CCD Astrometric Measurements and Historical Data Summary of WDS 12182-4251

Anushree Chaudhuri[1] and Grady Boyce[2]

1. Westview High School in San Diego, CA
2. Boyce Research Initiatives and Education Foundation (BRIEF)

Abstract: Precise astrometric coordinates, separation, and position angle of proposed binary system WDS 12182-4251 (DAM 1244) were determined from CCD (charge-coupled device) imaging analysis. The measurements acquired largely align with previously collected data available through databases such as the Washington Double Star (WDS) Catalog. Additionally, the historical data and other information available on this system have been gathered and examined.

Introduction

More than forty percent of the stars in the observable universe are gravitationally bound to one or more stellar components. By observing binary and multiple star systems, astronomers can determine whether a pair is gravitationally bound, and, if they are, determine their elliptical orbit, and consequently, the masses of the system's components. Since the mass of a star determines other properties, such as magnitude, spectral class, and luminosity, the accurate measurement of mass through binary star research is crucial to gaining a better understanding of the universe (Genet et al 2015). For this research, the candidate selection criteria were: presently visible with a Right Ascension (RA) between 10 and 16 hours to ensure the star was high enough in the sky to prevent atmospheric interferences, a separation between five and fifteen arcseconds to prevent merging cells on the CCD image while still observing a relatively close system, a magnitude difference less than five to prevent merging of centroids in the star image, and a number of observations greater than two but less than ten because this study focused on systems which did not already possess orbital solutions. Systems were chosen based on their proximity to these specifications.

Methods

An observing list was created from the Washington Double Star catalog (WDS), which contained systems matching the outlined specifications of separation, position angle, right ascension, differences in magnitudes, and number of observations (Mason & Hartkopf 2015). After requesting and examining historical data for several final candidates, WDS 12182-4251 (DAM 1244) was chosen as it most closely aligned with the decided specifications. Historical data of DAM 1244 from the WDS was analyzed to confirm the decision.

Figure 1. Exterior view of iTelescope 32, located at the Siding Spring Observatory in Australia.

CCD images of DAM 1244 were requested from

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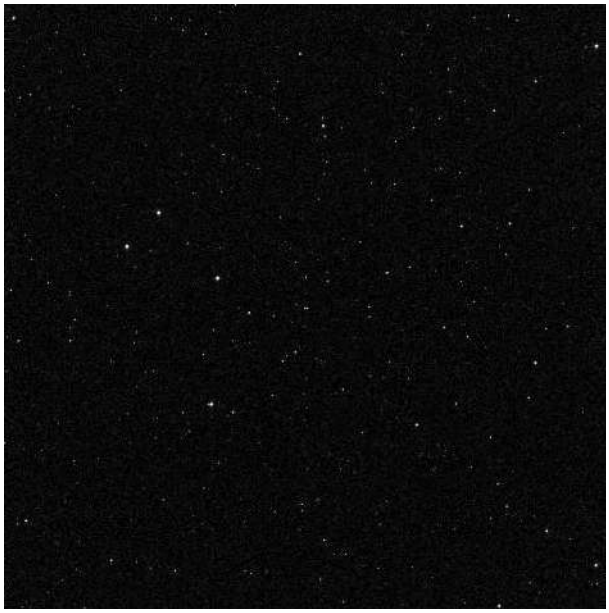

Figure 2. Unprocessed CCD image of WDS 12182-4251 under a blue filter with an exposure of 120 seconds.

Telescope 32 (T32) in the iTelescope network, located at an elevation of 1122 meters at the Siding Spring Observatory in Australia. T32, Figure 1, has a large CCD chip with a wide field of view, and a pixel scale of 0.63 arcseconds/pixel, complementing the imaging needs of this study.

Eight images were requested with varying exposure times and through different filters, as shown in Table 1.

Table 1. Number of images with filter and exposure time.

Filter	Images	Exposure (seconds)
Luminance	2	60
Luminance	2	90
Hydrogen alpha	2	180
Red	1	120
Blue	1	120
TOTAL:	8	

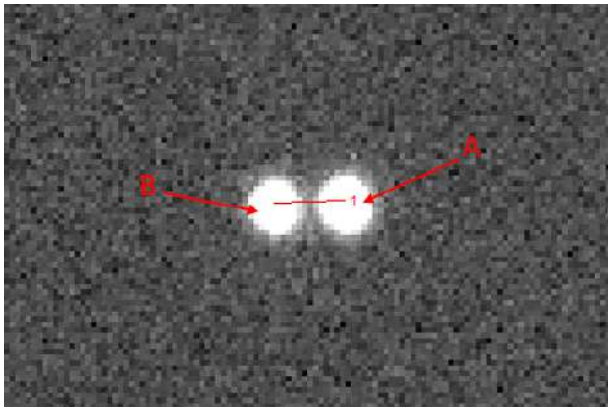

Figure 3. Processed CCD image of WDS 12182-4251 under a blue filter with an exposure of 120 seconds.

The luminance filter was used to provide a broad-spectrum view of DAM 1244. The other filters were used to limit photons to specific regions of the electromagnetic spectrum to narrow the stellar centroids for precise measurements.

Each individual image was processed through Maxim DL and plate-solved to embed the World Coordinate System (WCS) by comparing stars in the image against the UCAC4 catalog (Mason & Hartkopf 2012). MiraPro x64, a software from Mirametrics, was used to determine position angle (Theta), separation (Rho), and precise astrometric coordinates. The software located the centroids of the A and B components to accurately measure Theta and Rho between the stars. The measurements were recorded in a Microsoft Excel spreadsheet enabling statistical analysis of the data to determine the mean, standard deviation, and standard error of the mean. Figure 2 is a sample CCD image before processing. Figure 3 displays a CCD image after plate-solving and making astrometric measurements with MiraProx64.

Results

Table 2 shows the mean, standard error of the mean, and standard deviation for DAM 1244 Theta and Rho. Precise astrometric coordinates as measured in this study are also provided. Table 3 shows the raw data from all the images taken in this study.

Table 2. The mean, standard error of the mean, and standard deviation for astrometric measurements of WDS 12182-425.

Images	Statistics	Theta	Rho	Right Ascension	Declination
8	Mean	179.20°	8.47"	12n 18m 09.79s	-42° 50′ 34.11"
8	Standard Deviation	0.01°	0.04"	0.01	0.05
8	Standard Error of the Mean	0.006°	0.019"	0.003	0.024

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Table 3. Summary of raw data from CCD image measurements made in this study

Epoch (Julian Date)	Image	Exposure (seconds)	Theta (°)	Rho (")
2457845.39454	Luminance	60	179.245	8.4974
2457845.39454	Luminance	60	179.192	8.5004
2457845.39454	Luminance	90	179.215	8.4527
2457845.39454	Luminance	90	179.183	8.4878
2457845.39454	H-alpha	180	179.223	8.4711
2457845.39454	H-alpha	180	179.212	8.4767
2457845.39454	Red	120	179.214	8.4642
2457845.39454	Blue	120	179.190	8.4414

Discussion

CCD Image Measurements

No images were omitted from the final data as none contained concerning errors in diffraction or saturation, despite the relatively small separation between the A and B components. However, it was noted that the images under H-alpha filters experienced a substantial amount of image noise, Figure 4. Image noise is defined as random variations of brightness or color information and is usually produced by an excess of electrical fluctuation in the sensor/circuitry of a digital camera. The H-alpha images were taken with an exposure of 180 seconds; increasing exposure time for narrow spectrum filters, such as H-alpha, may help to improve image quality in the future. Plate-solving for all images was satisfactory.

WDS Historical Data

Table 4 shows previous historical measurements and data available for DAM 1244 from the US Naval Observatory. Using Richard Harshaw's (2014) classification system for common proper motion pairs (CPMs), the proper motion measurements for this system have been analyzed. Harshaw's ratings are calculated by normalizing values using an addition of the proper motion vectors. This results in a calculated statistic, or "rating", which classifies the pair's motion. Ratings close to 0.0% indicate an orbital relationship, while ratings close to 100.0% indicate an optical pair. The A component of DAM 1244 has a proper motion of [-17 -19], while the B component's proper motion is [-17 -25]. The system has a calculated rating of 0.002%, which indicates that it is a common proper-motion pair. Figure 5 shows a Microsoft Excel scatterplot of the XY coordinates of historical measurements.

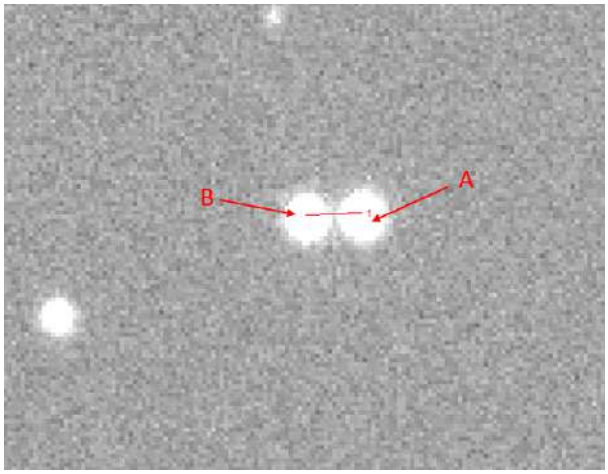

Figure 4. An H-alpha image which experienced a significant amount of image noise.

SIMBAD Data

A note included in SIMBAD, an online astronomical database, states that the A component of WDS 12182-4251 is at a distance of 844.3 kiloparsecs. As there are no references available for this statement, it is unclear if this data is accurate.

Table 4. Current measurements and data available on WDS 12182-4251; measurements before 2017.244 are courtesy of the Washington Double Star Catalog.

Epoch	Theta	Rho	Measurement Type
1899.385	173.0°	8.48"	Pa – Photographic with an astrograph
1988.130	178.7°	8.43"	Eu – UCAC Catalog
1999.345	178.7°	8.43"	E2 – 2MASS Survey
2000.341	178.8°	8.42"	Ed – DENIS Survey
2017.244	179.2°	8.47"	C – CCD/Two-dimensional Electronic Imaging

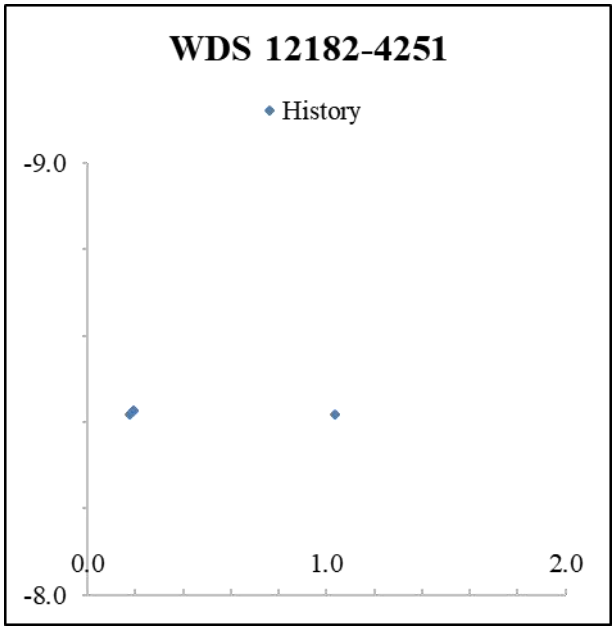

Figure 5. A scatterplot of previous measurements of DAM 1244.

Conclusion

Data from this study suggests that there has been a small increase in both separation and position angle for DAM 1244 since its first recorded measurement in 1899. The four previous measurements from the WDS Catalog are generally consistent with the current astrometric coordinates of the system. The proper motion measurements of the A and B components have been analyzed, and DAM 1244 may be considered a common proper motion pair (CPM) until more accurate data is obtained. According to Harshaw's classification system for CPMs, the rating of DAM 1244 also suggests that the pair may have an orbital solution. Therefore, while no conclusive claims can be made on the nature of this system as of now, there is a possibility that WDS 12182-4251 is gravitationally bound, despite there having been no drastic changes in motion.

Acknowledgments

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References

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Anushree Chaudhuri is a student from Westview High School in San Diego, California. She is passionate about STEM subjects and the physical sciences. The Astronomy Research Seminar presented an ideal opportunity to deepen her knowledge and experience in the field of astronomy and astrophysics.