Gaia and CCD Measurements of WDS 07195+4939AC

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Abstract: Images of WDS 07195+4939AC were obtained using the Great Basin Observatory Telescope. Position angle and separation of the A and C components were measured and compared to previously obtained measurements. Our measurements are consistent with previous ones, showing linear motion for the C component and suggesting that these components are not physically bound. Gaia measurements show that component A is at a distance of ~275 pc and component C is at a distance of ~675 pc further suggesting that the A and C components are not a gravitationally bound pair.

1) Introduction

For this project, we investigated whether WDS 07195+4939AC is a physically bound system. We searched the Washington Double Star Catalog (WDS) and selected WDS 07195+4939AC for observation because its right ascension, magnitude, and location were such that it could be observed by the Great Basin Observatory (GBO) telescope. This binary system was first observed in 1999, with 8 more observations, the most recent of which was in 2015. In order to help determine if the A and C components are physically bound, we made measurements of the current position angle and separation.

Methods

The Great Basin Observatory in Great Basin National Park was used to collect our images. The GBO is managed by the Great Basin National Park, the Great Basin National Park Foundation, as well as Southern Utah University, Concordia University, University of Nevada-Reno, and Western Nevada College. The GBO telescope is a PlaneWave 0.7m CDK 700, with an SBIG STX-16803 CCD camera, which gives a plate scale of 0.4 arcsec per pixel. The GBO's focal ratio is f/6.5 and, combined with the camera, provides a field view of 27X27 arcminutes. The telescope is equipped with 16 filters: LRGB, Ha, OIII, SII, BVRI, g'r'i'z', and a diffraction grating (Anselmo et al. 2018).

A total of 17 images of WDS 07195+4939AC were remotely acquired on February 15, 2020 (Figure 1). The exposure time for these images was 180 seconds. We plotted a seeing profile for the stars to confirm that they were not overexposed and confirmed that they were not. The V filter was used for the exposures, and the images were binned 1x1. The images were later plate-solved using the plate-solving feature available at http://nova.astrometry.net/ (Lang 2010), and calibrated through the use of bias, dark, and flat frames using AstroImageJ version 3.2.27 (Collins et al. 2017). AstroImageJ was also used to measure separation (ρ) and position angle (θ) of the stars. In order to improve accuracy, the center of each star was selected using the centroid feature. Finally, the data was transferred to Excel for calculations of the mean, standard error (for ρ and θ), and the standard deviation.

Results

Table 1 shows the mean, standard deviation, and standard error of our separation and position angle measurements.

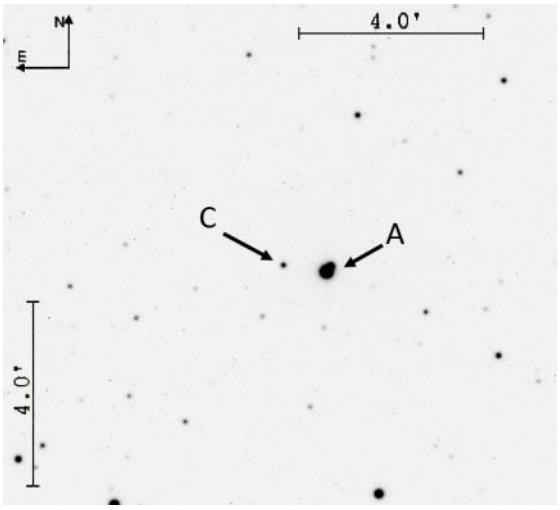

Figure 1: Image of the A and C components of WDS 07195+4939. This image has a plate scale of 0.4 arcsec/pixel.

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WDS No.	Nights	Date	Images		θ°	ρ″
07195+4939AC	1	Feb. 15, 2020	17	Mean	80.90	57.53
				Std. Dev	0.05	0.10
				Std. Error	0.01	0.02

Table 1: Observations from the data collected. Position angle (θ), Separation (ρ), mean, standard deviation, and standard error.

Discussion

As shown in Table 2, there are 8 measurements of the A and C components of WDS 07195+4939 in the Washington Double Star Catalog (Mason 2020). The first measurement was recorded in 1999, and the most recent is from 2015. The measurements in this table, as well as our recent measurement, are plotted in Figure 2, together with a linear fit and the R2 value. This figure shows that the C component is moving in a linear fashion, suggesting that the A and C components are not physically bound.

The history of measurements for this system is somewhat complex. The measurement from 1999 is from the 2MASS Catalog, while the 2003.07 measurement is from the UCAC4 catalog. The measurement from 2003.249 is that of the discoverer, Berkó et al. 2004, and this observation was acquired with a CCD on a 0.4m telescope. Berkó et al. 2004 do not provide the details of how they measured the separation and position angle, so we are unsure why their measurement is so different from the rest, being the measurement that is farthest down the linear fit shown in Figure 2.

To further investigate the motion of this system, we extracted parallax and proper motion data from the Gaia DR2 database (Gaia Collaboration et al. 2018). Table 3 shows these data for WDS 07195+4939 AC. It should be pointed out that uncertainties for Gaia DR2 parallaxes are published source by source, and their size depends on a variety of factors (Luri et al. 2018). The parallax uncertainties depend mostly on position on the sky and magnitude rather than on distance to the star. Furthermore, Luri et al. 2018 point out that the DR2 parallax uncertainties tend to be underestimated by ~10% for faint sources and up to ~30% for bright sources outside the galactic plane. In other words, evaluating the accuracy of parallax measurements based on their value alone (i.e. considering all parallaxes smaller than 5 mas as suspect) is a simplistic assumption.

Nevertheless, the Gaia parallax measurements in Table 3 show the A component to be at a distance of ~275 pc, while the C component is ~675 pc away. Both the A and C components are considered "bright" by Gaia standards, so their parallax uncertainties could be underestimated by 30%. Even if this is the case, it would appear that the parallaxes of these stars are sufficiently different to suggest that these components are not physically bound. This is further confirmed by the differences in their proper motions, although we should keep in mind that even gravitationally bound stars can exhibit differences in their proper motions, depending on where they are in their orbits.

Epoch	θ°	ρ″
1999.18	80.7	57.21
2003.07	80.8	57.329
2003.249	81.01	57.61
2012.981	80.88	57.392
2013.9949	80.88	57.478
2014.050	80.90	57.397
2015.0	80.927	57.440
2015.065	80.92	57.400

Table 2: Historical Data for WDS 07195+4939AC.

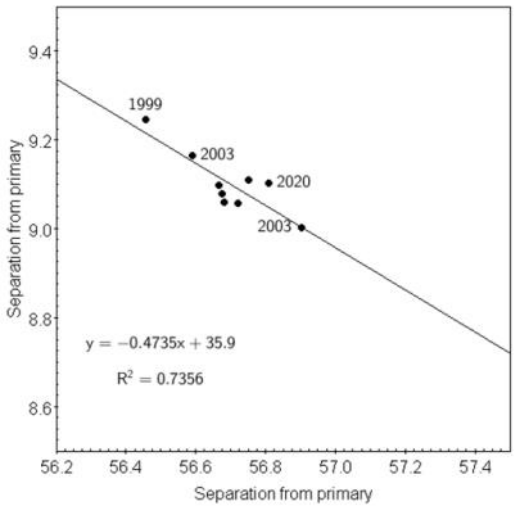

Figure 2: A plot of our measurement and the historical measurements of the system, in arcseconds. A linear fit and its parameters is shown. It can be seen that the motion of the B component is roughly linear, although one of the measurements from 2003 appears to be spurious.

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Component	Parallax (mas)	Distance (pc)	Proper Motion RA (mas/yr)	Proper Motion DE (mas/yr)
A	3.513±0.178	271-300	-10.024±0.240	-2.160±0.169
C	1.485±0.027	661-686	2.005±0.041	-10.538±0.028

Table 3: Parallax and proper motion data from ESA's Gaia database. These data indicate that this is not a gravitationally bound system.

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