Speckle Astrometry of WDS 18181-0120

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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 18181-0120 were calculated using Speckle Tool Box and compared with previous measurements. The A and B members' mean position angle was found to be 196.46° and the mean separation was 0.1357". The position angle was within 5% of the extrapolated 6th Orbit Catalog estimate, and the separation was within 15%. Previous analysis indicates that the pair are gravitationally bound.

1. Introduction

Antoine Labeyrie first employed speckle methods to reduce the effect of atmospheric distortion and more accurately measure binary stars with separations below what is possible with visual observation (Labeyrie 1970). New techniques and software make it a valuable and accessible field for first-time researchers. The technique uses hundreds of "stacked" images from large aperture telescopes and specialized software to "freeze" atmospheric distortion, making it possible with image processing tools like Speckle ToolBox (Harshaw et al, 2017)) to measure the Position Angle (θ) and Separation (ρ) of close binary stars. This method is an accessible and powerful technique, even when using telescopes of modest aperture.

In June 2023, a team of researchers spent three days observing with the historic 60” telescope on Mount Wilson, using speckle techniques on some 53 targets chosen from a spreadsheet combining the WDS catalog with the 6th Orbit Catalog and Ephemerides (McCudden, et al; 2022). Targets were chosen with separations down to 0.1" separation.

From the resulting target list, WDS18181-0120 (HDS 2587AB, HD 168073, TYC 5098-553-1, SAO 142206, HIP 89680) was chosen for analysis. It is located within the constellation Serpens Cauda (Ser) and was first resolved by Hipparcos in 1991. It has an estimated period of less than 150 years, a distance of 227.79 parsecs (743.05 light years), an apparent magnitude of 7.78, and a spectral class of A0. It is a triple system, but for the purposes of this paper only the AB components were addressed as the C member is outside the parameters for our object selection. A sample speckle image from Mount Wilson Observatory (MWO) is featured in Figure 1. It is a Grade 3 system.

WDS18181-0120 was chosen for observation due to its close ρ (<1.0") separation and was therefore a good test of the techniques and the telescope’s limits. The first measurements of the companion's ρ and θ were taken in 1991 by Hipparcos, with six subsequent observations being made, the last in 2019 by Tokovinin (see Table 1).

Our objective was to analyze the object using speckle interferometry and provide another observation, further establishing the orbital path of the companion and informing future estimates of its period.

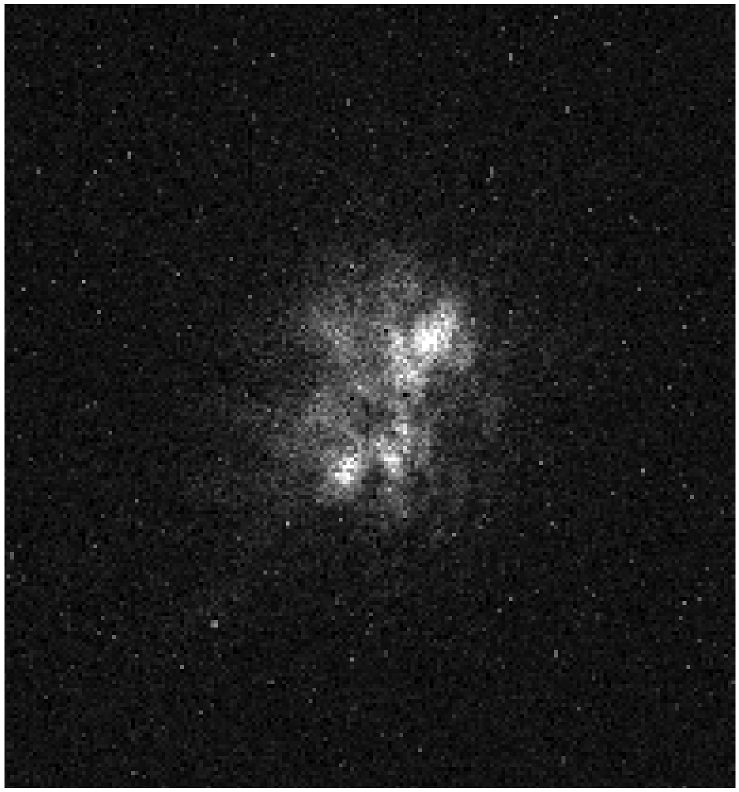

Figure 1. MWO Speckle Image of WDS 18181-0120 (0.02 second exposure).

Table 1. USNO Double Star data for WDS 18181-0120

Date	ρ (")	θ (°)	Observer
1991.25	0.133	350.0	Hipparcos (1997)
2013.643	0.086	318.7	Gili, R. (2022)
2014.3021	0.0677	329.1	Tokovinin, A. (2015)
2015.7357	0.0786	160.7	Tokovinin, A. (2016)
2017.5332	0.0920	172.7	Tokovinin, A. (2018)
2018.2347	0.0963	175.3	Tokovinin, A. (2019)
2019.5361	0.1031	181.4	Tokovinin, A. (2020)

2. Equipment and Methods

Data for WDS 18181-0120 was collected by the 60-inch telescope at the Mount Wilson Observatory on 2023.4873 (June 27, 2023). The telescope was used in its bent Cassegrain mode. 1000 images of 18181-0120 were taken with 20 millisecond exposure with a ZWO ASI 6200MM Pro camera fitted with a Astronomik ProPlanet 642 BP 2850002585 (IR pass) filter with a midpoint transmission at 750 nm. Five hundred images were also taken of HD 166991, using 20 millisecond exposures to be used as a reference star. The PlateSolve software was used to determine the pixel scale of .0306 arcseconds/pixel and rotation angle of 178.997° (Harshaw et al. 2017). Using these values, each of the three authors did five reductions each at both 128 and 256 pixel sized images using Speckle ToolBox (STB), then the mean ρ, mean θ, and standard deviation were calculated and are shown in Table 2.

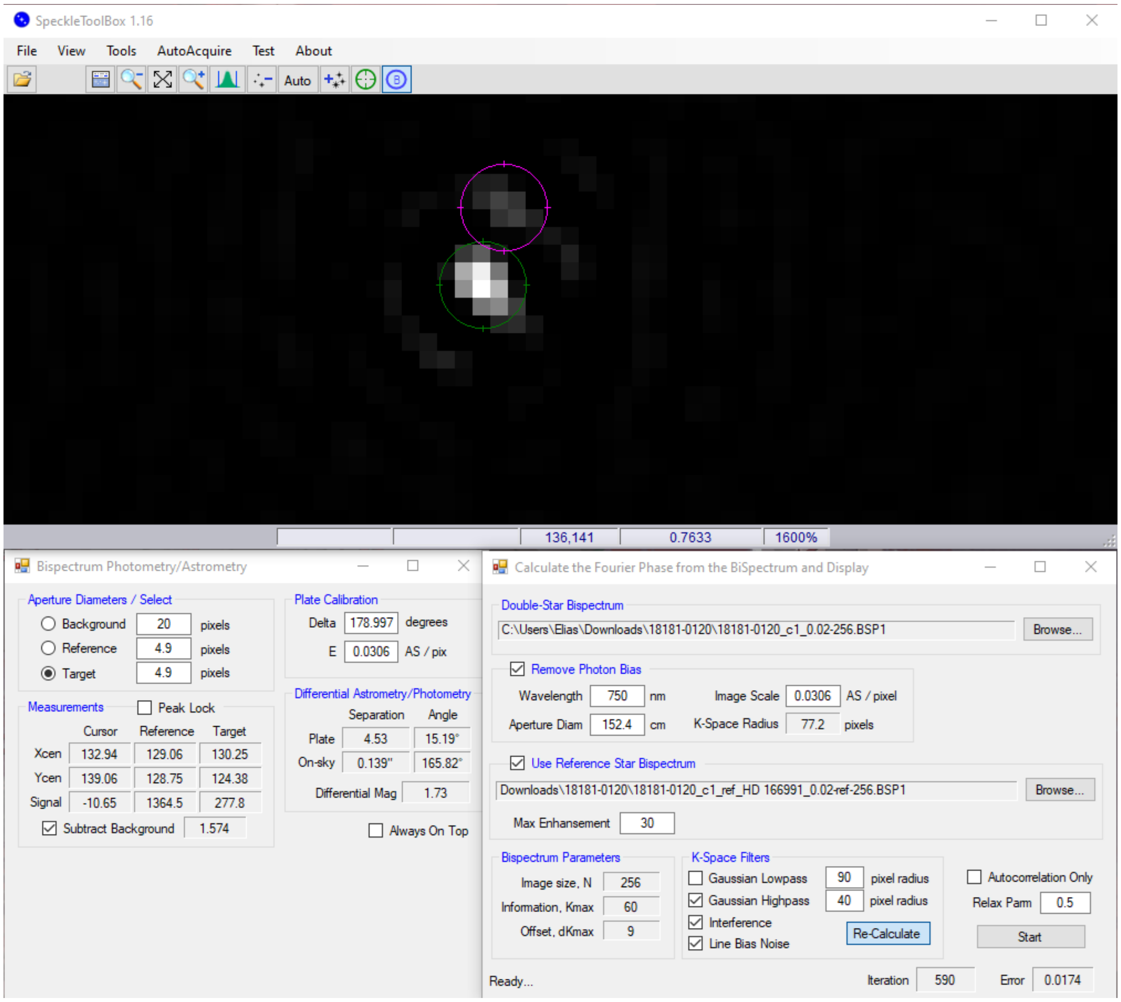

Figure 2: Screenshot of a 256 pixel STB data reduction on 18181-0120

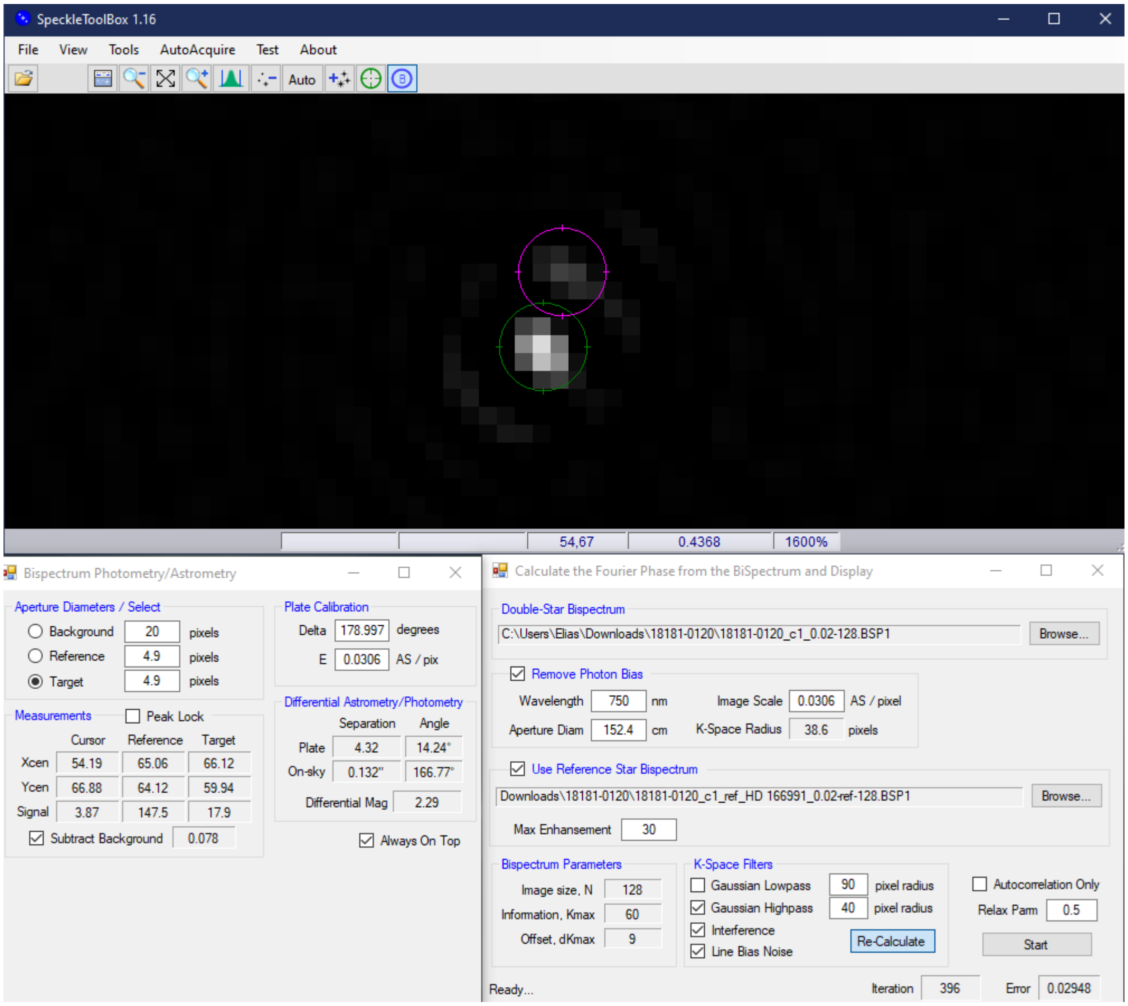

Figure 3: Screenshot of a 128 pixel STB data reduction on WDS 18181-0120

3. Data

The average values of ρ and θ calculated from the reductions (repeated 15 times) are shown in Table 2. The values for ρ and θ shown in columns 6 and 7 are extrapolated from the 6th orbit projections for 2023.4873. The standard error was calculated by dividing the standard deviation by the square root of the number of measurements.

Table 2. Average calculated values of ρ and θ for WDS 18181-0120 (HDS 2587) on 2023.4873

Pixels	ρ (")	Standard Error (")	θ (°)	Standard Error (°)	Extrapolated ρ (")	Extrapolated θ (°)
128	0.1357	9.28×10^{-4}	195.87	.876		
256	0.1357	1.57×10^{-3}	197.04	.806		
Average	0.1357	8.96×10^{-4}	196.46	.595	.118	195.61

The values found were plotted onto the orbital plot of WDS 18181-0120 from the Sixth Catalog of Visual Binary Stars displayed in Figure 4.

4. Discussion

The binary exhibits one discrepancy with respect to the 6th Orbit Plot in historical θ and ρ measurements, with the specific outlier being the Gili 2013 measurements (see Table 1 and Figure 4) (Gili et al. 2022). Subsequent observations by Tokovinin (2016, 2018, 2019, 2020) offer a more consistent orbital path. Our Mount Wilson Observatory observation is plotted as "MWO" in red.

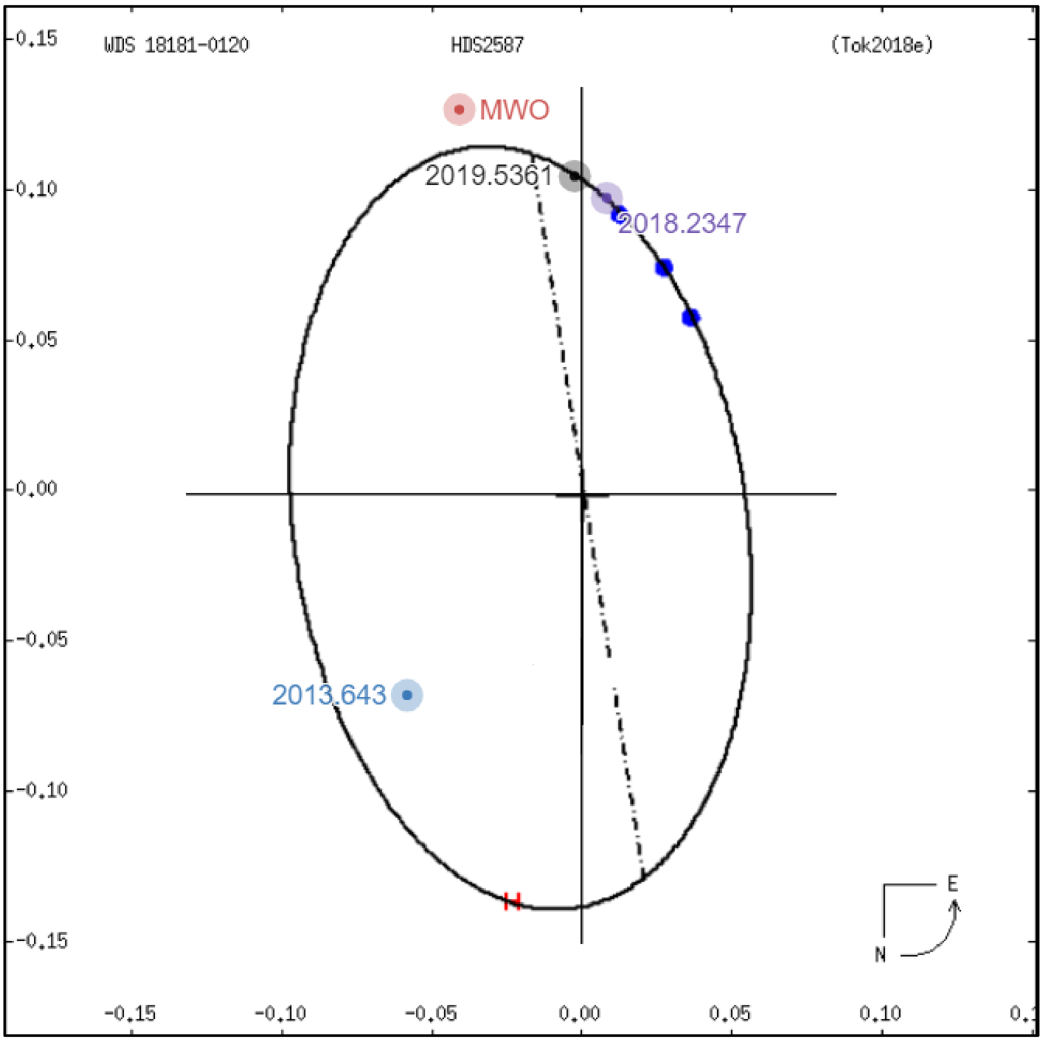

Figure 4: Plotting of Gili 2013, Tok 2018, Tok 2019, and the Mt. Wilson Observatory data onto the Sixth Catalog of Visual Binary Stars orbit for 18181-0120

Our observation fell outside the path displayed in the orbital plot of WDS18181-0120 from the Sixth Catalog of Visual Binary Stars (see Figure 4). The authors' measured θ of 196.46° differs by 4% from the interpolated value of 195.61°, and the observed ρ exceeds the interpolated value of 0.113" by 15%. If our observation is correct, it would mean the orbit is wider and the period somewhat longer than originally calculated.

5. Conclusions

Speckle techniques can accurately measure sub-100 mas separations and position angles, and represent a relatively accessible means to measure multiple systems. Remote access to large aperture, near professional-grade telescopes, coupled with free tools for Speckle Interferometry, have revolutionized binary star research. This combination of tools have made it possible for first-time researchers to contribute scientifically valuable binary star observations. Given the relatively short period of the WDS 18181-0120 system, and the small number of observations currently available, near-future observations could further establish the orbital path using the same methods. A larger number of observations could force the 6th Catalog of Binary Stars to revise the orbit.

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