WDS18338+1744: Speckle Analysis of a Quadruple in Hercules

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Abstract

Using data collected from the historic 60" telescope at the Mount Wilson Observatory on 2023.4873 (June 27, 2023), the position angle and separation of the multiple system WDS 18338+1744 were calculated using Speckle Tool Box and compared with previous measurements. The AB system's mean position angle was found to be 90.055° and the mean separation was 0.2057". The CD system's mean position angle was found to be 264.071° and the mean separation was 0.478". The AB system measurements exhibited a standard error of .001 for ρ and .109 for θ, and the CD system had an error of .005 for ρ and .082 for θ. Data for the AB system is compatible with the published orbit, while data for the CD system is inconclusive.

1. Introduction

In June 2023, 53 Known Binaries selected from a list merging the WDS and 6th Orbit Catalog and Ephemerides (McCudden, et al; 2022) were observed using the historic 60" telescope at Mount Wilson Observatory (MWO). From those binaries, WDS 18388+1744 (HU322, HD 171365, STF 2339, SAO 103853, HIP 90996, Tycho 2: 1574-01293-1, Gaia DR2 4523973547779600384) was selected for analysis due to its abundant past observations, including several speckle ones, and its quadruple nature. Images from Digital Sky Survey II and a sample speckle image from MWO are featured in Figures 1 and 2, respectively.

WDS 18338+1744 was also chosen to test the Speckle Toolbox software on stars with separation values between the AB and CD stars that differ by a factor of 10, and to compare the measurements with ample data gleaned from larger instruments using a variety of other methods, including spectroscopic, short-exposure CCD imaging, Hipparcos, and Tokovinin "HRCam" methods (see Tables 1 and 2). The speckle technique was pioneered by Antoine Labeyrie and "freezes" the effect of atmospheric distortion by "stacking" the images, offering a clear distinction between even very close members of a multiple system (Labeyrie 1970).

The AB (HU322 AB) system has an estimated period of 42.4 years and a distance of 183.49 parsecs (598.54 light years). The A member has an apparent magnitude of 7.74 and the B member's apparent magnitude is 8.91. The primary is spectral class F6V. This grade 2 double is physically related, and the orbit was first calculated in 2012 (Rica Romero 2012). Select data from the USNO is listed in Table 1. The table includes measurements from 1.5 m telescopes or larger.

Table 1. USNO Double Star data for WDS18338+1744AB

Date	ρ (")	θ (°)	Observer
1958.60	0.14	78.4	van den Bos, W.H. 1960
1958.61	0.12	70.2	Van Biesbroeck, G. 1960
1976.301	0.15	93.4	Walker, R.L. 1985
1983.4194	0.218	87.2	McAlister, H.A. 1987
1983.7144	0.221	88.3	McAlister, H.A. 1987
1984.3751	0.233	90.0	McAlister, H.A. 1987
1984.3833	0.228	91.7	McAlister, H.A. 1987
1985.4835	0.229	88.0	McAlister, H.A. 1987
1987.7552	0.225	89.0	McAlister, H.A. 1989
1991.3182	0.211	84.9	Hartkopf, W.I. 1994
1992.3094	0.202	84.5	Hartkopf, W.I. 1994
1992.6076	0.201	89.1	Balega, I.I. 1999
1995.5996	0.169	83.1	Hartkopf, W.I. 1997
1996.4214	0.152	81.5	Hartkopf, W.I. 2000
1996.6918	0.155	80.9	Hartkopf, W.I. 2000
1997.3904	0.148	81.2	Balega, I.I. 1999
1997.3932	0.144	80.7	Balega, I.I. 1999
1998.653	0.115	71.6	Scardia, M. 2000
1998.7754	0.128	79.9	Balega, I.I. 2002
2001.7535	0.077	73.5	Balega, I.I. 2006
2001.7535	0.076	73.7	Balega, I.I. 2006
2001.7535	0.075	73.6	Balega, I.I. 2006
2001.7535	0.077	73.5	Balega, I.I. 2006
2009.2592	0.0570	91.3	Tokovinin, A. 2010
2009.2592	0.0481	81.0	Tokovinin, A. 2010
2009.2592	0.0561	91.3	Tokovinin, A. 2010
2017.4294	0.1378	94.3	Tokovinin, A. 2018
2018.2539	0.1650	90.7	Tokovinin, A. 2019
2019.5363	0.1744	92.3	Tokovinin, A. 2020

The CD (WAK21 CD) system shares the AB spectral class, but is somewhat fainter with apparent magnitudes of 9.3 and 9.56 for the C and D members, respectively. The 28 observations available from the USNO reflect an increasing ρ and θ since 1975, but it is not known whether the system is physically related. There is no 6th Orbit Catalog plot for the system, and there is no consensus on its distance, but the two stars do have identical proper motions (Mason 2023, Rica Romero 2012). Select data from the USNO is listed in Table 2. The table includes measurements from telescopes of aperture greater than 1.5 m.

Table 2. USNO Double Star data for WDS18338+1744CD

Date	ρ (")	θ (°)	Observer
1976.301	0.16	248.4	Walker, R.L. 1985
1985.4836	0.319	256.7	Hartkopf, W.I. 2000
1996.4214	0.395	260.2	Hartkopf, W.I. 2000
1997.3803	0.406	258.9	Balega, I.I. 1999
1997.3932	0.405	259.0	Balega, I.I. 1999
1998.653	0.409	261.7	Scardia, M. 2000
1998.7754	0.414	260.3	Balega, I.I. 2002
2005.8651	0.409	262.5	Mason, B.D. 2009
2007.5878	0.454	260.2	Mason, B.D. 2009
2009.2592	0.4651	261.2	Tokovinin, A. 2010
2017.4294	0.4920	262.5	Tokovinin, A. 2018
2018.2539	0.4920	262.5	Tokovinin, A. 2019
2018.3985	0.4932	263.1	Tokovinin, A. 2019
2019.5363	0.4921	263.3	Tokovinin, A. 2020

Figure 1. WDS 18338+1744 from Aladin

2. Equipment and Methods

Data on WDS 18338+1744 AB and CD was collected by the historic 60-inch (1.52m) telescope at MWO on June 28, 2023 (2023.490 or JD 2460124.747). The telescope was used in its bent Cassegrain mode. One thousand 20 ms images of the target were taken with a ZWO ASI 6200MM Pro camera fitted with an Astronomik ProPlanet 642 BP 2850002585 (IR pass) filter with a midpoint transmission at 750 nm. A sample speckle image is shown in Figure 2. Five hundred images, also with 20 ms exposures were taken of HD 176938 to be used as a reference in the Speckle reduction. Dave Rowe's PlateSolve software (Rowe & Genet, 2015) was used to determine the pixel scale of 0.0306 arcseconds/pixel and rotation angle of 178.997° of the camera/optical train.

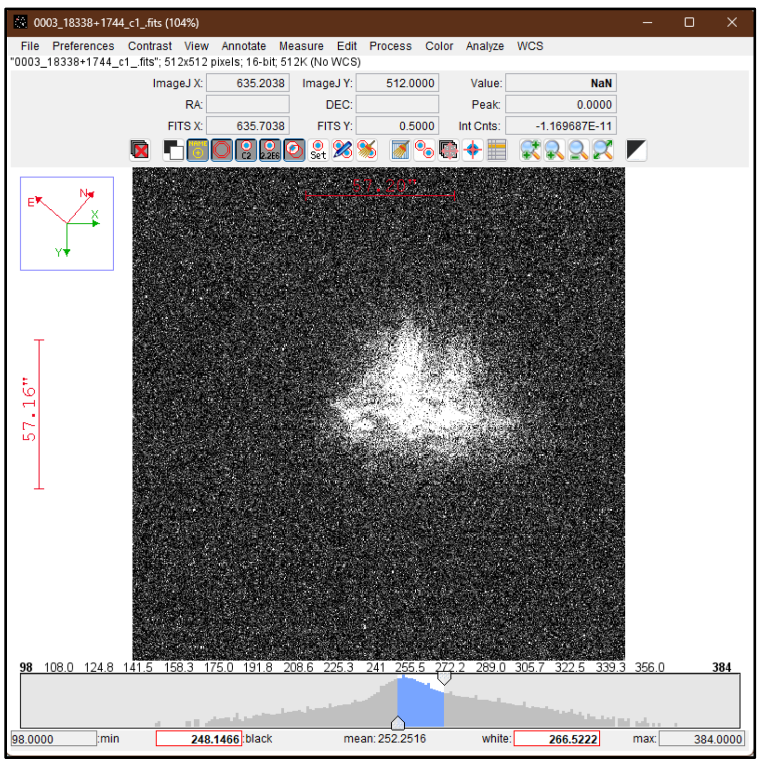

Figure 2: Sample speckle Image of WDS 18338+1744

3. Data

Five reductions each of both the AB and CD stars at 128, 256 and 512 pixel sized images using Speckle ToolBox (Rowe, 2017) were taken by each author, and the mean ρ, mean θ, standard deviation and standard error were calculated and are shown in Table 3.

Table 3. Measured values for WDS 18338+1744AB

Pixel size	AB ρ (")	Standard Deviation	AB θ (°)	Standard Deviation	CD ρ (")	Standard Deviation	CD θ (°)	Standard Deviation
128	0.206	0.00620	90.004	0.73667	0.468	0.00825	263.628	0.71638
256	0.205	0.00713	90.410	0.91310	0.493	0.00288	264.234	0.46406
512	0.206	0.0106	89.751	0.87987	0.472	0.09941	264.352	0.73651
Average	0.2057	0.00798	90.055	0.84321	0.478	0.03685	264.071	0.63898

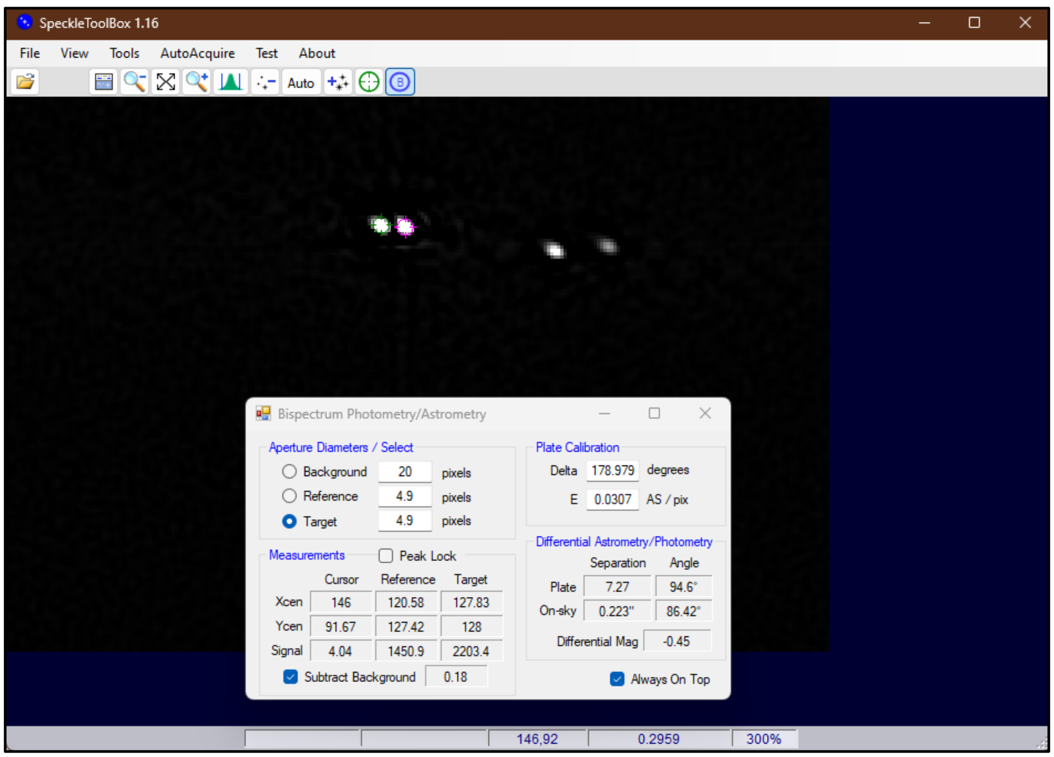

Figure 3: Sample Bispectrum Image from Speckle Toolbox of WDS 18338+1744, showing both the AB and CD stars

Table 4 - Current measurements of WDS 18338+1744AB compared to 6th Orbit extrapolated values

	ρ (")	θ (°)
Extrapolated 6th Orbit value	0.215	90.5
Our Measurements	0.20507	90.055
Standard Deviation	0.00798	0.84321
Standard Error	0.00178	0.18855

Our data is plotted along with recent large aperture speckle observations, with observation dates indicated in parentheses in Figure 4 using the commercial program Desmos. The published orbit (Rica Romero, 2012) is indicated by the dotted line. Our data is indicated as "MWO 2023 (2023.6)."

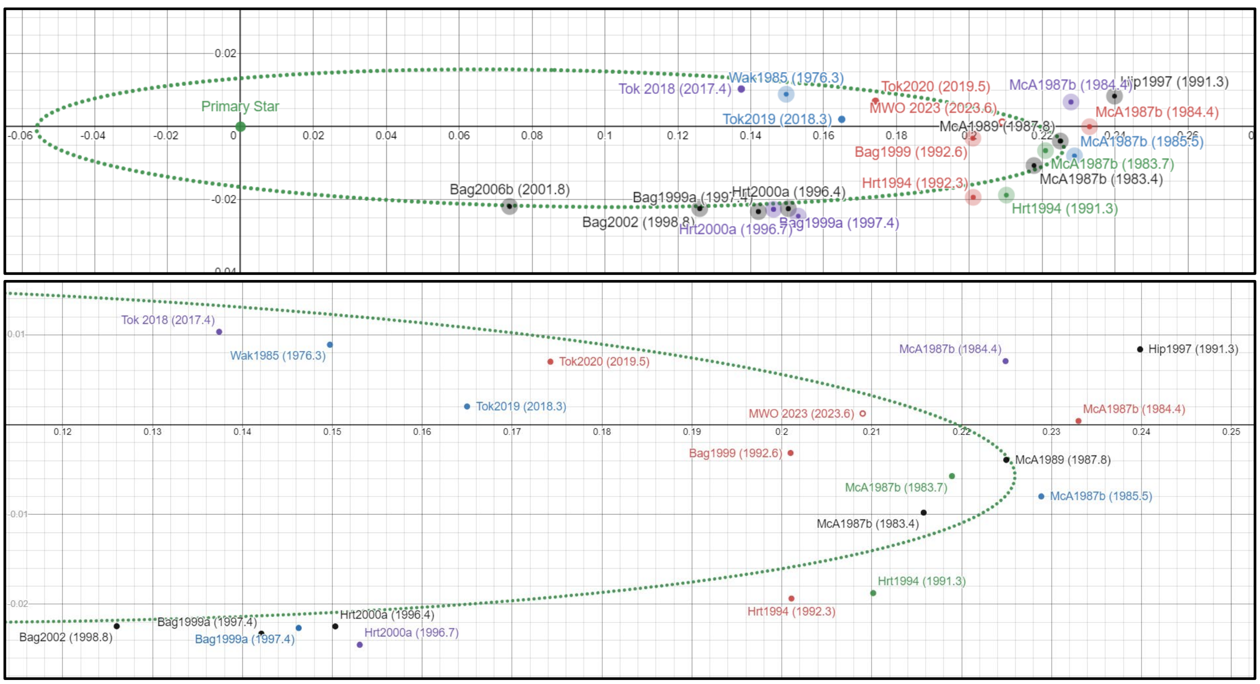

Figure 4- Speckle Observations of 18338+1744 (AB). Current Observation is labeled as MWO2023 (2023.6)

4. Discussion

Our observation fits well with the published orbital plot from the 6th Orbit Catalog (see Figure 4), although there is significant variation in previous measurements (e.g., the Hip1997 data point). Our ρ deviated from the extrapolated 6th Orbit Ephemeris value by .77% and the θ by 2.78%. Other recent speckle observations deviate from the calculated orbit by even larger margins, despite this being a Grade 2 orbit. The CD system was plotted using our observation and historical observations but showed no observable trend that would indicate a gravitationally bound system despite sharing an identical proper motion (Rica Romero 2012).

Further information on the CD system is lacking so it can not be concluded whether the pair is gravitationally bound to the AB system. Measurements taken on the AB system had a standard error of .001 for ρ and .109 for θ and the CD system had an error of .005 for ρ and .082 for θ. Such low error indicates that STB can simultaneously provide precise measurements on systems with ρ values that differ by a factor of 10.

Using the new orbit plotting tool in STB 10.01, and only confirmed, large aperture (>3m) Speckle data, including recent data that was not available to calculate the currently published orbit (FMR 2012b), we removed outlier points (including the 1991 Hipparchos measurement and ones later retracted (Tok2010)) and then fitted an orbit to the remaining data. It is possible (see Figure 5) that a new orbit calculation is necessary.

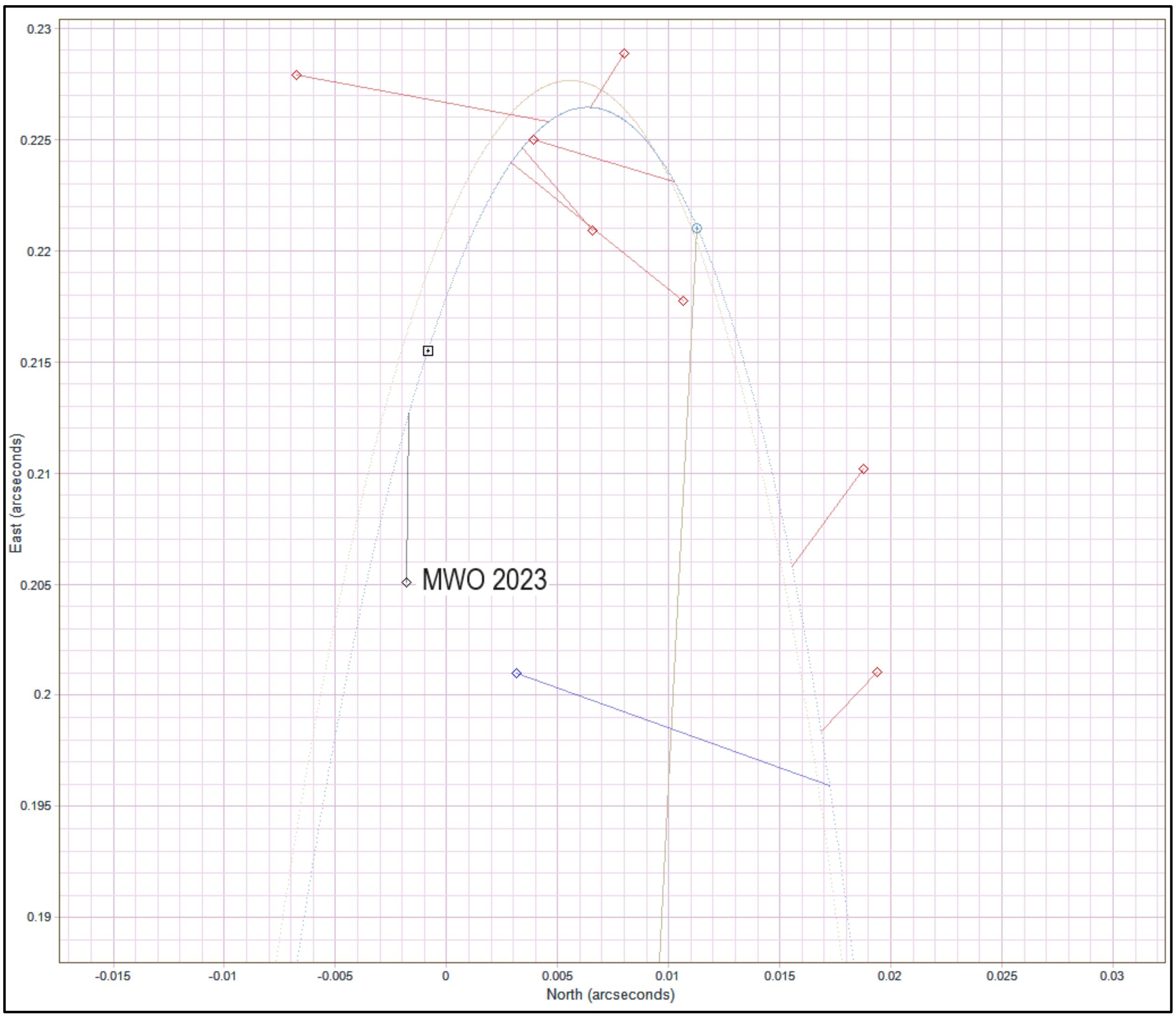

Figure 5. Published Orbit for WDS18338+1744AB in brown (FMR2012b) and recalculated orbit using STB 10.01 in blue. Current measurement (MWO 2023) is labeled.

5. Conclusion

Speckle interferometry via the STB software has become a valuable, powerful tool in the hands of researchers and amateur observers. Automated and amateur-sized telescopes can provide large amounts of data on known and suspected binaries that can easily and quickly be analyzed to further refine known orbits of double stars. These tools and methods can provide valuable data to nail down higher grade orbits, in an efficient and accessible fashion. Future use of software like Speckle Toolbox may compel revisions of published orbits for Known Binaries. In this case, we were able to use our measurements, add the most recent observations for WDS18338+1744 AB, and wield new tools to offer a modified orbital plot.

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