CCD Study of WDS 15098-0445

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Abstract: Astrometric measurements of WDS 15098-0445 were obtained using the iTelescope Network. The distance between the A and B components was found to be 26.314" and the position angle was found to be 35.197°. The distance between the A and C components was found to be 607.927" and the position angle was found to be 217.868°. The change in the AC pair is consistent with past data, which indicates it is an optical double. The change in the AB pair indicates it is also an optical double.

Introduction

WDS 15098-0445 is a triple star system in which the AB pair was first measured in 1999 and the AC pair was first measured in 1920. The AB and AC pairs have discoverer codes of OSO and LDS, respectively, which identify the original measurements. This star system was selected for research from the Washington Double Star Catalog (WDS) because it possessed the following characteristics: The AB pair had few measurements and had not been measured since 1999, the AC pair had first been measured in 1920 and most recently measured in 2000, and was listed as an optical double (Mason & Hartkopf, 2012). These characteristics were desired because the researchers wanted to provide more data for a system that had been overlooked. Additionally, because the AC pair was an optical double and initial research using the online double star search engine, Stelle Doppie, indicated that the A star is a "high proper motion star" (SiMBADWeb), the researchers hypothesized that the AB pair was also an optical double.

The AB pair, with three measurements spanning a period of four years (1995-1999), has shown relatively high changes in position angle (Theta) and separation (Rho) for stars separated by a Rho of 20 arcseconds (20"). Over a period of 80 years, the separation of the AC pair has changed by 64", with an average change of almost an arcsecond per year. The measurements from this paper show significant movement since 2000 for both pairs.

Materials and Procedure

The AB components have a differential magnitude of 5 while the AC components have similar magnitudes. Given the differential magnitudes and separations, many of the iTelescope Network's telescopes were suitable imaging platforms. Additionally, because the declination of the system is near the celestial equator, all iTelescope locations were able to image this double star.

iTelescope T3, a one-shot color imaging system located in Nerpio, Spain, was chosen to image both pairs. In the original set of images, the B component was not visible, thus the images were not usable. The second set of images was obtained using the Mayhill, New Mexico Telescope 11 (T11) in the iTelescope network. The imaging session utilized hydrogen-alpha, red, and luminance filters. All components of the system were visible using the T11.

Images were downloaded from the iTelescope FTP site and imported into MaximDL to calibrate each pixel in the images with the World Coordinate System (WCS) Right Ascension and Declination. The WCS calibrated images were imported into Mira Pro x64 to measure Theta and Rho values. This data was then imported into Microsoft Excel to organize each measure and for statistical analysis.

Data and Results

Both the AB and AC pairs were successfully captured in seven images. Tables 1 and 2 provide the meas-

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Table 1. Mira Pro measurement of the AB pair of WDS 15098-0445

AB Pair	Position Angle (degrees)	Separation (arc seconds)
Individual Measurements	35.47	26.29
	35.30	26.29
	35.20	26.29
	35.74	26.29
	34.52	26.24
	34.98	26.36
	35.18	26.44
Mean	35.20	26.31
Std. Dev.	0.385	0.385
Std. Error of Mean	0.146	0.025

Table 2. Mira Pro measurement of the AC pair of WDS 15098-0445

AC Pair	Position Angle (degrees)	Separation (arc seconds)
Individual Measurements	217.863	608.15
	217.868	608.18
	217.868	608.17
	217.864	607.95
	217.863	607.66
	217.874	607.69
	217.877	607.69
Mean	217.868	607.93
Std. Dev.	0.006	0.244
Std. Error of Mean	0.002	0.092

urements for each image individually as well as the mean, standard deviation, and standard error of the mean. The precision afforded via the Maxim and Mira software provides measurements to three significant figures. These were included in the Tables; however, to match historical measurements the values were rounded to match the precision of the WDS Catalog in Tables 3 and 4.

Discussion

AB Pair

The primary star in the AB pair is referenced by many catalogs, with SiMBAD specifically identifying the star as WOLF 1137, named after German Astronomer Max Wolf who compiled a catalog of over 1,500 low-luminosity, high proper motion stars, of which this star is the 1,137th in that catalog (SimBAD Web).

The first recorded data for this pair is from the Hipparcos mission in 1991 in which the location and magnitude of the A component was measured (HIPPARCOS). Osorio & Martin measured the AB pair in their paper, *A CCD Imaging Search for Wide Metal-Poor Binaries* (Osorio & Martin, 1995). The last reported measurement was recorded in 1999 by the Two-Micron All Sky Survey (2MASS).

Locating the AB pair in the T11 images was difficult due to the large difference in magnitude between the stars. There were a few candidate stars close to A, but none with a similar Theta and Rho to the last reported measurement. To locate the B component, ALADIN was used to obtain the image from 1999 from the 2MASS survey to compare with the Theta and Rho measurements of 51.7^{o} and 21.0" in the WDS (see Figure 1) (ALADIN).

After the B component was located, the 2017 T11 images indicated a Theta of 35.2^{o} and Rho of 26.4", a change of 16.5^{o} and 5.4" (see Figure 2). Measuring

Table 3. Historical data for the AB pair.

Epoch	Position Angle (degrees)	Separation (arcseconds)
1995	20.19	56.8
1999	20.99	51.6
1999	21.06	51.5
2017	*35.19*	*26.3*

Table 4. Historical data for the AC pair.

Epoch	Position Angle (degrees)	Separation (arcseconds)
1920.	225.00	677.0
1991.25	-	677.0
1999.20	217.30	614.04
1999.44	217.10	612.8
2000.268	217.30	613.5
2017	217.86	607.9

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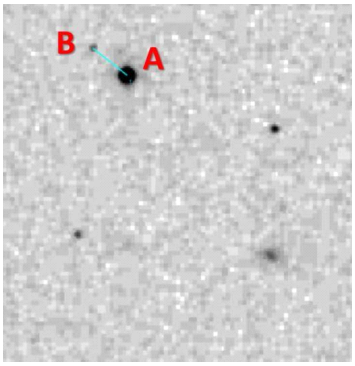

Figure 1. 2MASS image of AB from epoch 1999.

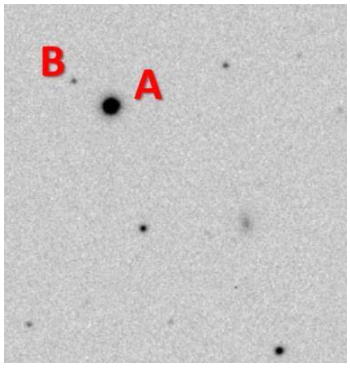

Figure 2. 2017 T11 image of AB from epoch 1999.

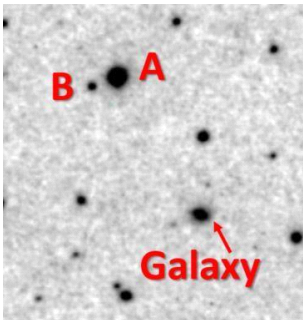

Figure 3. 1955 Palomar Sky Survey image from ALADIN.

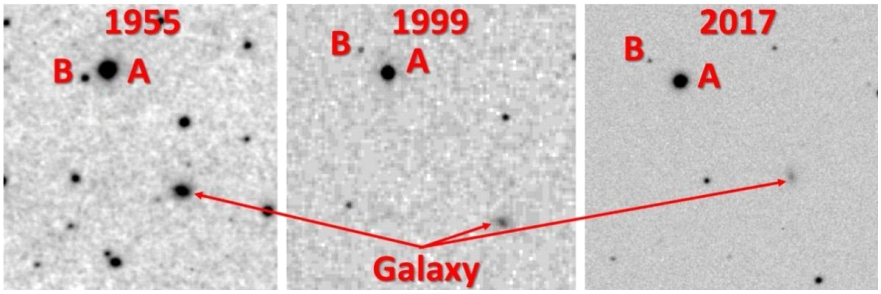

Figure 4. 1955-2017 image comparison

such a significant change in only 18 years raised doubt as to whether the 2017 T11 images correctly imaged the B component. To determine an accurate position for B, ALADIN was again consulted to obtain older images (ALADIN).

ALADIN provided access to the Palomar Sky Survey from 1955. This image was downloaded and imported into Mira to measure the star field. At first review, the area surrounding the AB pair did not resemble the previous images (see Figure 3). To establish the precise location of the B star in each image, a fixed background galaxy was used as a reference from which a galaxy-to-B component Theta and Rho measurement could be made. This measurement was then compared to the position of the B component in the 1999 and 2017 images with consistent results. Thus, the location of B was firmly established and the measurements from the 2017 T11 epoch were confirmed.

Reviewing the images obtained from ALADIN and the 2017 epoch, Figure 4 illustrates the motion of the primary A star against the background stars. Given its proper motion, the distance and angle changes, and the consistent position of B, it can be concluded that WDS 15098-0445 is an optical double and not a physically bound binary star.

AC Pair

The WDS notes indicate that the AC component (Figure 5) has already been established as an optical double (Mason and Hartkopf, 2012). The A component, as discussed above, is observed to have high proper

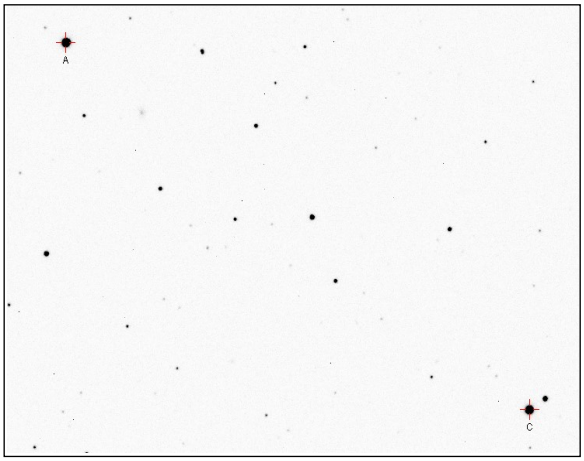

Figure 5. 2017 T11 image of the AC components.

motion which accounts for the historical Theta and Rho changes. The data from the 2017 images was consistent with the conclusion that the AC pair is an optical double.

Conclusion

The high proper motion of the A star accounts for the historical changes in Theta and Rho for both components. Through the use of a stationary background galaxy over short time frames, the position of the B component was correctly identified. From the historical data and the images obtained from ALADIN and 2017, we conclude that the AB pair is an optical double. The changes in the AC components were consistent with historical data.

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