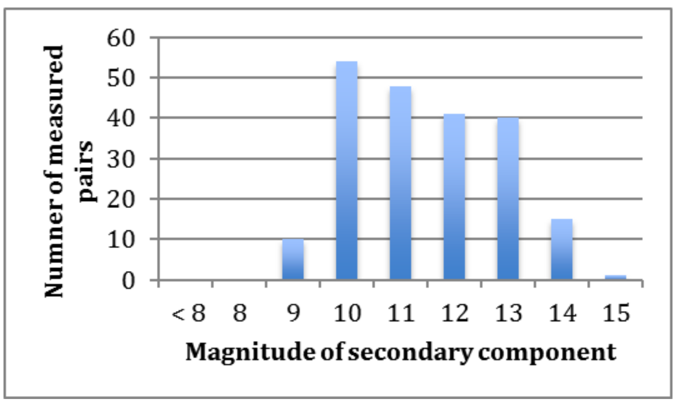


Figure 2. Distribution of measurements according to the magnitude of the secondary component

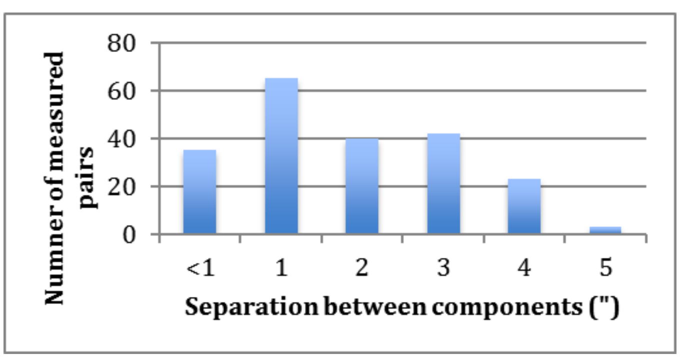


Figure 3. Distribution of measurements according to the separation of components.

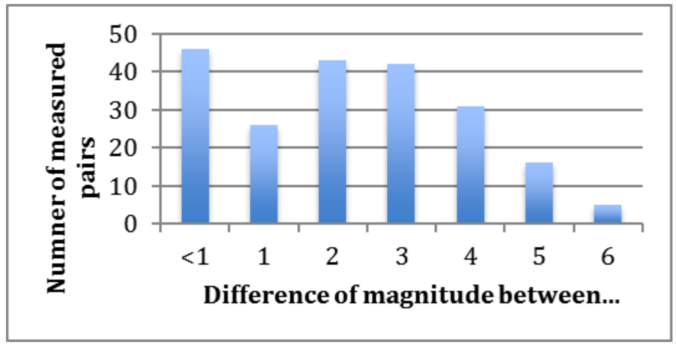


Figure 4. Distribution of measurements according to the difference in magnitude between the components

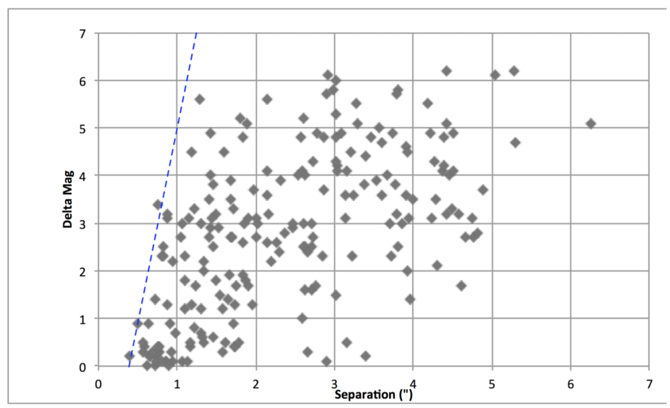
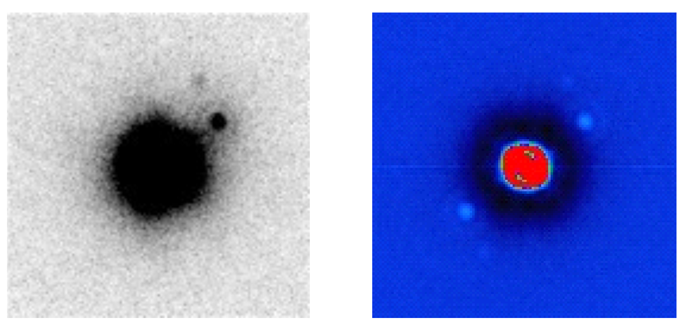


Figure 5. Plot of the all observations with the separation as X and the difference in magnitude of the two components as Y.



A 2455 (06426+1937) - 2016-12-09

Figure 6. Images of A 2455 (WDS 06426+1937) showing the new companion in Q4. Left: co-addition of 200 best frames; Right: auto-correlogram computed on 1000 frames. North is up, East is to the left.

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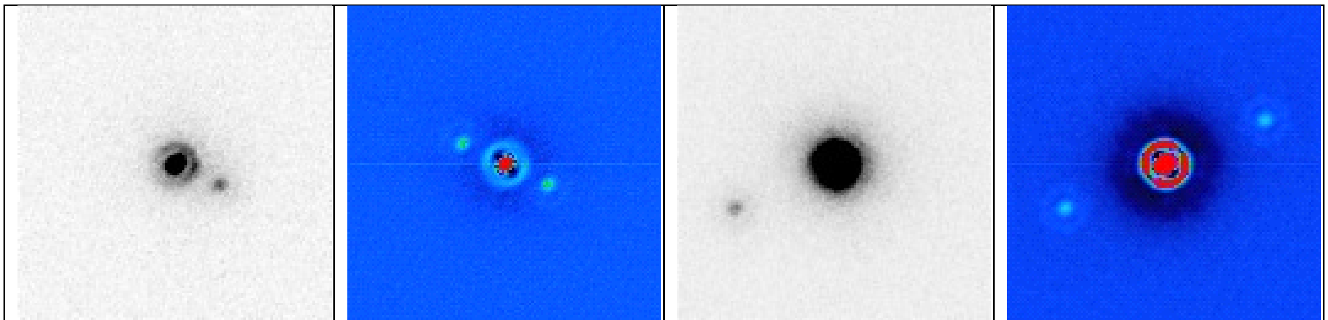
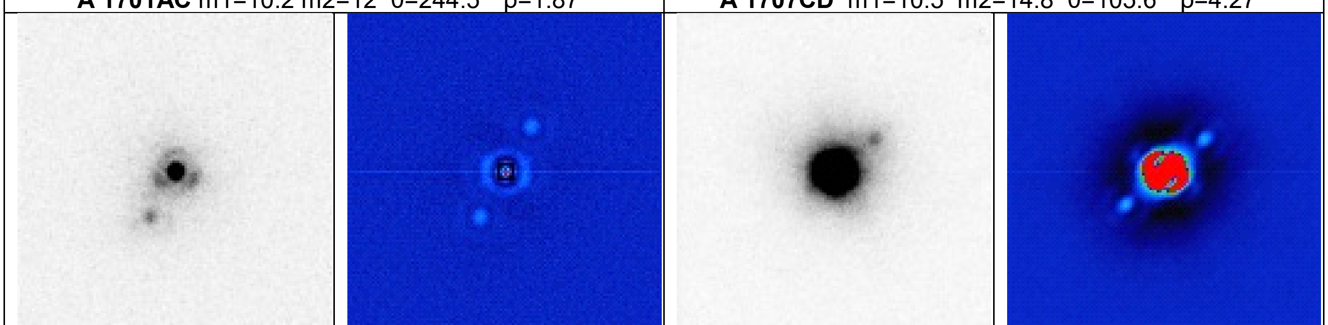
Plate 1 – Examples of images after reduction

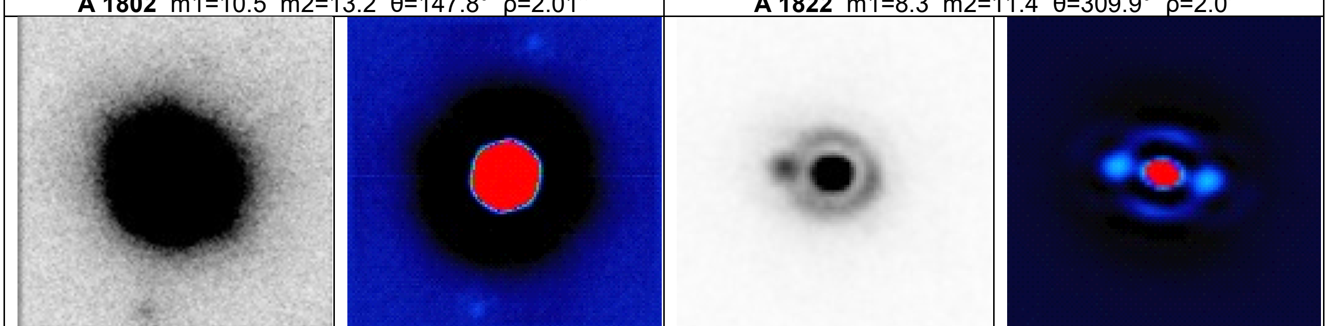
(left : co-addition of 30-200 best frames, right : auto-correlogram computed on 1000 frames. N up, E left)



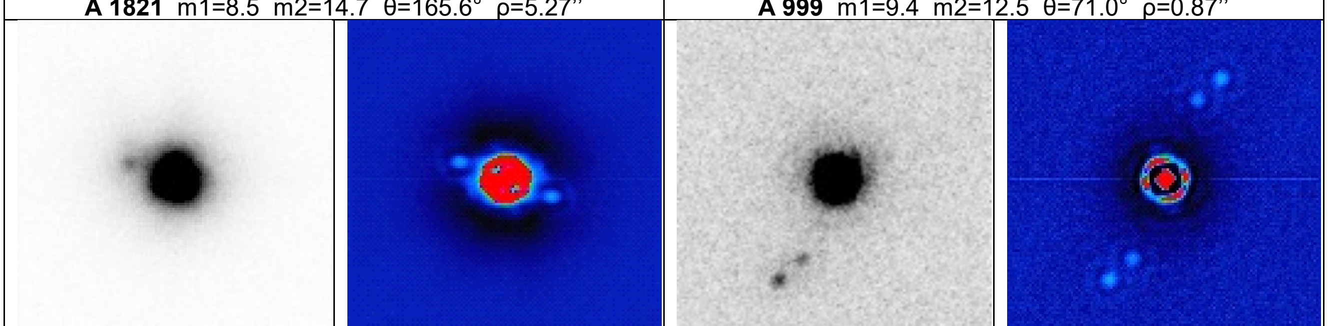
30 x 60ms	1000 x 60 ms	100 x 150ms	1000 x 150 ms
A 1701AC m1=10.2 m2=12 θ=244.5° ρ=1.87''		**A 1707CD** m1=10.5 m2=14.8 θ=105.6° ρ=4.27''	



50 x 60ms	1000 x 60 ms	50 x 40ms	1000 x 40 ms
A 1802 m1=10.5 m2=13.2 θ=147.8° ρ=2.01''		**A 1822** m1=8.3 m2=11.4 θ=309.9° ρ=2.0'	



200 x 100ms	1000 x 100 ms	50 x 60 ms	1000 x 60 ms
A 1821 m1=8.5 m2=14.7 θ=165.6° ρ=5.27''		**A 999** m1=9.4 m2=12.5 θ=71.0° ρ=0.87''	



100 x 80 ms	1000 x 80 ms	50 x 80 ms	1000 x 80 ms
A 918 m1=8.7 m2=13.8 θ=64.4° ρ=1.89''		**A 963BC** m1=13.3 m2=13.7 θ=301.8° ρ=1.17''	

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Table 1. Measurements

NAME	WDS ID	M1	M2	DATE2	PA (°)	SEP (arcsec)	DATE	N	NOTES
A 1499	00026+5534	8.4	9.9	1995	209.2	1.55	2016.929	1	
A 1253	00076+5246	7.7	11.2	1991	83.1	4.00	2016.929	1	
A 2201AB	00137+1838	8.2	11.3	1991	199.4 ± 0.65	1.15 ± 0.009	2016.953	2	
A 1802	00141+1207	10.5	13.2	2006	147.8	2.01	2016.953	1	
A 1804	00174+1002	9.2	10.4	2005	26.6	1.30	2016.953	1	
A 1805	00240+0955	9.9	13	2000	316.	4.74	2016.953	1	
A 2301	00254+2036	8.9	11.2	2001	228.4	2.84	2016.953	1	
A 805	00291+1119	8	14.2	2000	307.9	4.43	2016.929	1	1
A 806CD	00355+1150	10.9	13.9	1932	235.9	1.31	2016.929	1	
A 2302	00380+0234	10.1	10.2	1994	153.6 ± 0.03	0.74 ± 0.001	2016.929	4	
A 1806	00403+0517	9.8	12.9	2000	18.4	3.13	2016.929	1	
A 2204	00415+1731	10.1	11.3	2001	340.4	1.09	2016.953	1	
A 917	00428+2924	10.4	11.1	2001	118.6	1.31	2016.953	1	
A 2304	00429+0051	10.1	12.5	1996	73.	2.29	2016.929	1	
A 810	00434+1136	9.3	14.6	1933	314.2	3.02	2016.953	1	
A 1807	00438+0529	10.1	11.7	2002	153.4	2.62	2016.953	1	
A 918	00440+5436	8.7	13.8	1964	64.4	1.89	2017	1	
A 2305	00442+0229	10.2	10.8	2000	2.3	1.32	2016.929	1	
A 2206	00466+2013	8.7	11.9	1997	293.7	4.57	2016.953	1	
A 920	00469+1232	8.9	11.5	1966	231.1	1.84	2016.953	1	
A 1509AB	00516+3925	9.8	9.8	2008	26.8 ± 1.43	0.72 ± 0.006	2016.953	2	
A 1509AC	00516+3925	9.8	14.9	1929	334.1	6.26	2016.953	1	
A 1901	00523-0022	9.4	10.8	2000	311.7 ± 0.86	0.72 ± 0.006	2016.929	3	
A 2207	00530+1806	9.1	12.3	2000	164.8	3.78	2016.929	1	
A 2208	00549+1928	9.3	10.5	2001	91.3	1.57	2016.929	1	
A 1511	00554+4023	6.9	11.4	2002	43.4	1.19	2017	1	
A 925	00587+4457	7.7	10.4	1994	108.6	1.04	2016.953	1	
A 1513	01015+3936	10	12.3	2002	298.6	3.72	2017	1	
A 2309	01036+0313	10.4	13.1	1934	60.8	1.69	2017	1	
A 2004	01038+0646	7.1	10.4	1996	242.5	1.72	2017	1	
A 2312	01100+0305	9.6	12.8	1954	311.	0.88	2017	1	
A 2103	01163+1015	9.1	12.4	2000	184.2	4.49	2017	1	
A 1520	01167+4028	9.5	11	2002	238.9	3.01	2017	1	
A 2211	01204+0931	8.7	12.7	1967	359.1	2.63	2017	1	
A 1906	01216+2123	9.5	12.3	2004	38.2	4.82	2017	1	
A 938	01219+4717	7.9	11	2002	290.1	3.94	2017	1	
A 1263	01254+4405	9.7	12.8	2002	211.7	4.23	2017	1	
A 1907	01257+3621	7.8	13.4	1932	220.1	2.14	2017	1	
A 2316	01285+0338	9.7	13.4	2000	65.9	4.88	2017	1	
A 941AB	01286+4509	8.6	11.5	1991	242.4	1.43	2017	1	
A 941CD	01286+4509	10.9	11.2	1994	358.3 ± 0.41	0.77 ± 0.004	2017	4	
A 2214	01292+2004	10	10.2	1999	215.6	0.74	2017	1	
A 2318	01305+0258	8.9	12.5	1991	156.9	3.60	2016.915	1	
A 2215	01322+1142	9.1	11.8	1987	356.	1.68	2016.915	1	
A 2401	01351+0145	9.8	12.1	1951	338.1	1.10	2016.915	1	

Table 1 continues on next page.

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Table 1(continued). Measurements

NAME	WDS ID	M1	M2	DATE2	PA (°)	SEP (arcsec)	DATE	N	NOTES
A 2402	01364+0347	8.5	14.2	1933	318.6 ± 0.02	3.79 ± 0.065	2016.915	2	
A 817	01372+4843	10	9.1	1999	17.95 ± 1.20	0.5 ± 0.005	2016.9945	9 (2)	
A 2319	01374+1955	10.4	10.7	2006	201.7	0.92	2016.989	1	
A 1265CD	01376+5511	10.8	11	1991	352.9 ± 1.88	0.39 ± 0.000	2017	5	
A 2007	01379+2554	8.7	10.4	2003	220.2	4.61	2016.989	1	
A 1915	01391-0048	9.9	10.1	1991	267 ± 0.54	0.66 ± 0.007	2017	4	
A 2405	01459+0411	10.6	10.7	1991	226.7 ± 0.33	0.86 ± 0.016	2017	2	
A 1811	01547+3801	8.7	11.9	1997	93.4	1.50	2017	1	
A 2323	01548+1728	9.5	10.8	2001	146.2	1.74	2017	1	
A 1525	01564+4243	9.6	11.3	1991	209.3	1.23	2017	1	
A 2011	01584+2547	8.8	13.7	1987	296.6	3.74	2017	1	
A 2410	01594+0258	10.2	12.6	1937	221.1	2.66	2017	1	
A 1812AB	02003+3738	8.2	13.9	1929	236.2	2.90	2016.929	1	
A 1921	02009+5258	9.6	9.7	2007	66.5	2.90	2016.989	1	
A 820	02018+4738	9.7	12.7	1991	246.3	2.02	2016.915	1	
A 2216	02021+1211	8.6	10.5	2002	143.3	1.66	2016.989	1	
A 1924	02021+3347	10.6	10.9	2008	160.6	0.56	2016.915	1	
A 1813AB,C	02022+3643	8.2	11.1	2009	198.2	1.52	2016.915	1	10
A 1925	02035+3422	9.3	12.3	1991	230.5	3.70	2016.915	1	
A 205	02144+3946	9	10.7	2001	310.3 ± 0.10	1.75 ± 0.000	2016.922	2 (2)	
A 1271	02169+5328	9	11.7	1998	349.2	4.67	2016.915	1	
A 959AB	02180+3116	9.2	12.2	2011	3.9	3.85	2016.915	1	
A 1273	02180+5614	8.9	12.5	1999	335.6	3.91	2016.915	1	
A 1701	02210+4239	10.2	12	1991	244.5	1.87	2016.915	1	
A 963AB	02227+5705	9.3	13.3	1999	142.5	4.45	2016.929	1	2
A 963BC	02227+5705	13.3	13.7	1953	301.8	1.17	2016.929	1	2
A 658	02279+4129	9.3	10.9	2002	212.1	2.70	2016.989	1	
A 1815	02282+3850	6.9	10.8	1970	156.1	1.68	2016.929	1	7
A 1817	02294+4000	9.4	11.9	1929	228.9	2.71	2016.929	1	
A 2017	02297+0453	9.2	13.1	1946	65.7	3.53	2016.953	1	
A 2019	02300+0632	10.1	10.6	2000	251.2	1.34	2016.953	1	
A 966	02300+4649	9.8	12	1991	320.5	2.19	2016.929	1	
A 967	02304+4526	7.3	12.8	1927	220.1	4.18	2016.915	1	
A 2332	02313+0131	8.3	13.1	1930	149.5	3.47	2016.953	1	
A 968	02313+4703	9	9.4	2009	26.1	1.74	2016.989	1	
A 2218	02344+2040	9.2	13.3	1972	114.2	2.15	2016.929	1	
A 2021	02352+0649	9	13.8	2000	16.9	4.39	2016.953	1	
A 2336	02392+0343	8.8	12.5	1978	313.3	2.86	2016.953	1	
A 2337AB	02414+0426	6.9	12.7	1955	252.7	2.99	2016.953	1	
A 826	02448+3129	9.2	12.4	2001	164.3	4.42	2016.953	1	
A 2024	02459+0714	8.7	11.4	1978	234.4	1.41	2016.929	1	
A 1821AB	02471+3744	8.5	14.7	1999	165.6	5.27	2016.953	1	
A 2222AB	02473+1717	8.6	13.5	1961	302.7	4.50	2016.929	1	8
A 1822	02496+3648	8.3	11.4	1991	309.9	2.00	2016.915	1	
A 2340	02522+0352	10	10	1991	37.4 ± 0.42	0.61 ± 0.009	2016.929	4	

Table 1 continues on next page.

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Table 1(continued). Measurements

NAME	WDS ID	M1	M2	DATE2	PA (°)	SEP (arcsec)	DATE	N	NOTES
A 1929	02542+2658	9.4	14.2	1930	301.7	3.02	2016.915	1	
A 2341BC	02544+0946	10.1	10.7	2000	4.1	1.46	2016.929	1	
A 1823	02550+3644	8.5	13.4	1987	162.6	3.08	2016.915	1	
A 2415	03024+0238	10.5	10.8	2000	246.4	2.66	2016.934	1	
A 1284	03077-0032	9.5	11.6	1999	35.5	4.31	2016.934	1	
A 2031	03112+0710	8.3	13.2	1933	249.2	1.42	2016.953	1	
A 828	03143+0911	10.3	11.1	1991	204.3	1.22	2016.929	1	
A 1285	03164-0025	10.4	10.9	2001	288.8 ± 0.00	1.79 ± 0.000	2016.9435	2 (2)	
A 2032	03168+0501	9.3	11.8	1991	270.	2.62	2016.929	1	
A 2032	03168+0501	9.3	11.8	1991	269.8	2.61	2016.934	1	
A 1705	03211+4322	9.9	10.1	2008	187.7	3.40	2016.915	1	6
A 2343	03233+1634	8.5	13.2	1989	15.6	5.29	2016.915	1	
A 1287	03247+4046	7.8	13.8	1931	94.5	3.02	2016.915	1	4
A 979	03258+3044	10.1	11	1999	268.4	1.72	2016.915	1	
A 2417BC	03282+0409	10.3	10.3	1997	133.2	0.89	2016.915	1	
A 982BC	03294+4656	11.3	13.8	2007	233.	3.80	2016.915	1	
A 1825	03313+2515	8.1	14.2	1930	305.9	2.92	2016.929	1	
A 2418	03364+0153	10.5	10.6	1995	243.3	0.73	2016.915	1	
A 1538	03389+4243	10.3	10.7	2000	263.2 ± 0.11	0.59 ± 0.003	2016.929	4	
A 1537	03389+4308	8.9	13.6	1916	117.2	3.60	2016.929	1	
A 1539	03402+4059	9.9	14.4	1916	192.8	3.20	2016.929	1	
A 2421	03412+1936	10.4	10.9	1991	152.6	1.17	2016.929	1	
A 1707CD	03419+4331	10.5	14.8	1987	105.6	4.27	2016.929	1	
A 2422	03421+1657	9	12.6	1991	290.	2.15	2016.915	1	
A 1540	03422+4149	9.5	15.6	1998	220.9	5.04	2016.929	1	5
A 987	03425+2946	10.2	10.3	2001	188.3	1.13	2016.915	1	
A 2346	03435+0109	10.1	11.8	1991	61.4	1.91	2016.915	1	
A 989AB	03435+2935	9.8	10.3	2013	356.6	3.16	2016.915	1	
A 988	03441+4728	8.8	13.7	1932	143.3	4.22	2016.929	1	
A 1827	03450+0819	9.4	10.8	2013	19.9	3.96	2016.915	1	
A 1291	03481-0034	10	10.1	1999	49.9	0.86	2016.915	1	
A 991	03488+4641	8.2	11.2	1991	317.9	1.86	2016.929	1	
A 1829	03491+0649	9.8	11.7	1986	303.2	1.83	2016.915	1	
A 832AB	03491+1139	10	10.4	2000	114.2	1.74	2016.934	1	
A 2347	03528+0145	7.9	12.1	1929	258.	4.38	2016.915	1	
A 1542	03530+4112	9.5	12.2	2002	289.1	4.77	2016.934	1	
A 992	03537+4627	9	11.3	1993	198.	3.23	2016.929	1	
A 993	03545+4547	8.3	11.3	1991	59.4 ± 0.42	1.06 ± 0.031	2016.929	3	
A 2348	03548+1911	9.1	13.2	1929	321.6	3.16	2016.929	1	
A 2349	03552+0417	9.3	11.3	1982	58.6	1.34	2016.915	1	
A 2423	03561+0043	9.6	12.3	1991	344.7 ± 0.05	2.73 ± 0.032	2016.915	2	
A 1935	03565+0734	8.6	9.5	2008	359.7	0.63	2016.915	1	
A 465	03598+2848	9.5	10.8	2000	202.35 ± 0.25	1.96 ± 0.000	2016.9315	2 (2)	
A 995	03599+4454	9	13.2	1991	276.	3.04	2016.929	1	
A 1709CD	04035+4211	9.4	13.2	2000	208.3	3.77	2016.94	1	

Table 1 continues on next page.

Measurements of 208 Aitken Visual Binary Stars with a 280 mm Reflector

Table 1(continued). Measurements

NAME	WDS ID	M1	M2	DATE2	PA (°)	SEP (arcsec)	DATE	N	NOTES
A 997	04057+4537	8.9	11.1	2008	190.2	1.34	2016.94	1	
A 1294	04057+5304	8.1	11.8	1989	208.9	1.97	2016.934	1	
A 999	04147+4512	9.4	12.5	2008	71.	0.87	2016.94	1	3
A 2618	04166+0247	8.3	11.6	1929	10.5 ± 0.14	1.22 ± 0.013	2016.934	2	
A 1000	04180+4536	8.3	13.1	1933	273.1 ± 0.41	2.57 ± 0.026	2016.934	3	
A 1833	04197+3955	8	13.8	1917	94.5	3.80	2016.934	1	
A 1001	04205+4559	9	13.1	2008	183.5	3.04	2016.94	1	
A 1299	04239+4548	8.9	13	1933	177.8	2.59	2016.934	1	
A 1300	04302+5343	9.9	12.4	2010	151.5	0.82	2016.94	1	
A 1838	04308+0427	10.3	10.4	1999	151.2	0.95	2016.934	1	
A 1008	04321+5713	8.5	12.3	1991	140.9	3.38	2016.94	1	
A 1301	04332+4507	9.4	14.3	1933	225.3	2.77	2016.94	1	
A 836	04343-0045	9.7	10.7	2013	205.6	2.58	2016.94	1	
A 1715	04353+4305	9.3	13.4	1998	239.8	4.37	2016.94	1	
A 1841	04368+0523	8.6	13.8	1933	149.8	2.61	2016.94	1	
A 837	04373+0017	9	12	1991	345.5	2.60	2016.934	1	
A 1842	04374+0528	10.7	11	2002	118.6	1.57	2016.934	1	
A 839	04389+0011	9.4	12.6	1989	297.7	2.16	2016.94	1	
A 2036	04391+1024	9.7	11.4	2001	292.	2.76	2016.934	1	
A 1940	04424+0559	8.8	13.3	1933	204.4 ± 0.23	1.6 ± 0.006	2016.94	2	
A 2620AB	04438+0155	10.2	10.5	1991	263.9	0.69	2016.934	1	
A 3006CD	04441+0205	10	13.5	1930	316.7 ± 1.09	1.4 ± 0.012	2016.94	2	
A 1941BC	04458+0708	10.3	14.4	2012	12.	4.51	2016.94	1	
A 2507	04465+0242	10.6	10.9	1991	337.6 ± 1.66	0.75 ± 0.010	2016.934	4	
A 2037	04471+1003	7.3	12.3	1989	87.6	3.56	2016.94	1	
A 1015AB	04478+5716	9.9	11.2	2007	175.7	1.18	2016.94	1	
A 1017	04492+0002	10	10.9	1991	355.75 ± 0.04	0.905 ± 0.011	2016.937	2 (2)	
A 1546AB	04503+4350	9.1	14.2	1919	40.5	3.29	2016.94	1	
A 1943	04523+0541	8.7	11.3	1993	232.4	2.26	2016.934	1	
A 2426	04527+2000	9.5	11.5	2007	192.6	3.93	2016.94	1	
A 2040	04532+0833	7.8	12.6	1919	256.9 ± 0.01	2.86 ± 0.001	2016.94	2	
A 1548	04538+4405	9.4	14.2	1916	324.5	1.83	2016.94	1	
A 1549	04564+4130	9.5	11.8	1961	205.9 ± 0.45	0.83 ± 0.008	2016.94	4	
A 2626	04578+0359	9.2	13	1931	279.	1.46	2016.94	1	
A 2628	04589+0210	10.1	10.2	1999	158.9 ± 0.20	0.81 ± 0.004	2016.934	4	
A 2427	04594+2012	8.4	11.9	1991	258.7	4.28	2016.94	1	
A 2713	05510+0953	9.2	12.7	1981	133.4	1.68	2017.014	1	
A 1948	05560+0753	10.7	11.2	1989	108.5 ± 1.12	0.57 ± 0.017	2017.014	4	
A 2805	05573+1127	8.5	14.1	1922	170.1	1.29	2017.014	1	
A 1949	06011+0706	9.3	10.6	1991	359.8 ± 0.47	0.87 ± 0.005	2016.94	4	
A 2662	06031+0025	9.3	12.3	1971	161.	2.47	2017.014	1	
A 2513	06059+1636	9.3	11.1	1991	302.2	1.10	2016.94	1	
A 215	06062+3107	10.4	10.9	1992	30.6	1.62	2016.94	1	
A 1048	06064-0058	7.7	13.2	1916	283.7	3.27	2017.014	1	
A 2664	06084+0135	9.2	9.6	1995	259.1 ± 0.35	0.77 ± 0.001	2017.014	4	

Table 1 concludes on next page.

Measurements of 208 Aitken Visual Binary Stars with a 280 mm Reflector

Table 1(conclusion). Measurements

NAME	WDS ID	M1	M2	DATE2	PA (°)	SEP (arcsec)	DATE	N	NOTES
A 121	06093+2839	10.8	11	1991	163.8 ± 0.37	0.66 ± 0.003	2016.94	4	
A 1572	06109+5330	9.5	10.2	1991	99.6	0.97	2016.94	1	
A 2808	06123+0827	9.6	11	1991	1.7	1.64	2017.014	1	
A 2114	06143+3906	9.6	12.7	1919	281.6	1.44	2016.94	1	
A 667	06150+3053	10.5	10.6	1991	175.7	1.06	2016.94	1	
A 1730	06192+5410	9.4	13	1986	107.2	3.14	2016.94	1	
A 1319	06224+4612	7.5	9.8	1991	129.5 ± 0.37	0.8 ± 0.005	2016.94	4	
A 2811	06238+0528	9.1	13.5	1921	38.8	3.39	2017.014	1	
A 2813	06263+1059	8.6	13.7	1922	109.5	4.42	2017.014	1	
A 2670	06264+0311	9.8	13.7	1920	334.5	2.32	2017.014	1	
A 2725	06284+1143	9.2	13.2	1987	126.7	1.43	2017.014	1	
A 2450	06296+1659	8	11	1991	52.1	2.70	2016.94	1	
A 854	06298-0006	8.6	11.2	1991	166.2	2.14	2017.014	1	
A 2816AB	06312+0956	8	10.2	1991	317.3	0.95	2016.94	1	
A 2673AB	06344+0318	7.4	9.9	1991	299.1	1.45	2017.014	1	
A 2674	06367+0032	8.9	11.7	1921	313.	2.37	2017.014	1	
A 2675AB	06374+0253	9.3	13.3	1921	175.4	2.53	2017.014	1	
A 2822	06379+0855	10.3	10.7	1991	122.7 ± 0.24	0.76 ± 0.001	2016.94	4	
A 2676	06397+0203	8.8	13.3	1921	353.1	3.92	2017.014	1	
A 2933	06416+0413	9.1	10.9	1991	183.6	1.49	2016.94	1	
A 2455	06426+1937	9.3	13.6	1919	297.8	3.02	2016.94	1	
A 2455AC	06426+1937	9.3	14.5	1919	16.7	1.80	2016.94	1	9
A 2454	06429+4137	9.8	12.7	1986	257.1	2.46	2016.94	1	
A 2824	06438+0327	8.8	11.9	1989	339.6	1.90	2017.014	1	
A 2829	06478+0015	8.8	12.8	1987	91.5	3.67	2017.014	1	
A 2832	06548+1126	8.1	11.7	1991	329.8	3.24	2016.94	1	
A 2834	06562+1430	8.2	12.5	1975	267.9	2.72	2016.94	1	
A 2121	06590+2105	8.3	12.9	1987	122.1	3.90	2016.94	1	

Notes for Table 1:

1. $\Delta M = 6.1$
2. See Plate 1
3. $\Delta M = 3$ sep<1 – see Plate 1
4. $\Delta M = 6$
5. $m_2 = 15.6$; exp = 100ms
6. Possible quadrant inversion. Companion is viewed in Q3
7. R filter
8. m_2 as reported in WDS is likely to be under-estimated (probably >13.5)
9. New companion C - see Sec. 5 and Fig 6
10. Has orbit (ref: Nov2006e, grade=5). O-C(θ)=-2.2° O-C(ρ)=-0.25

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Table 2 – Pairs with showing a significant displacement (Delta(PA)>10° and/or Delta (SEP)>0.5'') wrt. their last measurement as reported in the WDS

NAME	WDS ID	DATE2	NOBS	Delta(SEP)	Delta(PA)	Note
A 805	00291+1119	2000	5	0.53	2.9	
A 806AB	00355+1150	1991	5	0.05	84.8	3
A 1806	00403+0517	2000	10	0.53	3.4	
A 810	00434+1136	1933	3	0.72	1.9	
A 1509AC	00516+3925	1929	3	2.36	18.9	
A 1901	00523-0022	2000	6	0.12	27.7	
A 2207	00530+1806	2000	9	0.62	1.2	
A 925	00587+4457	1994	6	0.16	11.6	
A 1907	01257+3621	1932	3	0.64	1.1	
A 941CD	01286+4509	1994	6	0.17	14.7	
A 1265CD	01376+5511	1991	6	0.31	195.9	1
A 963AB	02227+5705	1999	6	0.55	3.5	
A 1817	02294+4000	1929	3	0.51	1.9	
A 2337AB	02414+0426	1955	4	0.79	0.3	
A 2222AB	02473+1717	1961	4	0.3	13.3	
A 1929	02542+2658	1930	3	0.62	4.3	
A 828	03143+0911	1991	13	0.02	10.7	
A 1705	03211+4322	2008	17	0	179.7	2
A 1825	03313+2515	1930	3	0.82	5.1	
A 2418	03364+0153	1995	12	0.07	10.7	
A 1707CD	03419+4331	1987	3	0.63	0.4	
A 988	03441+4728	1932	3	0.52	0.3	
A 2348	03548+1911	1929	3	0.56	0.4	
A 2349	03552+0417	1982	4	0.47	13.4	
A 995	03599+4454	1991	5	1.04	20	
A 2618	04166+0247	1929	5	0.58	18.5	
A 1000	04180+4536	1933	3	0.57	2.1	
A 2620AB	04438+0155	1991	5	0.19	12.1	
A 2805	05573+1127	1922	2	0.09	39.9	
A 1949	06011+0706	1991	5	0.17	10.2	
A 1048	06064-0058	1916	2	0.57	0.3	
A 2811	06238+0528	1921	2	0.99	11.2	
A 2670	06264+0311	1920	2	0.52	4.5	
A 2676	06397+0203	1921	2	0.02	12.1	
A 2455	06426+1937	1919	1	0.62	3.8	

Notes for Table 2

1. There may be a quadrant inversion in the latest WDS measure (1991: PA=157). The first measure (1906) gives PA=348
2. Quadrant inversion ? Our images definitely shows the companion in Q3
3. We have no explanation for the large Delta(PA) observed here. . The first WDS measure (1904) gives PA=146

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(Continued from page 434)

The details of all measurements is available online [10].

Figure 5 shows a plot of all measurements with the separation as the X axis (in arcsec) and the delta mag as the Y axis. This plot can be viewed as an approximation of the "accessible domain" with the instrumental setup used here. The blue dotted line on the left, in particular, gives an idea of the how much the former quantity limits the latter. For example, pairs with a delta mag > 3 seems to require a separation > 0.8" to be reliably measured.

For several pairs our measurement shows a significant variation compared to the latest one reported in the WDS catalog. Table 2 lists the pairs for which the variation in PA is greater than 10° and/or the variation in SEP is greater than 0.5 arcsec. The columns DATE2 and NOBS respectively gives the date of the last measurement and the total number of measurements reported in the WDS (as of 2016-11-01). The variations Delta (PA) and Delta(SEP) are computed as the absolute value of the difference between these values and ours. Pairs with the greatest variations and a sufficient number of observations (such as A 1901, A 1907, A 828, or A 2418) could make good candidates for a preliminary orbit calculation.

5. A New Component for WDS 06426+1937

WDS 06426+1937 (A 2455) is a pair with a large delta mag (m_1=9.3, m_2=13.6). The WDS only lists two observations, in 1911 and 1919. We observed it on the night of December 9, 2016. When reducing the data, a very faint companion was noticed on an image obtained by adding the 100 best frames of the sequence. The presence of this companion was confirmed on the autocorrelogram computed on 1000-frames sequences (see Figure 6). We did not find mention of this component in the literature and it has no entry in the WDS catalog. The measured position angle and separation are:

PA = 324.8° and SEP=3.89"

The magnitude of this new component, based upon that of the B component, is estimated between 14 and 15.

Conclusion

The results reported here confirm and extend the conclusions given in [4]. They show that pairs with a secondary component up to mag 14 and/or separation down to 0.6 arcsec can be routinely measured with an 11" telescope. This increases the probability to discover yet unobserved companions with small amateur-level instrumental setups, as demonstrated here with the case of A 2455.

From a technical point of view, this paper also demonstrates that using autocorrelation-based reduction methods is not reserved to the measurement of close pairs, relatively bright pairs, under the seeing limit but that these techniques can be fruitfully applied to obtain precise measurements of pairs with very faint components and/or large delta mag.

Acknowledgments

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