Speckle Observations of Albireo A

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Abstract: A 120 cm Cassegrain reflector was used in 2019 and 2020 for recordings of the close double star Albireo A (= MCA 55 Aa,Ac) with a fast CMOS camera. In total, more than 100.000 images were analyzed mainly with speckle interferometry, in parts also with lucky imaging. The image scale was calibrated with data from the Gaia catalog DR2 on the basis of wide field images including component Albireo B. Positions of Aa,Ac were found to markedly deviate from earlier orbit calculations by Scardia et al. in 2008, and Roberts and Mason in 2018, but were reasonably close to new ephemeris data by Mason, and by Scardia et al. in 2019, respectively.

Introduction

Albireo (β Cygni) is one of the most famous double stars in the sky, especially for its brightness and striking color contrast of components A and B. Up to now, the pair has generally been deemed as true binary, being physically bound. In fact, parallax data from the Hipparcos mission indicated about similar distances of A and B from earth, with overlapping error margins. Also, proper motion data were not too different, both in strength and direction. But as no definite orbital motion has yet been detected, the orbital period would be very long. Beside these astrometric considerations, there are also arguments from astrophysics, e. g. masses, spectral classes, and others, which seem to support the physical nature.

However, this picture became partly inconsistent with recent data from Gaia DR2, exhibiting significant differences of both parallax and proper motion values of A and B [1]. As a result, the separation would be as large as 62 ly, which is not reasonable for a binary. Further, the proper motion of A would have changed direction by roughly 90 degrees within 14 years, or even less, which seems to be rather unlikely. One problem may be that Albireo A is too bright for Gaia, leading to saturation of the detectors, hence less accurate measurements. Another problem is that A is double itself, but not resolved, neither by Hipparcos nor by Gaia. Thus, the apparent proper motion of A may be influenced by orbital motion of Aa-Ac. In order to take this into account, precise knowledge of the orbital parameters is needed. However, observational data are scarce. These aspects have recently been addressed by Bastian and Anton in 2018 [2].

In recent years, up to 2018, an orbit of Aa-Ac was assumed, which was evaluated by Scardia et al. on the basis of mostly speckle observations from 1976 to 2008 [3]. The period would be 214 years. As the angular coverage was only small, the quality grade was estimated to 4 – 5, which means preliminary indeterminate. In 2018, Roberts and Mason derived another solution upon including a few measurements taken in 2004. The eccentricity would be rather large, and the period reduced to 69 years [4]. Things changed in 2019, when Scardia et al. came up with observations from 2017, which led to an orbit with period 120 years [5]. Also, in 2019, Mason made a new computation with taking into account a measurement of ours from that year (see below) [6]. This resulted in an orbit with period 213 years, close to that of Scardia 2008, but with differences in other parameters. Obviously, more observations are needed in the future for further refining the orbit parameters. Our present measurements are just aimed to contribute to this issue.

Instrumentation

One of us (Ohlert) used a telescope of Cassegrain type with aperture 120 cm, focal length 951 cm, located in Trebur, Germany, which is operated by the Astronomie Stiftung Trebur (*Astronomy Foundation Trebur*). On three nights in July 2019 and one night in June 2020, several series with up to 13000 images each were recorded with a CMOS camera (QHY 5L-IIm) with exposure times of 5 or 10 ms, at rates of up to 200 frames per sec. Imaging of the pair Aa,Ac is difficult, namely because of the narrow separation in the range of 0.3 – 0.4 arcsec, combined with the large difference in brightness of Aa and Ac (2.43/5.08 mag), and of color (K3II/B9V). Therefore, a photometric Blue-Johnson filter was used in all series. This also helped

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to partly compensate for the difference of sensitivity of the camera in the blue and yellow. In fact, by reducing the glare of A, the visibility of Ac was significantly improved. As disadvantage, seeing effects are more pronounced at short wavelengths compared with longer ones, but this is hoped to overcome by taking large numbers of frames.

Data Processing

Speckle images were mostly analyzed with the program "Reduc" by Florent Losse, without pre-selection, because this appeared impracticable with such large numbers of frames [7]. At each night, some series were also recorded with a larger field of view in order to include component B at position angle 54.04 degrees, and distance 34.59 arcsec according to Gaia DR2 [1]. These were searched for "lucky images", which were stacked and used for calibration of the image scale as well as the orientation of the camera. As a side effect, the speckle clouds of B were analyzed too, in order to check for possible artefacts, but none were found. While the data from Gaia refer to the epoch 2015.5, no significant change is expected in the course of five years, and the scatter of other literature data is too large as to derive an accurate movement even in the long term.

Results

Figure 1 shows a wide field image of Albireo Aa,Ac–B, obtained in July 2019 by superposition of 211 lucky images, selected by visual inspection from a recording of about 9400 frames. Exposure time was 5 msec. The seeing was only mediocre, which resulted in a rather diffuse background. Nevertheless, the pair Aa,Ac is clearly resolved, which can better be seen upon enlarging. The inset at bottom left shows the result of speckle autocorrelation of all 9400 frames. The separation and orientation of the spots corresponds to that in the lucky image. This and several similar views served for calibration of the scale and orientation by referring to the position angle and separation for A and B as derived from Gaia, as mentioned above. This resulted in an original resolution on the camera chip of 0.081 arcsec/pixel. Searching for lucky images in the speckle clouds by visual inspection in all the thousands of frames is tedious, and only few were found with more or less isolated speckle pairs corresponding to the result of the autocorrelation program. An example is shown in figure 2. Generally, all frames were re-sampled before stacking, which results in smoothened intensity profiles, and in higher precision in determining the peak centers, both in lucky imaging and in speckle analysis.

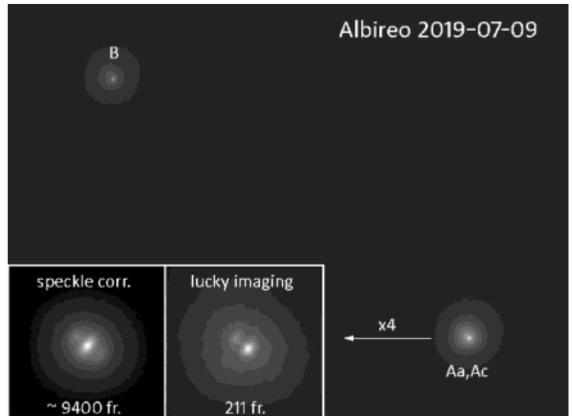

Figure 1: Wide field view of Albireo Aa,Ac – B, recorded on 2019-07-09. Stack of 211 lucky images. Contrast was enhanced by unsharp masking. An enlargement of the close pair is shown in the inset as indicated. The other inset shows the superposition of the speckle correlation of Aa,Ac using all 9400 frames of the series. North is up, east is left.

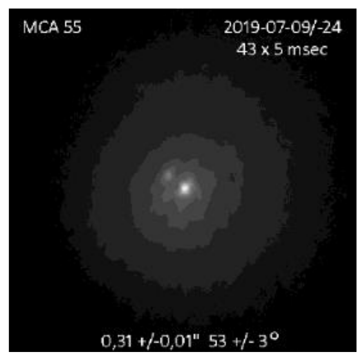

Figure 2: Superposition of 43 lucky images selected out of 15000 frames in two recordings from nights 2019-07-09 and 2019-07-24. Original frames were re-sampled before stacking with factor 4x4.

Another observation run was performed in the night of 2020-06-22/23. Nine series of consecutive recordings delivered consistent results. An example is shown in figure 3. Similar to the process described above, speckle autocorrelation was done with all 4492 frames of the recording "Alb 1 A+B" (see table 2 below), without pre-selection. The pair was also clearly resolved in all other series recorded that night.

In the following two tables, all evaluations of recordings made in 2019 and 2020 are listed with the respective parameters. Wide field images with components A and B are analyzed with lucky imaging for calibration, while the results for the close pair Aa,Ac are from speckle autocorrelations.

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date/ # of recording	Besselian year 2019+	lucky imaging of Aa-B for calibration			speckle correlations of Aa,Ac		
		frames used	PA/ degrees	rho/ arcsec	frames used	PA/ degrees	rho/ arcsec
9.7./S2	.523	370	54.04 !	34.59 !	9400	51.4	0.312
9.7./S1	.523				10000	52.5	0.317
24.7./S5	.564				10100	55.8	0.305
24.7./S6	"				1100	53.5	0.320
24.7./S7	"				10000	49.1	0.313
24.7./S8	"				12500	54.1	0.304
25.7./S10	.567				4300	56.8	0.325
mean values ± s.d.						**53.3 ± 2.6**	**0.314 ± 0.008**

Table 1: List of recordings from 2019-07-09 to 2019-07-25. The mean Besselian date was 2019.540. Numbers of frames used for analyses are also listed. Series S2, recorded on 2019-07-09, was also evaluated with lucky imaging and served for calibration with Gaia data (with exclamation marks, see text).

file name	U.T.	lucky imaging of Aa-B for calibration			speckle correlation of Aa,Ac		
		frames	PA/degrees	rho/arcsec	frames	PA/degrees	rho/arcsec
Alb 1 A+B	00:25	304	54.04 !	34.59 !	4492	50.2	0.327
Alb 2 A+B	00:27				4484	54.8	0.317
Alb 3 A+B	00:29				4414	50.6	0.346
Alb 4 A+B	00:56				4489	51.8	0.320
Alb 1 AaAc	00:32				12050	53.9	0.321
Alb 2 AaAc	00:35				12466	51.4	0.325
Alb 3 AaAc	00:45				12500	52.1	0.339
Alb 4 AaAc	00:48				12500	52.4	0.333
Alb 5 AaAc	00:52				12500	48.9	0.322
mean values ± s.d.						**51.8 ± 1.8**	**0.328 ± 0.010**

Table 2: List of recordings at 2020-06-23 at times as indicated. Besselian date was 2020.478. Numbers of frames used for analyses are also listed. Series Alb 1 A+B was evaluated with lucky imaging and served for calibration with Gaia data (exclamation marks, see text). Measures for Aa,Ac are obtained from speckle analyses.

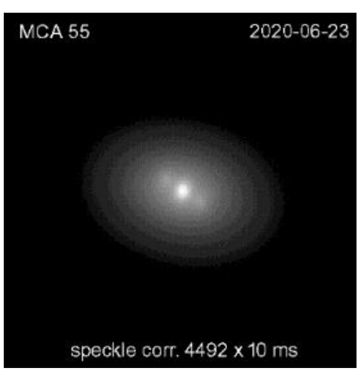

Figure 3: Speckle autocorrelation of MCA 55 Aa,Ac from all 4492 frames of series Alb 1 A+B, recorded on 2020-06-23 (see table 2). North is up, east is left

In figures 4 and 5, our position data are compared with ephemeris calculations from other authors, which have already been mentioned in the introduction. Our results seem to fit the new ephemeris data from 2019 by Mason, as well as by Scardia et al. reasonably well, when one would accept a certain scatter of all data, including those on which the orbit calculations are based. Apparently, those from 2008 (Scardia), and from 2018 (Roberts & Mason) are obsolete. Still, a better refinement of the orbital elements is expected with more measurements to be made in the future. It may well be that the true orbit will lie in between the two solutions from 2019.

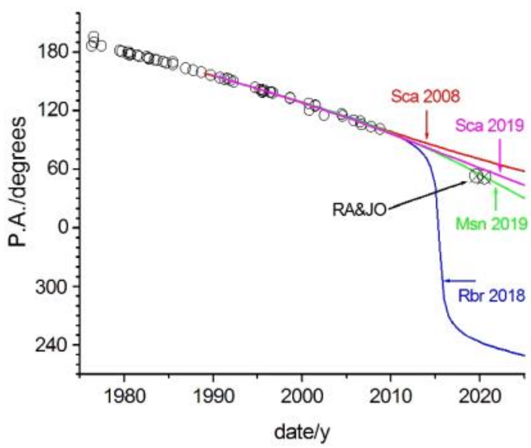

Figure 4: Plot of the position angle of MCA 55 Aa,Ac vs. time (Besselian year). Open circles are speckle data from the "speckle catalog" [8], crossed circles are our own measures. Curves in color are ephemeris data from Scardia et al. (red, from 2008 [3,9], and magenta, from 2019 [5]), Roberts & Mason (blue, from 2018 [4,9]), and Mason (green, from 2019 [6]), respectively.

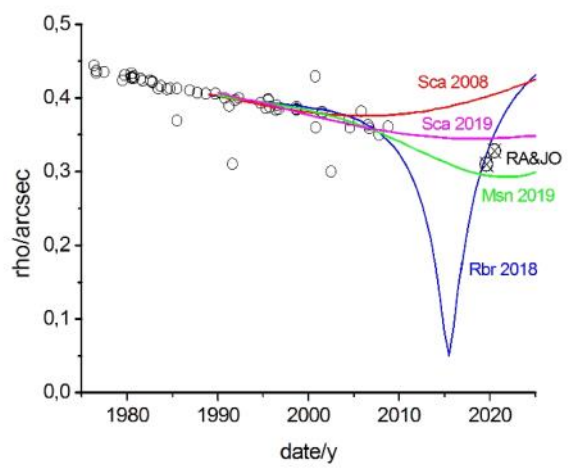

Figure 5: Plot of the separation rho of MCA 55 Aa,Ac vs. time. Meaning of the symbols as in figure 4.

Acknowledgements

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References

[1] Gaia Archive, Data Release 2, 2018: http://esac.esa.int/archive/

[2] Bastian, U., and Anton, R., 2018, A&A, 620, L2.

[3] Scardia, M. et al., 2008, Astronomische Nachrichten, 329, 54.

[4] Roberts, L.C. & Mason, B.D., 2018, MNRAS, 473, 4497.

[5] Scardia, M. et al., June 2019, IAU Commission G1, Double Stars Information Circular No. 198.

[6] Mason, B.D., United States Naval Observatory, private communication, 2019.

[7] Losse, Fl., http://www.astrosurf.com/hfosaf

[8] Hartkopf, W.I. et al., Fourth Catalog of Interferometric Measurements of Binary Stars, U.S. Naval Observatory, online access Oct. 2019.

[9] Hartkopf, W.I. et al., Sixth Catalog of Orbits of Visual Binary Stars, U.S. Naval Observatory, online access Oct. 2019.

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