CCD Astrometric Measurements of WDS 08167+4053 using the iTelescope network

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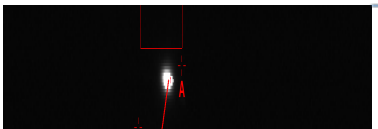
Abstract *Separations and position angle astrometric measurements were made of the multiple star system WDS 08167+4053 AB, AC, and BC components. Our measurements were compared with historical measurements from the United States Naval Observatory Washington Double Star Catalog and compared favorably with these historical observations.*

Introduction:

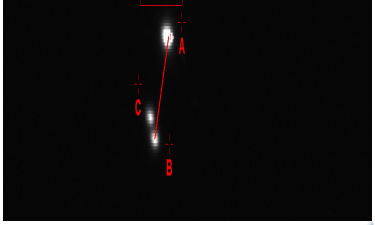
Our study was conducted as part of a college seminar provided by Cuesta eCollege supported, by the Institute for Student Astronomical Research (InStAR), and conducted by Boyce Research Initiatives and Education Foundation at the Army and Navy Academy (ANA). ANA is a college preparatory Middle and High School with a military structure focused on personal growth and leadership. Our team is shown if figure 1.

Figure 1: Team Nail - Left to right: Dewei Li, Junyao Li, Aren Dennis and Bill Riley.Taken at ANA.

The authors chose a system having a maximum delta magnitude difference of four between pairs. Otherwise the brighter star would outshine the dimmer stars. With a magnitude difference of four or less, all of the stars in the system could be clearly separated. The team also chose a system with a separation greater than 7.0 arc-seconds so that the components could be clearly resolved. The component magnitudes are 9, 9.9 and 10.1 for A, B and C respectively. We chose a system that had not been observed in last five years but had more than three observations so that we could compare our observations with historical values. The research and CCD imaging focused on double star WDS 08167+4053. Our team used the global iTelescope network to perform imaging and then used MaximDL v6 and Mirametrics Mira Pro x64 for astrometric analysis. Figure 2 shows Mira Pro measurement of a typical AB pair of WDS 08167+4053.



East



North

Figure 2: WDS 08167+4053 with AB pair marked in Mira Pro x64.

Equipment and Procedures:

The team used telescope T7 from the iTelescope network. T7 is a Planewave 17" CDK located in Nerpio, Spain elevation 5413 feet. We took images on two different nights with Luminance and Ha filters using three different exposure times. Telescope T7 and CCD camera specifications are show in figure 3.

T7 Planewave 17" CDK

Optical Design: Corrected Dall-Kirkham Astrograph
Aperture: 431mm
Focal Length: 2929mm
F/Ratio: f/6.8
Mount: Paramount PME

Instrument Package
CCD: SBIG STL-11000M
Anti-Blooming Gate (ABG)
Resolution: 0.63 arc-secs/pixel
Array: 4008 by 2672 (10.7 Mega pixels)
FOV: 28.2 x 42.3 arc-mins

Observatory: Nerpio, Spain

Figure 3. iTelescope Platform used in the Boyce Astro Binary Star Research Seminar.

Once the images were acquired they were preprocessed by iTelescope with the appropriate dark and flat images and downloaded to begin the research. For the CCD image plate solving, the authors utilized MaximDL v6 to perform astrometric calibrations which inserted World Coordinate System (WCS) positions into the FITS header. For this process, MaximDL typically found 179 out of a database of 790 stars in the CCD image, and then matched them to the Fourth U.S. Naval Observatory CCD Astrograph Catalogue (UCAC4).

Each image was then opened in Mirametrics Mira x64 Pro to find accurate position angles and separations of the components of our double star system. Having correctly identified the A, B, and C stars in this binary star system, each combination was measured for position angle and separation. Mira Pro assists accuracy in measurements by locating the centroid of each star being measured. The authors recorded the centroid RA and Dec, and then calculated the position angle and separation between the stars. We tabulated data in Microsoft Excel and calculated the standard deviation and standard error of mean from the astrometric results.

Results

The team took images using iTelescope T7 on two nights, epoch 2015.775 and 2015.795. Exposures of 60, 120 and 240 seconds with Ha and Luminance filters were used. Table 1 shows the observational results for pairs AB, AC, and BC of WDS 08167+4053 with the following data: Pair Name, Observations Used, Position Angle, and Separation. The authors provide the average of the measurements, standard deviation, and the standard error of the mean for separation in arc seconds and position angles in degrees.

			WDS 08167+4053	

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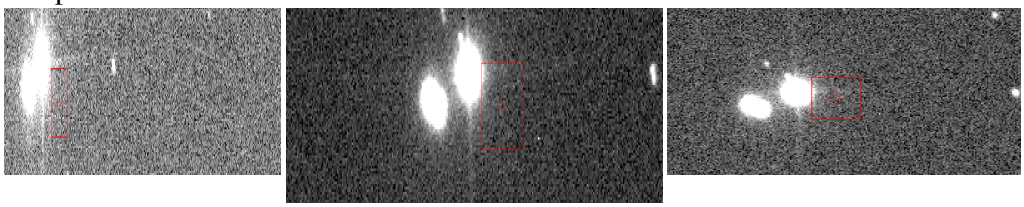
			WDS 08167+4053	
	Observations used		**Position Angle(degrees)**	**Separation(arcseonds)**
		Mean	344.6	20.8
AB Pair	19	Standard Deviation	0.36	0.02
		Std. Error of Mean	0.083	0.005
		Mean	333.8	17.8
AC Pair	25	Standard Deviation	0.82	0.10
		Std. Error of Mean	0.164	0.02
		Mean	209.7	4.74
BC Pair	19	Standard Deviation	0.32	0.03
		Std. Error of Mean	0.073	0.069

Table 1: Mira Pro measurement of the pairs of WDS 08167+4053.

A total of thirty two images were taken of our system. We determined that several of these images would give inaccurate results due to diffraction spiking and fused centroids. See figure 4. We used only images that had clearly defined components as shown in figure 2. By changing the sample radius in Mira x64 Pro the position angle varied by as much as one degree in these fused images. Some sample radii also produced an erroneous centroid falling between components B and C.



Diffraction spiking Luminance filter 120 second exposure

BC pair fused Luminance 120 second exposure

BC pair fused Luminance 60 second exposure

Figure 4. Typical examples of images with no measurement used.

X Y Plots:

We used Microsoft Excel to make a scatter plot of the XY position of each pair. The results are shown in figures 5. Our data is indicated by an amber hexagon.

The authors found two questionable historical observations (epoch 1957 and epoch 1983) with regard to the position angle. These points might require further investigation as they are several standard deviations from the mean. The mean for the rest of this data group is 341 and the standard deviation is 2.11.

Epoch	Position Angle	Separation	Note
1957.19	249.6	20.4	PA differs
1969.051	338.64	20.454	
1973.137	339.137	20.534	
1974.047	339.198	20.474	
1982.041	339.911	20.387	
1982.937	339.733	20.378	
1983.44	335.5	19.224	PA differs

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1984.216	340.292	20.452	
1987.14	340.403	20.382	
1987.263	341.8	20.47	
1987.263	341.3	20.54	
1989.938	341.161	20.534	

Table 3. Historical data AB pair. The two position angles appear questionable

Figure 5. XY plot of AB pair historical position. Our data is shown with a hexagon. Squares indicate component C and diamonds indicate component B. Questionable point at Epoch 1957 removed.

Historical Comparison of Data:

WDS Number Pair		Observation		Position Angle deg.			Separation arc-sec		
		WDS Historical		WDS Historical		New	WDS Historical		New
	#	First	Last	First	Last	2015	First	Last	2015
WDS	AB 20	1957.19	2010.265	249.6	343.8	344.7	20.4	20.88	20.8
08167+4053	AC 12	1969.052	1998.28	327.12	331.1	333.8	17.912	17.98	17.8
	BC 19	1894.31	1998.28	210	209.9	209.9	4.419	4.8	4.75

Table 2. Comparison with WDS Catalog data

Figure 6. XY plot of AB pair historical position. Our data is shown with a hexagon. Squares indicate component C and diamonds indicate component B. Questionable points at Epoch 1957 and 1983 removed. Slopes and lengths of AB and AC are very similar.

Figure 7. XY plot of BC pair historical position. Our data is shown with a hexagon. If the outlier points at Epochs 1895, 1957 and 1980 are removed there is no apparent movement between B and C.

Discussion:

Fusing of Stars:

Several measurements were dropped as some component stars blurred together. On some others spikes appeared giving an inaccurate centroid. Examples are shown in Figure 4. Potential fusing of a centroid happens when adjacent stars are close and one cannot accurately pinpoint the center of the component. Such a situation is common in stars with small separations. In our case the BC pair had a separation of only 4 arc seconds. This resulted in the blending of the two stars, and thus an inaccurate centroid. Stars B and C shown in figure 4 blend into each other and accurate measurements could not be obtained.

Different Proper Motion:

Trend line of the AB positions over time has a slope of -0.060 and a length of 1.87 arc seconds, and the trend line of the AC positions over time has a slope of 0.051 and a length of 1.96 arc seconds. In Figure 7 of the XY of BC over time if the three outliers are omitted, the points are tightly grouped. This data does not support the WDS classification of different proper motions.

Historical Observations:

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Conclusion

Our observed data was consistent with that of the USNO's. Our measurements show consistency and continue the trend. Our measurements do not support different proper motion of components B and C.

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