An Astrometric Observation of Binary Star System WDS 15559-0210 at the Great Basin Observatory

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Abstract: Researchers at Concordia University Irvine measured the position angle and separation of the double star system WDS 15559-0210 using a SBIG STX-16803 CCD camera on the PlaneWave 0.7-m CDK 700 telescope at the Great Basin Observatory. Images of the binary star system were measured using AstroImageJ software. Twenty observations of WDS 15559-0210 were measured and analyzed. The calculated mean resulted in a position angle of 345.95° and a separation of 5.94". These measurements were consistent with the previous values for this binary system listed in the Washington Double Star Catalog.

Introduction

Double stars are two stars that appear to be close together from Earth's perspective. Observations can be made over decades to determine whether double stars are gravitationally-bound binaries, (that is, physical pairs travelling together but not in a mutual orbit) or chance optical alignments of separate stars. If the star system is a binary, an orbit can be resolved and, if we know the distance to the system, the total system mass ("dynamical mass") can be computed. Knowing the stellar mass is critical to understanding the life cycle of the star (Genet 2016).

Binary star research is a new endeavor at Concordia University Irvine (CUI) and has great scientific potential and educational merit. In this pilot study, a student-led team at CUI made observations of WDS 15559-0210 using the remotely-controlled telescope (Figure 2) at the newly constructed Great Basin Observatory (GBO). The purpose of these observations was to introduce the student research team to astrometric data collection and analysis and to use the GBO as a research instrument to gather scientific data for use in double star astrometry. The GBO was constructed through the collaborative efforts of CUI, Southern Utah University, University of Nevada-Reno, Western Nevada College, Great Basin National Park, and the Great Basin National Park Foundation to support a vigorous program of astronomical research, education, and outreach. The observatory is located at Great Basin National Park, high in the mountains (6825 ft), and distant from any major city or population. The altitude, seclusion, and low-humidity of the desert allow for ideal dark-sky (21.32-21.48 mags/arcsecond^2) conditions required for obtaining high-quality observations (Great Basin Na-

Figure 1. The Concordia University Irvine Astronomy Research Team after the first in-person meeting. Left to right: Russell Genet, Rachel Freed, Lila Musegades, Mackenzie Graham, Andrew Poore, Michelle Caldwell, Selena Masson, Aludith Mayares, John Kenney, III, and Cole Niebuhr.

Figure 2. *The 0.7m CDK 700 PlaneWaveTelescope at the Great Basin Observatory in eastern Nevada celebrating its "first light" on 25 August 2016.*

Figure 3: Inside of the observatory dome at Great Basin Observatory in Great Basin National Park, Nevada.

tional Park, 2016).

The binary system WDS 15559-0210 was selected for study from the Washington Double Star catalog using the following parameters: the system was visible from the Great Basin Observatory, had a proposed period, a separation greater than 5", magnitude values less than seven, and a magnitude difference less than five. WSD 15559-0210 was selected because it had many previous data points, high-fidelity data gathered by CCD cameras, and it appeared to be veering off the 1973 calculated orbit. Thus a new data point would either contribute to the validation of the original orbit or provide important data for a needed recalculation.

Equipment

The Great Basin Observatory (GBO) is equipped with a PlaneWave 0.7-m CDK 700 telescope (Great Basin Observatory, 2016). The GBO utilizes a SBIG STX-16803 CCD camera that is attached to the telescope (STX-16803 2017). The images obtained from the observatory were analyzed with the db3.2.1 version of AstroImageJ, a public-domain image processing program, to measure separations and position angles (Collins et. al., 2017). It should be noted that a user account code is needed from nova.astrometry.net in order to use the plate solving capabilities of the program.

Image Analysis

On 18 June 2017, 20 images were taken by GBO using a 10-second exposure time and no filter. The images were then analyzed using AstroImageJ. In the software, the radius parameter under the "Plate Solving with Options" was set to 5 pixels, the "Radius of Object Aperture" setting was decreased from 30 to 6 pixels, and the "Centroid Aperture" feature was left on default. These settings allowed the program to identify the binary stars as two separate objects and orient measurements to the center point of each star.

A difficulty did arise using the "Plate Solve" method when both stars would be initially identified as objects but the secondary would be removed if the process was allowed to finish. This occurred because AstroImageJ would attempt to validate the automatically selected objects through astrometry.net; however, the information for both components were stored under the same entry causing AstroImageJ to only verify the primary star. It is for this reason that measurements were made after the objects were identified but before the validation process finished.

Results

Table 1 shows the results for position angle and separation for this study. The average position angle from this study was 354.95 ± 0.09°, and the average separation was 5.94 ± 0.04". The observations were made on 18 June 2017 or date 2017.4600.

Discussion

The 2012 Washington Double Star Catalog reports 205 observations for WDS 15559-0210 and, after the exclusion of incomplete entries and outliers greater than two standard deviations away from best fit, 161 of these past observations were plotted in conjunction with the new point in Figure 4 (Washington Double Star Catalog 2012). A reproduced orbit was provided for comparison by creating a trend line from data points

Table 1. Position angle and separation measurements made by the Concordia team from GBO data acquired on 18 June 2017.

Time Stamp	Position Angle	Separation	Time Stamp	Position Angle	Separation
6:00:43	355.63	6.02	6:10:36	354.25	5.73
6:01:54	355.17	5.91	6:11:55	355.58	5.64
6:02:53	355.26	5.91	6:13:00	354.34	5.93
6:03:48	354.79	5.97	6:14:00	354.41	5.96
6:04:46	354.73	5.99	6:15:05	355.10	6.25
6:05:46	354.93	5.95	6:16:11	355.16	6.22
6:06:44	354.78	5.72	6:17:11	354.73	5.70
6:07:43	354.56	5.82	6:18:15	355.54	6.08
6:08:38	355.46	5.87	6:19:16	354.99	5.95
6:09:36	354.86	5.93	6:20:14	354.70	5.94

	Position Angle	Separation
Mean	354.95	5.94
Standard Deviation	0.41	0.18
Standard Error of the Mean	0.09	0.04

derived from the WDS orbital plot. The observation from this study appears to fit well with the previous data and, as shown in Figure 4, the cumulative plot shows a deviation from the published orbit.

Conclusion

The new data generated by this study fits well with previous data and cumulatively show a deviation from the proposed orbit for the binary system WDS 15559-0210. Moreover, this study, the first of its type using

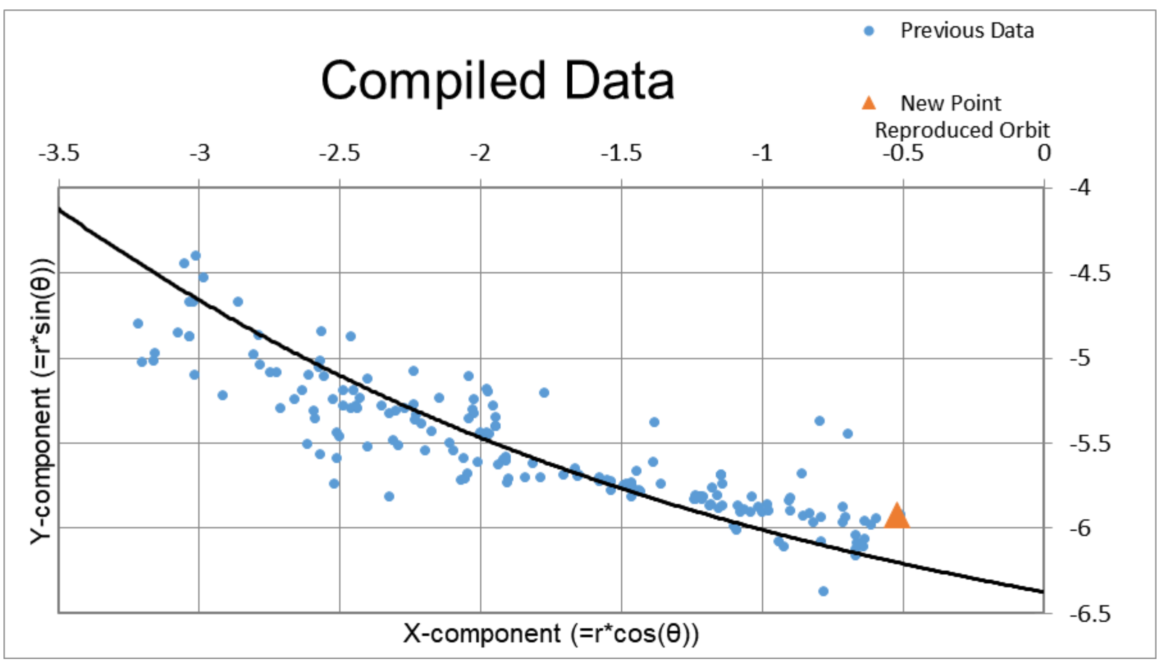

Figure 4. The new point gathered in this research, shown as an orange triangle, aligns with the path of the previous data points, shown as blue dots, provided by information in the WDS. The compiled data shows a trend away from the published orbit.

the GBO, also serves to verify the capabilities of this new telescope.

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