CCD Measurements of Common Proper Motion Pair CBL 125

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Abstract: Position angle and separation measurements from CCD images are reported for the common proper motion double WDS 05237-3819 CBL 125. Analysis of proper motion and parallax data suggests strongly that the components of CBL 125 are physically bound by gravity or, at the least, have a common origin.

Introduction

Double star WDS 05237-3819 (CBL 125) was selected for research as the focus of a course on double star astrometry at Mt. Everest Academy. These are the criteria that were used for selecting a double star research candidate: (1) the primary and secondary components had to be between magnitude eight and twelve with a magnitude difference of less than three to prevent the stars from blooming together during CCD imaging; (2) the separation had to be at least five arcseconds, because if they were too close together, they might be impossible to measure; and (3) the double had to be high enough in the sky at the telescope's location to get a good image with acceptably low atmospheric distortion and to avoid altitude limitations imposed by the observatory walls. CBL 125 met these criteria.

CBL 125 is in the southern constellation Columba. It was first recognized as a common proper motion pair by Caballero et al. in 2010 by using data mining techniques on the Positions and Proper Motions Extended (PPMX) catalog. CBL 125 was then added to the Washington Double Star (WDS) catalog and historical measurements were calculated using star coordinates obtained from the Astrographic Catalog (1906, 1912), Tycho-2 (1991), UCAC4 (1998), DENIS (1999), 2MASS (1999) and WISE (2010). Brian Mason of the United States Naval Observatory (USNO) remarked in private correspondence that CBL 125 has never before had a telescope pointed at it for the sole purpose of measuring it alone.

Figure 1. iTelescope T32, a PlaneWave 17" CDK

This project reports new measurements of CBL 125's position angle (theta) and separation (rho) obtained from CCD images and discusses the possibility

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Table 1. Measurement Details

WDS ID	Discoverer Code	Besselian Epoch	# of Exposures	Nights		Theta (degrees)	Rho (arcseconds)
05237-3819	CBL 125	B2016.7960	8	1	Mean	193.37	23.986
					STDEV	0.149	0.107
					SEM	0.056	0.040

of CBL 125 being gravitationally bound.

Equipment and Procedures

Eight FITS images of CBL 125 were acquired through the iTelescope network using Telescope T32 (Figure 1), located in Siding Springs, Australia. This is a PlaneWave 17" Corrected Dall-Kirkham (CDK) Astrograph Science and Imaging Platform with a focal length of 2912 mm, an aperture of 431 mm, and a focal ratio of f/6.8. The CCD camera is a FLI Proline 16803 with a resolution of 0.63 arcseconds per pixel, enough to enable high quality measurements. T32 was utilized because CBL 125 is not visible from the network's northern hemisphere locations.

Two images were taken using a Hydrogen-Alpha (Hα) filter with an exposure length of 120 seconds. Six images were taken using a Luminance filter: two with an exposure length of 60, two with an exposure length of 120, and two with an exposure length of 180 seconds.

Six additional images were taken on a separate night from the original eight, but the images were distorted to the point of obscuring all the stars. The images could not be measured. The distortion was likely caused by an imaging system error or software glitch. Those images were discarded from the study.

Measurements from one of the images resulted in a separation value more than ten arcseconds off the other measurements. It was then plate solved again and re-measured, which produced a more reasonable measurement.

The images were imported into MaxIm DL 6, software by Cyanogen Imaging, to plate solve the images with its PinPoint Astrometry function. PinPoint Astrometry automatically sets the pixel scale and image angle by reading the FITS header and matching stars within the image against the UCAC4 catalog. When a solution was found, the World Coordinate System (WCS) data was saved to the image and inserted into the FITS header.

The WCS calibrated images were imported one at a time into Mira Pro x64, an image processing application developed by Mirametrics. Mira's vertical transfer function was used to see the stars more clearly during the measuring process. The distance measuring tool was used to measure the position angle (theta) and the separation angle (rho). With the software set to automatically compute the star centroid, a line was drawn between the two stars and the distance tool automatically found the distance between them in arcseconds and the angle in degrees in relation to celestial north. The values were then copied into an Excel spreadsheet for analysis. Statistics were calculated from the data. The image times were averaged and the Besselian epoch was calculated. The equation used is listed below, where *JD* stands for the Julian date of the measurement (Greaney, 2012.)

Table 2. Comparison of Last and New WDS Measurements for CBL 125

	Last WDS Value	New Value	Difference
Epoch	2010.5589	B2016.7960	
Rho (arcseconds)	24.021	23.986	-0.035
Theta (degrees)	193.4	193.37	-0.030

$$BesselianEpoch = 1900 + \frac{JD - 2415020.31352}{365.242198781}$$

Results

Table 1 contains the mean of the new measurements, the standard deviation, and the standard error of the mean.

Discussion

The new measurements are very close to the most recent values from 2010, as shown in Table 2. CBL 125 has eight measurements of position angle and separation listed in the WDS as shown along with the new measurement in Table 3. Unfortunately, there were no measurements of this star between 1912 and 1991. The 1912 measurement obtained from Perth Observatory plates is a position angle of 192.2 degrees and a separation of 24.289 arcseconds, while the 1991 Hipparcos measurement is a position angle of 194.1 degrees and a separation of 23.808 arcseconds. The position appears to differ by almost two degrees during that time period, indicating a change. However, there are two incompatible values for rho reported from the 1906 Perth plates and more than a two degree difference in position com-

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Table 3. Measurements of CBL 125

Date of Measurement	Position Angle (degrees)	Separation Angle (arcseconds)	Source: Method
1906.06	194.8	22.765	Perth Observatory: Photographic, with astrograph*
1906.06	194.8	24.601	Perth Observatory: Photographic, with astrograph*
1912.05	192.2	24.289	Perth Observatory: Photographic, with astrograph*
1991.63	194.1	23.808	Tycho-2: Hipparcos space telescope
1998.963	193.5	24.037	UCAC4: ground-based CCD camera
1999.0775	193.5	24.06	DENIS (Deep Near-Infrared Survey): ground-based telescope
1999.173	193.43	24.06	2MASS (Two Micron All-Sky Survey): ground-based short-wavelength infrared telescopes
2010.5589	193.4	24.021	WISE (Wide-field Infrared Survey Explorer): infrared imaging space telescope
B2016.7960	193.37	23.986	Smith et al.: ground-based CCD camera

*Measurements are from a reduction of the Astrographic Catalogue data by the USNO.

pared to the measurement obtained from the 1912 Perth plate. It is possible that the two degree difference in position between 1912 and 1991 is due to errors in the early plates. Figure 2 contains a plot of the historical data with the new data point included.

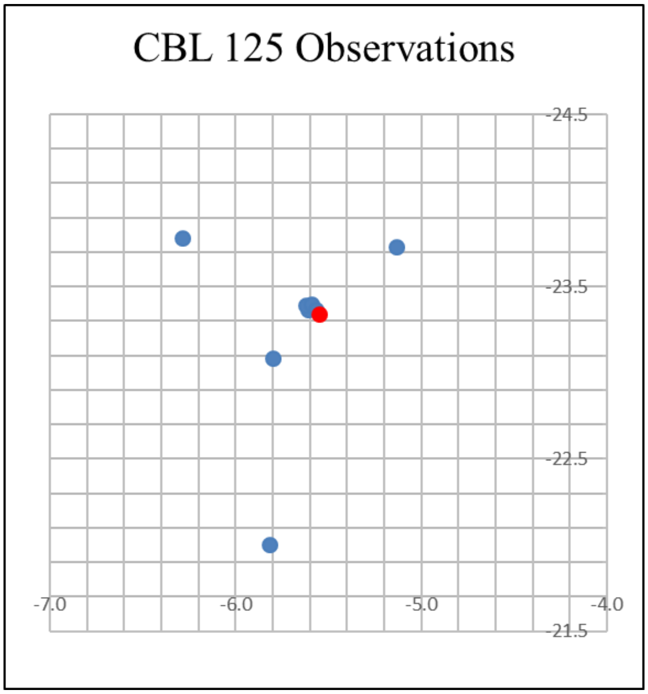

Figure 2. XY plot of historical and new position data of CBL 125B with CBL 125A off chart at (0,0). The new measurement is designated by a red circle.

Is CBL 125 a Physical Pair?

Physical pairs have similar proper motions. New data obtained from the Gaia survey (Gaia DR1) confirms that the components of CBL 125 have similar proper motion values (Table 4). The Gaia proper motions, displayed graphically in Aladin Sky Atlas (Figure 3), also show that the stars are moving through space together.

The stars in a physical binary cannot have significantly different distances from Earth. Gaia DR1 provides parallax data for both of CBL 125's components (Table 5). Parallax can be used to estimate the distance to celestial objects. The equation for determining distance with parallax to an object in parsecs is 1/parallax, given the parallax in arcseconds. The calculated distances shown in Table 6 are within one standard error which is consistent with the pair being in close proximity. CBL 125's common proper motion and close parallax values strongly suggest a physical relationship between the pair.

Table 4. Proper Motion of CBL 125 Components from Gaia DR1.

Component	PM RA (mas)	PM Dec (mas)
A	26.974 ± 0.901	40.753 ± 0.867
B	26.583 ± 1.062	41.912 ± 1.200

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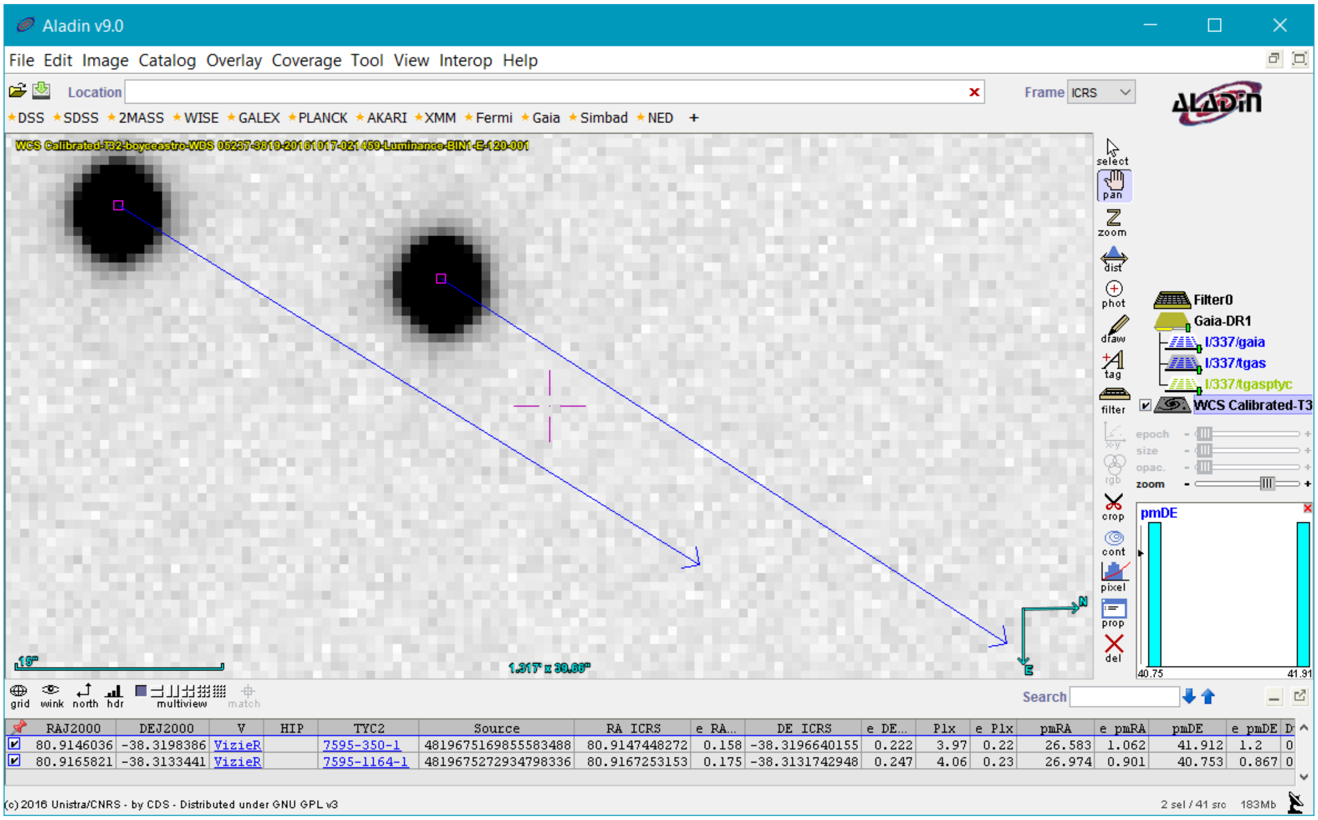

Figure 3. The proper motions (blue arrows) of CBL 125AB graphically displayed by Aladin Sky Atlas.

It is possible to estimate the minimum linear separation between two double stars using trigonometry. The tangent of an angle in a right triangle is equal to the opposite side divided by the adjacent side. Consequently, the linear separation (opposite side) is equal to the tangent of the separation angle multiplied by the distance to the system (adjacent side). For very small values, an angle is equivalent to its tangent. In the case of CBL 125, multiplying the separation angle of 23.986 arcseconds by the average distance to the system of 249.1 parsecs results in a linear separation of 5975 AU. While wider than most pairs, it could still qualify as a physical binary. This provides additional evidence of a physical relationship between the stars of CBL 125.

Table 5. Parallax data from Gaia DR1. All units are in milliarcseconds. The error is the sum of the individual error and the additional DR1 systematic parallax error of ±0.3 mas.

Components	Parallax	Error
A	4.06	±0.53
B	3.97	±0.52

Conclusion

The new 2016 measurements are very close to the most recent WDS values from 2010, with residuals of -0.035" and -0.030°. It cannot be concluded that CBL 125 is a true binary at this time. However, common proper motion and similar parallax values suggest that CBL 125 could be a wide binary with a very long period or, at the least, that its components have a common origin.

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Table 6. Calculated distance of CBL 125

	Parsecs			Light Years		
	Min Distance	Midpoint	Max Distance	Min Distance	Midpoint	Max Distance
A	217.86	246.31	283.29	710.24	802.96	923.51
B	222.72	251.89	289.86	726.06	821.16	944.93

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About the Authors: Team Gamma Ray Burst (Figure 4) is comprised of 8th grade Mt. Everest Academy students Schuyler Smith and Benjamin Shimabukuro, Mt. Everest Academy teacher Norman Negus, and San Diego Community College District instructor Randy Shimabukuro, who all attended the Astronomy Research Seminar at Mt. Everest Academy in Fall 2016 sponsored by BRIEF.

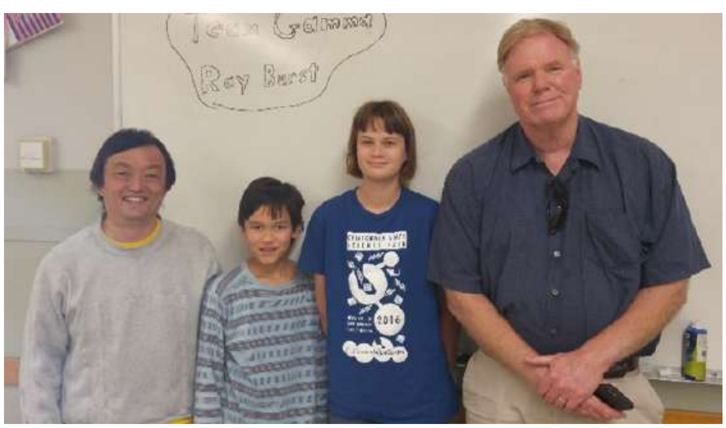

Figure 4. Left to right: Randy Shimabukuro, Benjamin Shimabukuro, Schuyler Smith, Norman Negus