Measurements of HJ 5175 and Collection of New CCD Images

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Abstract: New measurements of position angle and separation for the WDS 20327-8155 (HJ 5175) double star system with components AB, AC, and BC are analyzed and reported from images taken at the Siding Spring Observatory in Australia. The resultant measurements, plotted alongside previously measured position and separation, seem to suggest two things: the original measurement, calculated by John Herschel, appears to be inaccurate, and without the Herschel measurement, the plots indicate a steady increase in distance between the stars in the system.

Introduction

The analysis and measurements of WDS 20327-8155 were performed with the goal of adding additional data for this double star system into the Washington Double Star Catalog (WDS). This double star consists of three components in two different pairs: AB and AC. The WDS (Mason & Hartkopf 2015) reports that the first recorded measurements of the AB and AC pairs were in 1836 by John Herschel. Since 1836, the AB pair has had a total of 10 measurements with the AC having 12. The proper motions of all three stars show a dissimilar movement and notes in the WDS suggest that through proper motion or other techniques, the AB pair is non-physical.

This project was an attempt to acquire a new position angle (Theta) and separation (Rho) for the AB and AC components of this double star. Images were acquired through the remote telescope system, iTelescope and processed on the Boyce Astro Research Computer (BARC) using advanced image and processing software.

The WDS reported apparent magnitude of the A, B, and C stars are listed as 10.9, 11.4, and 12.9 respectively. The latest measurements for separation have been recorded at 8.35 arc seconds for the AB component, and at 12.25 arc seconds for the AC component. The number of measurements taken is also relatively small, with 10 for the AB component, 12 for the AC component, and none for the BC component. Thus, the new BC measurement within this paper will provide the first.

Materials and Methods

Candidate Selection Criteria

To determine a candidate star for this paper, the first priority was to consult the WDS for neglected double stars. Neglected double stars have little to no recently gathered data, therefore a measurement from this paper would add to their historical measurements, making a more significant impact to the astronomy community than adding another measurement to a well-documented system. The second selection criterion was stars with older first measurements, giving a unique opportunity to explore the historical significance of the stars themselves and how astronomy and measuring had differed in the past. The final criterion was that stars should have a minimum separation of 6 arc seconds and a small difference in reported apparent magnitude to ensure we could perform accurate measurements.

HJ 5175 fits the above criteria with one important note: the WDS neglected doubles list reports this double star was last measured in 1955. However, the WDS for Right Ascension hours (RA) 1800-0000 reports the

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T32 Details

Instrument Package
CCD: FLI Proline 16803
Full Well: 100x Saturation Exposure (ABG)
Resolution: 0.63 arcscec/pixel
Array: 4096 x 4096 pixels
FOV: 43.2 x 43.2 arcmin
Observatory: Siding Spring

Telescope Optics
Optical Design: Correct Dall-Kirkham Astrograph
Aperture: 431mm
Focal Length: 2912mm
F/Ratio: f/6.8
Mount: Planewave Ascension 200HR

Figure 1. iTelescope T32 located at the Siding Spring Observatory in Australia

last measurement on HJ 5175 was in 2015. With the 2015 and this 2017 measurement, it is recommended that this double star be removed from the neglected double star list.

Telescope & Camera Selection

HJ 5175, with a declination of -81 degrees, is best viewed from the southern hemisphere. Of the southern telescopes available, via the iTelescope network, selection for this double star focused on a low arc second per pixel resolution to increase our chances to clearly separate our stars and produce an accurate measurement. Telescope T32, located at Siding Spring Observatory in Australia, features a large CCD chip with a wide field of view, Figure 1, and satisfied the selection criteria with a resolution less than one arc second per pixel.

Image Acquisition & Measurement

To ensure a good statistical average, a total of five images, two with a luminance filter for 60 seconds and three with a hydrogen alpha filter for 120 seconds, were acquired. After receiving each image, MaximDL was used to place the World Coordinate System (WCS) Right Ascension and Declination into each image. This process involved a comparison of stars in the image against the UCAC4 (Mason & Hartkopf 2012) Catalog to determine an accurate position. Once this was determined, the files were saved and imported into Mira Pro x64 for measurement.

Mira Pro x64 was used to locate and measure position angle (Theta) and separation (Rho) between stars in each pair for this double star system. These measurements were made with the aid of algorithms capable of locating each stellar centroid given correctly adjusted and processed images. Theta and Rho for each image were then calculated and recorded to an Excel spreadsheet. The Excel measurements were imported for a calculation of standard deviation and average for each pair.

Data and Results

All images were acquired on a single night through T32. Each measurement's statistics are outlined in Table 1. The 2017 measurements for Theta and Rho are outlined as the "Mean" for each pair. This is an average of the Theta and Rho from all 5 measurements. All pairs, including the new measurement for the BC pair, are outlined.

Discussion

The 120 second exposure time with a hydrogen alpha filter resulted in the A and B components having some overlap, Figure 2. However, through an analysis

Table 1. Final measurement and statistics for each pair.

MEASUREMENTS FOR WDS20327-8155				
Pair	Observations Used		Position (DeG.)	Separation (a.s.)
AB	5	Mean	300.7	10
		Std. Dev.	0.65	0.16
		Std. Err.	0.13	0.032
AC	5	Mean	196.7	12.3
		Std. Dev.	0.29	0.09
		Std. Err.	0.058	0.017
BC	5	Mean	163.3	17.7
		Std. Dev.	0.42	0.09
		Std. Err.	0.084	0.018

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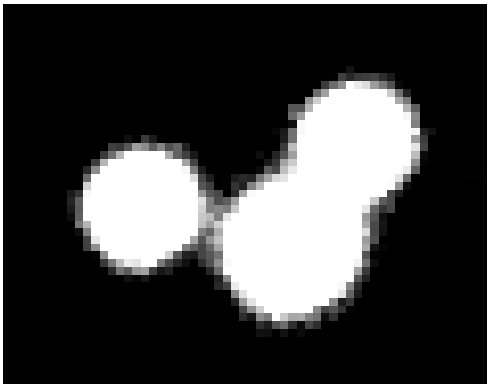

Figure 2. Hydrogen alpha filter with a 120 second exposure time

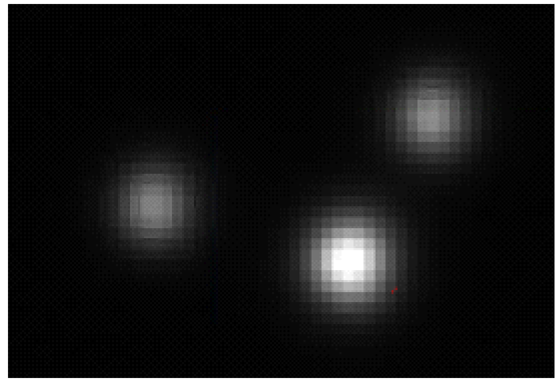

Figure 3. Luminance filter with a 60 second exposure time

of the centroids with Mira, this did not impact the stellar centroids and precise measurements were achieved. A 60 second exposure time with a luminance filter clearly distinguish all the components, Figure 3.

One issue encountered was the initial measurements taken by John Herschel in 1836 of the AB and AC components. Those measurements deviate significantly from the rest of the historical trend in the following years. All historical measurements for the AC and AB components are plotted in Figures 4 and 5 respectively.

When Herschel's measurement is removed from AB, a well-defined linear trend is established. As illustrated in Table 2, Herschel's measurement stated that the separation was 6.0 arc seconds, but removing that point shows a linear trend that involves a steadily increasing separation from 1.9 arc seconds to 8.35. The AC component, Table 3, also depicts the discrepancy between Herschel's points and the trend, as his measurements are significantly different than the rest.

Factoring in 2017 measurements, Figure 6 illustrates the new measurements in alignment with historical data. The points circled are the new measurements. All the points are labeled with their position first, then their separation second. The AB measurement follows the linear trend of the graph, while the AC measurement is similar to the previous measurement. The BC component measurement is new.

Conclusion

The 2017 measurements were in line with current trends for each pair. Processing the acquired star data through Mira x64, and deriving the resultant Theta and

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Table 2. Emphasizing the Discrepancy in the AB Measurements

AB Component Measurements				
Date	Theta	Rho	X	Y
1836.44	292.7	6	-5.53536	2.31544
1934.8	275.9	1.9	-1.88994	0.19531
1954.68	293.8	3.94	-3.60499	1.58997
1956	298.7	3.11	-2.72797	1.49350
1959.64	294.5	4.17	-3.79459	1.72927
1992.638	295.5	7.33	-6.61602	3.15565
1996.501	299.1	7.94	-6.93783	3.86150
1998.378	299.2	8.16	-7.12312	3.98093
1998.538	299.3	8.16	-7.11617	3.99336
2000.67	299.6	8.35	-7.26036	4.12441

Table 3. Emphasizing the Discrepancy in the AC Measurements

AC Component Measurements				
Date	Theta	Rho	X	Y
1836.44	198.1	9	-2.79559	-8.55464
1895.7	203.7	11.57	-4.65006	-10.59422
1895.71	200.6	11.51	-4.04922	-10.77405
1895.71	201.1	11.96	-4.30506	-11.15812
1918.82	198.8	12.24	-3.94408	-11.58699
1954.68	199.6	12.36	-4.14583	-11.64383
1956.1	194.7	12.04	-3.05489	-11.64590
1959.64	198.4	12.49	-3.94211	-11.85146
1996.501	196.5	12.25	-3.47895	-11.74554
1998.378	196.6	12.26	-3.5023	-11.749
1998.538	196.6	12.33	-3.5223	-11.8161
2000.67	196.3	12.25	-3.43794	-11.7576

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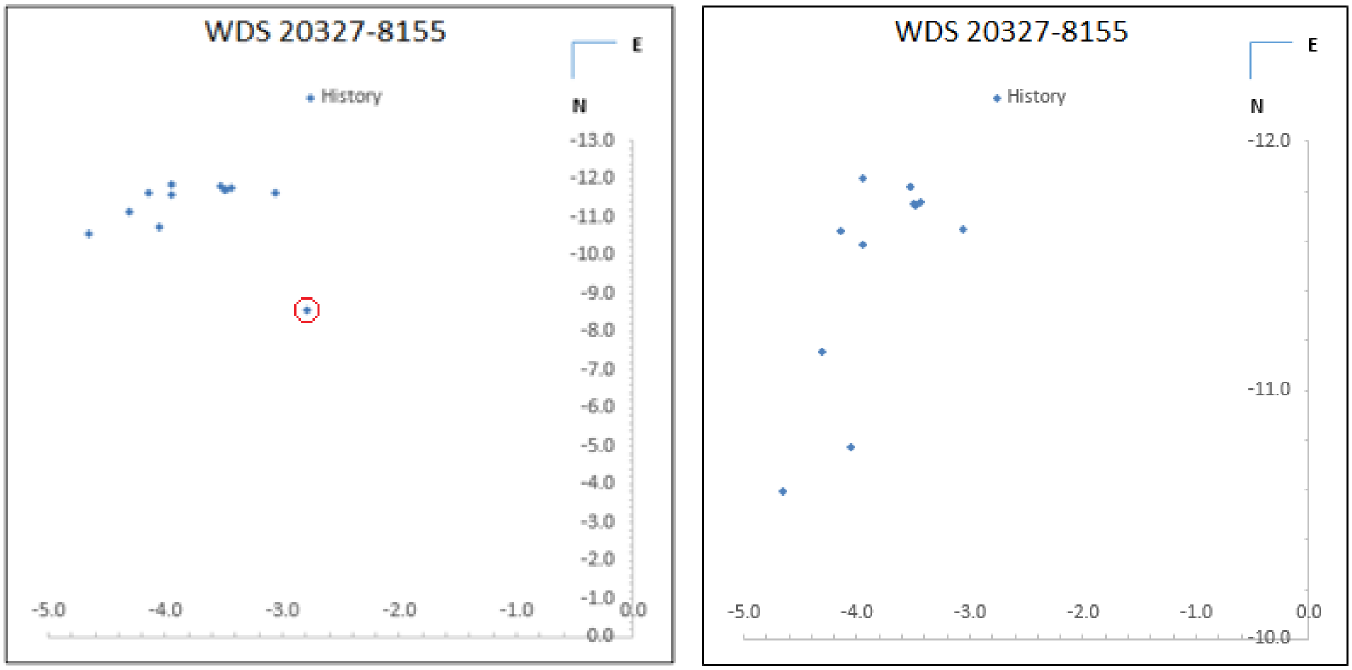

Figure 4. Plotted historical data for AC including John Herschel's 1836 measurement (left) compared to the plotted historical data for AC exempting John Herschel's 1836 measurement (right)

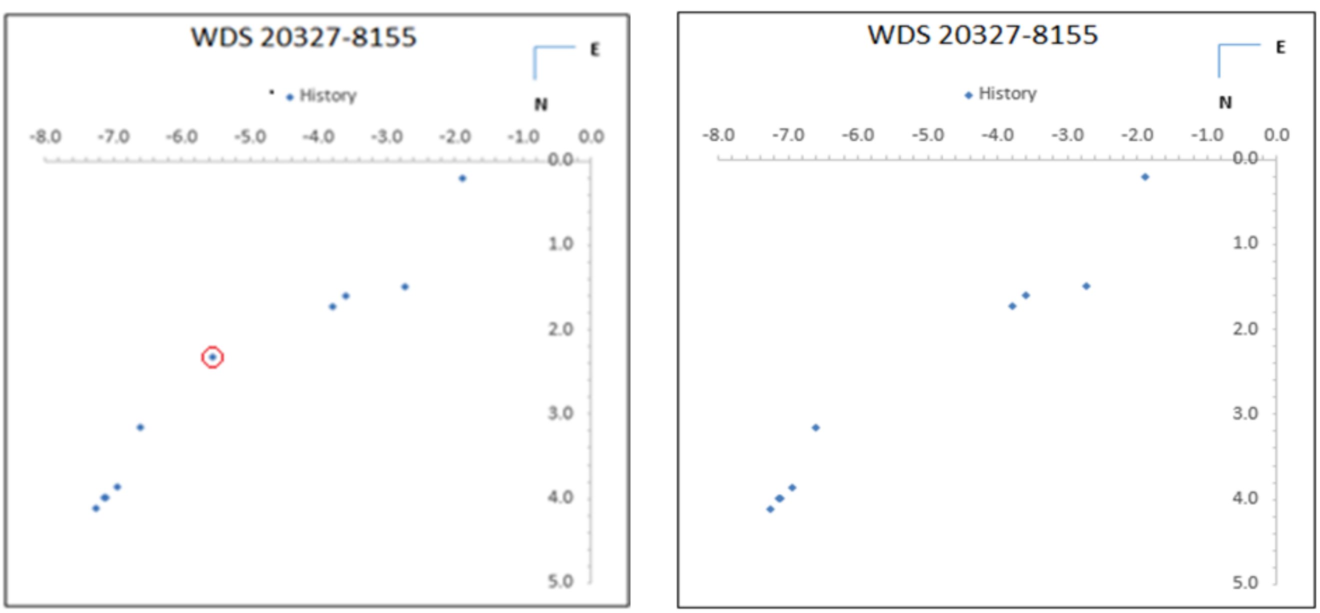

Figure 5. Plotted historical data for AB including John Herschel's 1836 measurement (left) compared to the plotted historical data for AB exempting John Herschel's 1836 measurement (right)

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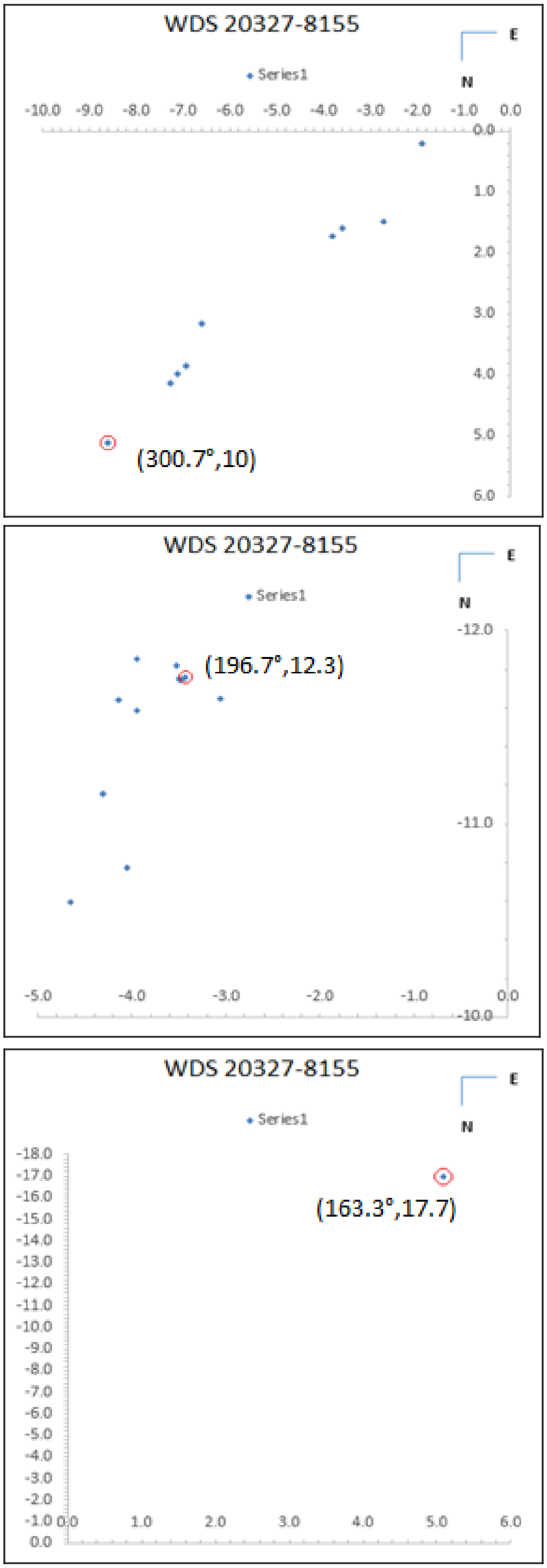

Figure 6. Updated measurements for the AB (top), AC (middle), and BC (bottom) components

Rho measurements, the plotted historical data, including the new measurements, suggest a highly irregular movement pattern which does not follow Newton's laws of motion. Historical information stated that the first measurement was made by the polymath John Herschel, and appears erroneous. When omitted from the data, a clear, linear projected path of movement is observed. Therefore, the conclusion was drawn that the system may not be gravitationally bound, but instead an optical alignment. Factoring in 2017 measurements, they are in alignment with historical data. The AB measurement follows the linear trend of the graph, while the AC measurement is similar to the previous measurement. The BC component measurement is new.

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