Speckle Observation of WDS 15493+6032 HU 912

Joe Smith[1], Bretton Simpson[2], and Pat Boyce[3]

1. Stanford Online High School, Redwood City, California
2. University of California San Diego, La Jolla, California
3. Boyce Research Initiatives and Education Foundation (BRIEF), California

Abstract

The physical system of WDS 15493+6032 HU 912 was observed on June 14, 2022 using the 60-inch telescope at Mount Wilson Observatory. Speckle interferometry was performed on the target system, yielding a mean position angle and standard deviation of 159.4° ± 0.372° with a mean separation and standard deviation of 0.333″ ± 0.008″. Astrometric measurements of this system were calculated using the SpeckleToolBox software [2]. Our measurements of this system return a statistically significant ($p < 0.05$) deviation but also fall along the predicted orbital solution, indicating that the orbital solution for HU 912 does not currently require refinement.

1. Introduction

Our observation of WDS 15493+6032 HU 912 was made on June 14, 2022 at the site of the historic Mount Wilson Observatory. The United States Naval Observatory maintains the Sixth Orbital Catalog for binary stars. In this Sixth Catalog of Orbits of Visual Binary Stars [4], a standardized integer-based grading scale from 1 to 5 is employed for the orbits of known gravitationally bound stars. Grades 3 to 5 are considered in need of some to significant improvement regarding the determination of their orbital solutions. Our target system of WDS 15493+6032 HU 912 has an orbital solution considered Grade 3 [6], suggesting a need for continued observation. HU 912 also fits within an ideal magnitude range between 6 and 9, with a magnitude of 8.60 for the primary stars and a magnitude of 9.01 for the secondary star [5]. Since HU 912 fits the ideal parameters defined above, it was selected to be the target system for observation. As these stars are closely spaced, we needed to employ the measurement method of Speckle Interferometry. Therefore, in addition to observing HU 912, an additional well-understood reference star is necessary to calibrate observations. The nearby target star, WDS 15542+1659 A 2080, was selected as our reference star due to its close proximity, comparable magnitude, and similar air mass. First cataloged in 1905, the target star had been observed a total of 59 times prior to our observation, most recently in 2010. The target star's spectral class is F5.

2. Equipment and Methods

WDS 15493+6032 HU 912 was observed for a duration of one night on the 60" Hale telescope at the Mount Wilson Observatory, Figure 1. The date of the observation was June 14, 2022, or 2022.45. The telescope has a focal ratio of f/16 - a focal length of 24m. The camera used was a ZWO ASI 6200MM (a monochrome CMOS camera) setup with an Astronomik Proplanet-642 BP IR pass filter, with a pixel scale of 3.8 μm and a plate scale of 0.03045 arcseconds per pixel. The field of view for this setup is 5.08′ x 3.38′.

During this observation run for HU 912, a series of a thousand images were taken. An equivalent amount of images were taken for the reference star, necessary to complete the Fourier transform in speckle interferometry [1]. While the reference star is a double star, all other single star systems were either too distant or there was a significant difference is magnitude such that they would not serve as appropriate reference stars, leaving A 2080 as the reference star of choice. As a consequence of the target pair's apparent separation being below 4", speckle interferometry is convenient because it allows for the correction of atmospheric distortion present when observing such a closely-bound double star. Speckle interferometry requires a large amount of images in order to minimize this atmospheric distortion by "freezing" the images over a very short time scale, hence the thousand images taken. The data reduction and bi-spectrum analysis were performed within Speckle Toolbox 1.16 (STB) [2], outputting the then-current astrometric values of the position angle (θ) and separation (ρ).

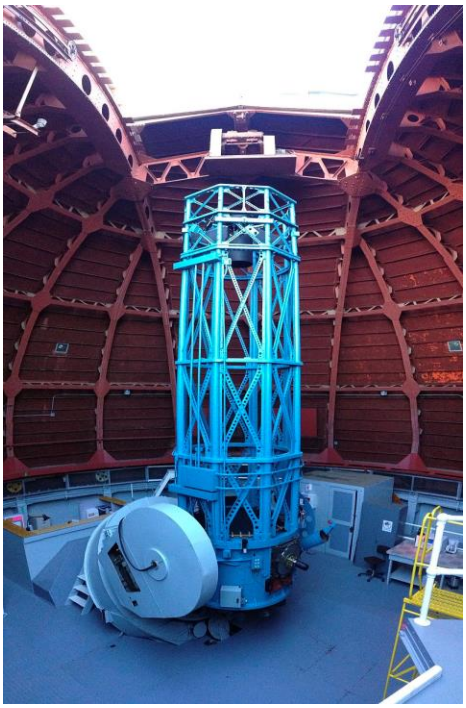

Figure 1: The Mount Wilson Observatory 60" telescope used to image WDS 15493+6032

3. Data

Examples of the specifications for bi-spectrum analysis of HU 912 and astrometry of the autocorrelogram within STB are shown in Figures 2 and 3. The imaged FITS cubes were generated from the same dataset and analyzed independently by three team members, each outputting astrometric measurements, Table 1. These separate calculations allow an average and standard deviation (S.D.) to be calculated. The averages of ρ and θ and the S.D. are shown in Table 2. The ephemeris for the date of observation and the measurements from the last recorded observation are also shown in Table 2.

Table 1. FITS Cube Measurements.

FITS Cubes No.	θ	ρ
No. 1	159.34	0.328
No. 2	159.42	0.329
No. 3	159.15	0.342

Table 2. Measurements of HU 912.

Date	θ	θ S.D.	ρ	ρ S.D.
2010.31	132.1°	-	0.325″	-
2022.45	159.4°	0.372°	0.333″	0.008″
Ephemeris - 2022.45	148.0°	-	0.340″	-

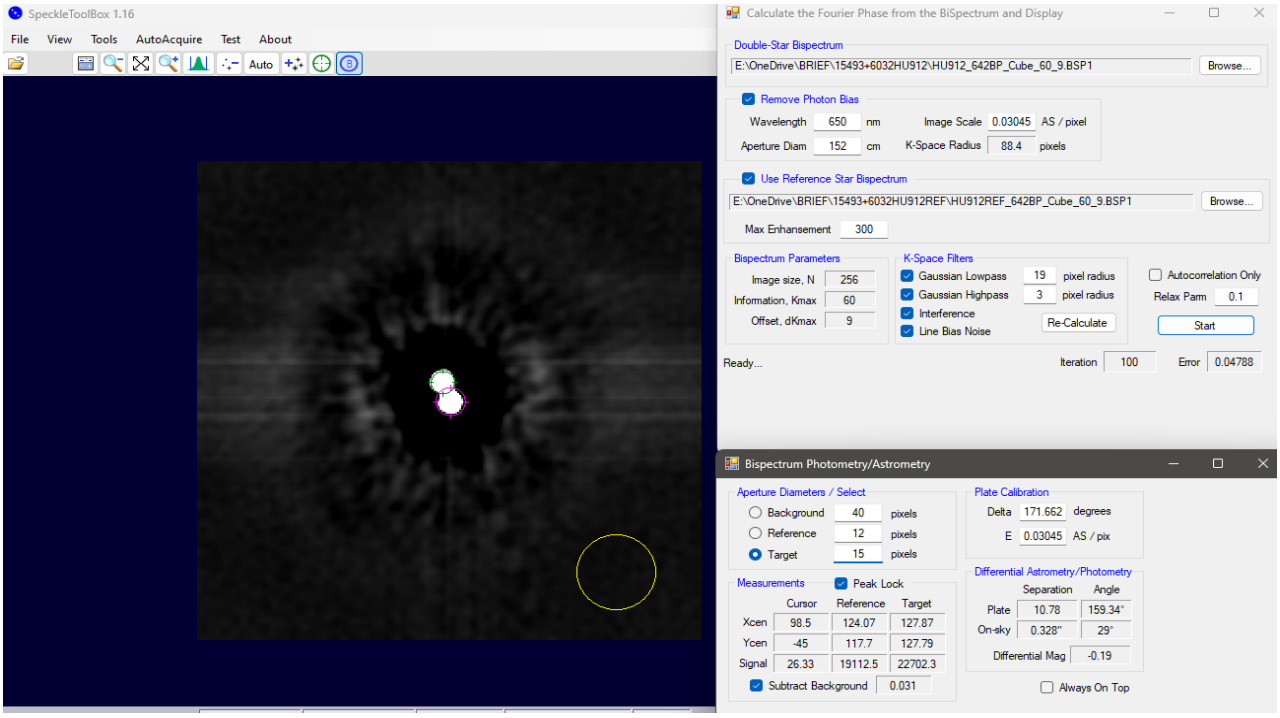

Figure 2: Steps of STB bi-spectrum reconstruction showing panels with specifications for the reconstruction and astrometry.

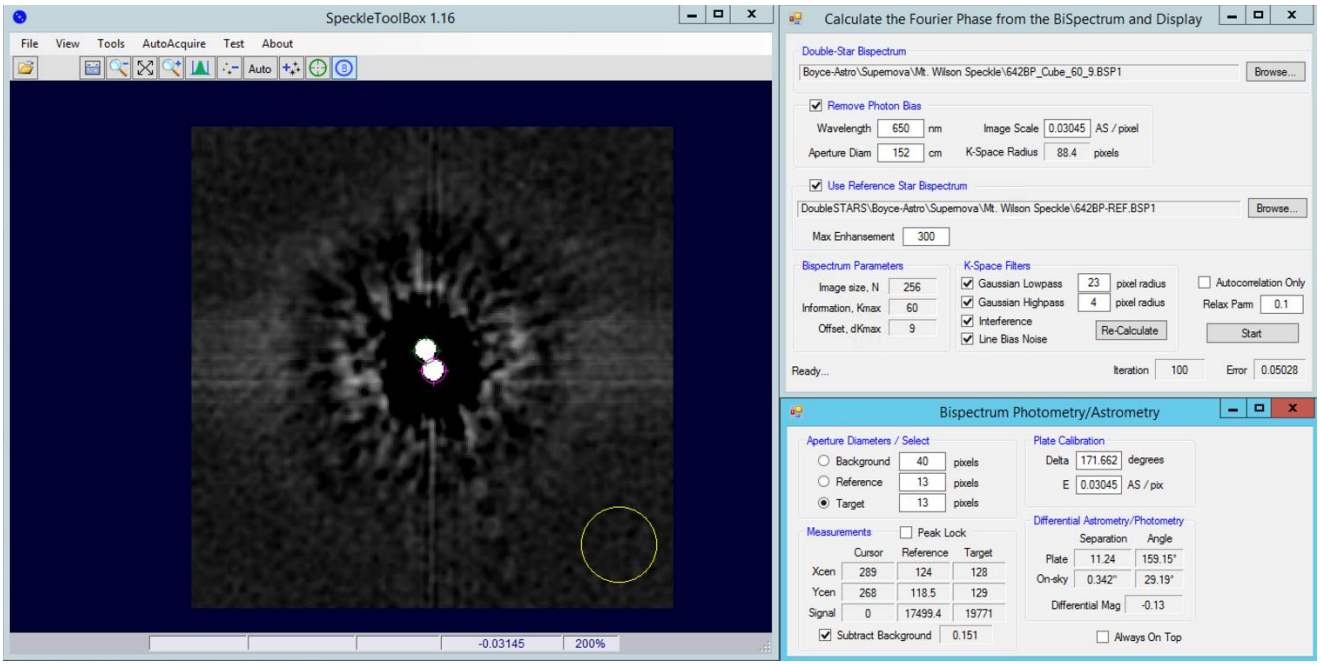

Figure 3: Steps of STB bi-spectrum reconstruction showing panels with specifications for the reconstruction and astrometry.

4. Discussion

We compared the measurements collected in Table 1 to predicted values from an ephemeris for θ and ρ. A linear interpolation was used to find the ephemeris for the given date of the observation [3]:

$$(1)\ y = y_1 + a(y_2 - y_1)$$

where y is the ephemeris for ρ or θ on the given date, y_1 the ephemeride for a given year and y_2 the year after it, and a the decimal value of the date falling between the given years. As an example, the date of this observation was 2022.45. It follows that a is 0.45, and y_1 and y_2 the ephemerides for 2022 and 2023. Upon identifying the values for the ephemerides from the Sixth Catalog of Orbits of Visual Binary Stars, it is found that the ephemeris for this system is 148.0° and 0.34″ for θ and ρ, respectively. The orbital solution from the Sixth Catalog of Orbits of Visual Binary Stars is shown in Fig. 4, where the observed measurement is represented as the red star and the ephemeris the blue star.

The difference between the observed and predicted values for the θ and ρ is 11.40° and 0.007″, respectively, and the S.D. for each is 0.372° and 0.008″, respectively. It follows that there is an approximate 30 σ difference for the θ and a 1 σ difference for the ρ present, indicative of a highly statistically significant measurement. By convention, a measurement must fall, assuming a confidence of 95% ($p < 0.05$), at least 2 σ away from the null (i.e., the mean) to be statistically significant. However, while there may be a discrepancy between the calculated ephemeris for the date of the observation, as can be seen in Figure 4, the observed data fall along the graph of the orbital solution, indicating that the orbital solution and the set of all ephemerides do predict the measurement recorded.

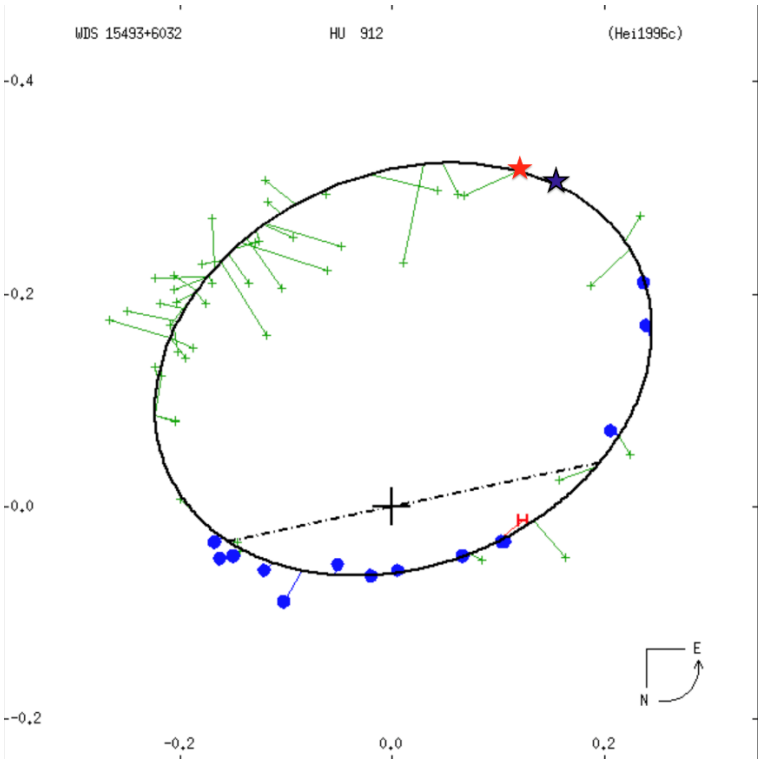

Figure 4: Orbital plot of HU 912 with the measurement denoted by the red star and the ephemeris by the blue star.

5. Conclusion

We report updated measurements of WDS 15493+6032 HU 912 with a position angle of 159.4° ± 0.372° and a separation of 0.333″ ± 0.008″. While there is a significant difference between the predicted ephemeris and the measurement observed, it does not imply that the orbital solution itself requires refinement as the measurement still falls along the orbital solution. Therefore, we conclude that the orbital solution of HU 912 does not require refinement at the present moment.

Acknowledgements

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