

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

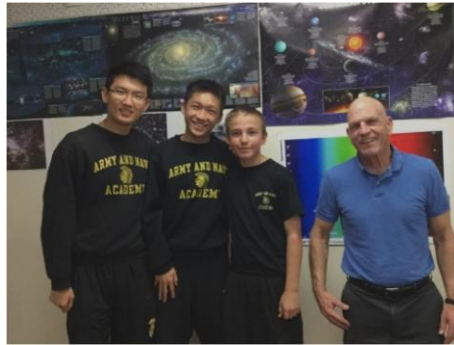
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3. Boyce Research Initiatives and Education Foundation

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

### Introduction

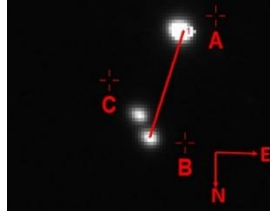
Our study was conducted as part of an Astronomy Research Seminar offered by Cuesta College, supported by the Institute for Student Astronomical Research (InStAR), and conducted by Boyce Research Initiatives and Education Foundation (BRIEF) at the Army and Navy Academy (ANA) in Carlsbad, California. ANA is a college preparatory Middle and High School with a military structure focused on personal growth and leadership. Our team is shown in Figure 1.



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

The selection criteria for observations were double stars having a maximum magnitude difference of four between the stars, angular separation greater than seven arc seconds, presently observable in the night sky, and lacking recent reported observations. Limiting the magnitude difference allowed the candidates to be clearly separated without stars of brighter magnitudes becoming overexposed during CCD imaging. Separations above seven arc-seconds ensure that the separate stars can be resolved on the CCD chip given the instruments used for this project.

WDS 08167+4053 matched the candidate criteria. This multiple star system lacks recent measurements, has a separation greater than 7.0 arc-seconds, and component magnitudes of 9, 9.9 and 10.1 for A, B and C stars respectively. Additionally, this system contains more than three published observations, allowing a comparison between the measurements of this paper against the historical values. Figure 2 shows WDS 08167+4053 in Mira Pro typical measurement of an AB pair.



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

### Equipment and Procedures

CCD measurements were completed using telescope T7 from the iTelescope network. T7 is a Planewave 17" CDK located in Nerpio, Spain at an elevation of 5413 feet. Images were taken on two different nights, with luminance and Ha filters, and three different exposure times. Telescope T7 and CCD camera specifications are show in Figure 3.



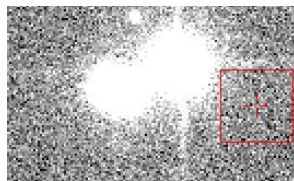
T7 Planewave 17" CDK

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

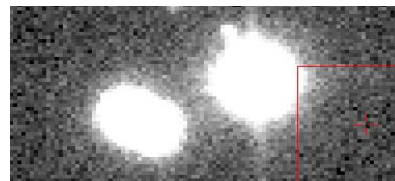
Instrument Package  
CCD: SBIG STL-11000M  
Anti-Blooming Gate (ABG)  
Resolution: 0.63 arc-secs/pixel  
Array: 4008 by 2672 (10.7 Mega pixels)  
FOV: 28.2 x 42.3 arc-mins  
Observatory: Nerpio, Spain

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

Images were acquired at epochs 2015.775 and 2015.795 with exposures of 60, 120, and 240 seconds using Ha and luminance filters for a total of thirty-two images. Several of the images, seen in Figure 4, were discarded due to diffraction spiking and fused centroids that were producing significant variances in position angle and erroneous centroids throughout several attempts to obtain accurate data from those images.



Diffraction spiking  
Luminance filter  
120 second exposure



BC pair fused  
Luminance120 second exposure

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

The remaining images were preprocessed (dark and flat subtraction) by iTelescope and then downloaded for analysis. MaximDL v6 was used to insert World Coordinate System (WCS) positions into the FITS headers through comparison of the image star field against the Fourth U.S. Naval Observatory CCD Astrograph Catalogue (UCAC4). During this process, MaximDL typically used approximately 180 stars out of a database of 790 stars for this particular star field.

Mirametrics Mira Pro x64 was used to locate accurate position angles and separations of the component stars. The A, B, and C stars were identified, marked, and then measured for position angle and separation through the algorithms of Mira Pro which are able of locating the centroid of each star. Each stellar centroid RA and Dec, calculated position angle, and angular separation between the stars were recorded and entered into Microsoft Excel to calculate the standard deviation and standard error of mean from the astrometric results.

## Results

Table 1 shows the average of the measurements, the standard deviation, and the standard error of the mean for separation in arc seconds and position angles in degrees of the AB, AC, and BC pairs of WDS 08167+4053.

<b>WDS 08167+4053</b>				
<b>Pair</b>	<b>Observations used</b>		<b>Position Angle (degrees)</b>	<b>Separation (arc seconds)</b>
<b>AB</b>	19	Mean	344.6	20.8
		Standard Deviation	0.36	0.02
		Std. Error of Mean	0.083	0.005
<b>AC</b>	25	Mean	333.8	17.8
		Standard Deviation	0.82	0.10
		Std. Error of Mean	0.164	0.02
<b>BC</b>	19	Mean	209.7	4.74
		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.

The comparison between these measurements and the published measurements in the WDS are found in Table 2.

WDS Number	Pair	WDS Hist.	Observation Epoch		Position Angle deg.			Separation arc-sec		
			WDS Historical		WDS Historical New			WDS Historical New		
			First	Last	First	Last	2015	First	Last	2015
WDS 08167+4053	AB	20	1957.19	2010.265	249.6	343.8	344.7	20.4	20.88	20.8
	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.** Table of Historical data from the WDS catalog indicating WDS First and Last measurements compared to our 2015 measurements.

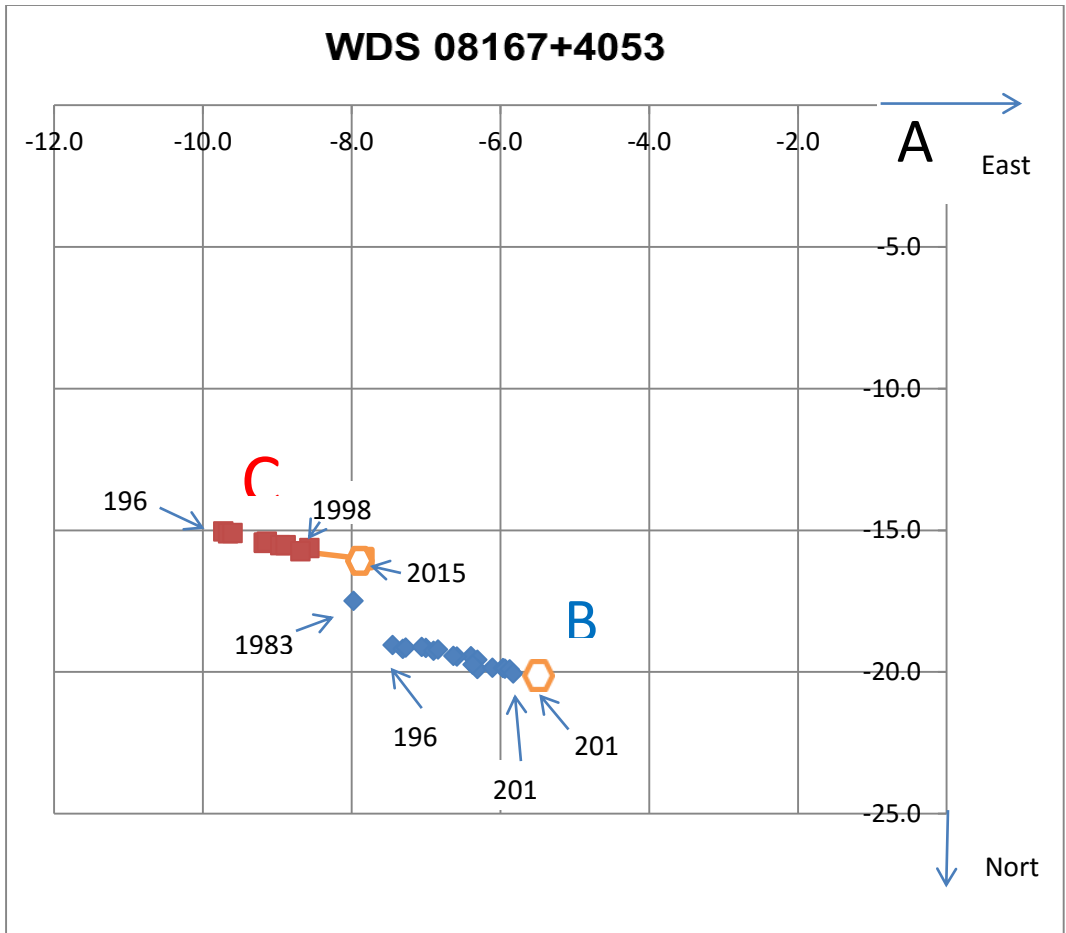
## Discussion

Several CCD images, and their respective measurements, were dropped due to the saturation and diffraction flaws described above. Fusing of stellar centroids in a CCD image occurs when adjacent stars are too close together on the CCD imaging chip, allowing the light from each star to blend preventing an accurate location of each independent stellar centroid. Such a situation is common in stars with small separations. In imaging this binary star system, the BC pair had a separation of only 4 arc seconds. This resulted in the blending of the two star's centroids, and thus inaccurate measurements. Review of the WDS historical data, Table 3, raised questions surrounding the historical measurements of two 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 data group is 341 degrees and the standard deviation is 2.11 degrees.

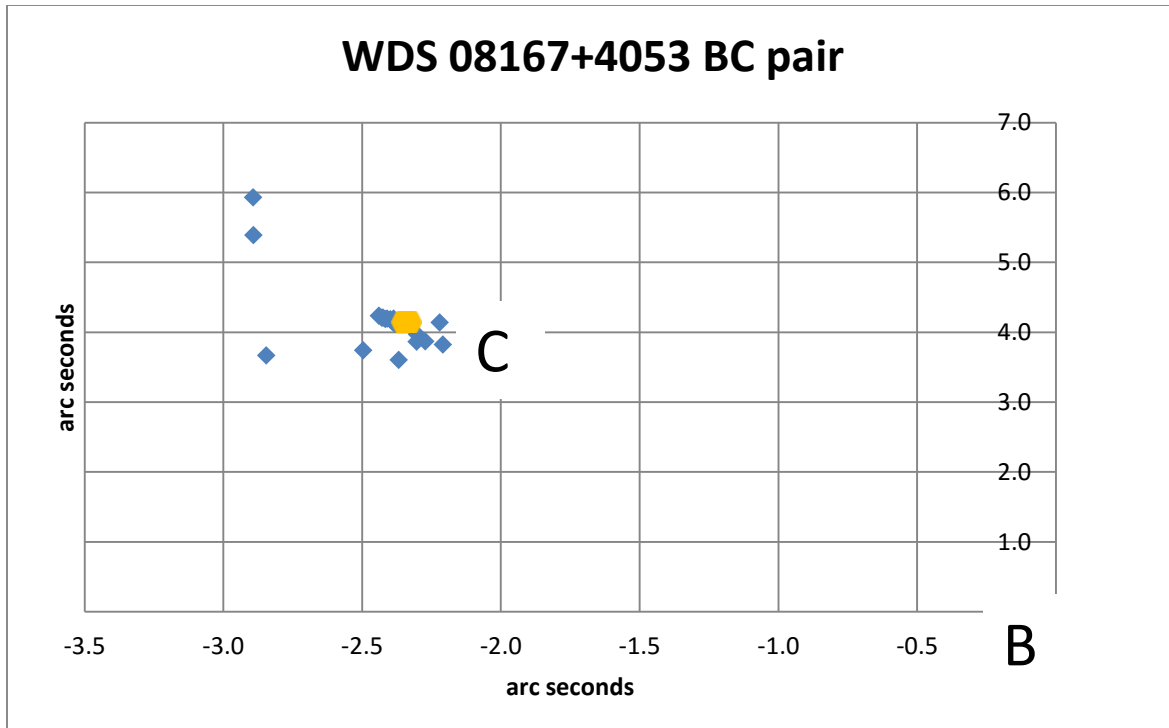
<b>Epoch</b>	<b>Position Angle</b>	<b>Separation</b>	<b>Note</b>
1957.19	249.6	20.4	*PA differs by 89.04 degrees
1969.051	338.64	20.454	
1973.137	339.137	20.534	
1974.047	339.198	20.474	
1982.041	339.911	20.387	
1982.937	339.733	20.378	
1983.44	335.5	19.224	
1984.216	340.292	20.452	
1987.14	340.403	20.382	
1987.263	341.8	20.47	
1987.263	341.3	20.54	
1989.938	341.161	20.534	
*Measured with a Micrometer possibly accounting for the ~90 difference in measurement trends.			

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

Microsoft Excel was used to develop a scatter plot of the XY coordinate position of each pair. The results are shown in Figures 5 and 6. The measurements from this activity are indicated by an amber hexagon.



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



**Figure 6.** XY plot of BC pair historical position. Our data is shown with an amber hexagon.

## Conclusion

Our observed data was consistent with that of the USNO WDS Catalog published measurements showing consistency and a continuation of the historical trend.

## Acknowledgements

The authors thank the United States Naval Observatory for providing historical measurement data and iTelescope for the use of their service. Additionally, we thank the Boyce Research Initiatives and Education Foundation (B.R.I.E.F.) for their generous financial donation that allowed us to use the iTelescope robotic telescope system and their proprietary software. We thank Mirametrics for providing access to Mira Pro x64 for accurate astrometric measurements of our binary star system. The authors thank Russ Genet for providing guidance.

## Reference

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