New Measurements of WDS07204+2344, WDS 07205+2340, WDS 07204+2353, and WDS 07204+2339

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Abstract

We obtained 10 images of the star systems WDS 07204+2344, 07205+2340, 07204+2353, and 07204+2339 from the Las Cumbres Telescope Network. These images were analyzed in AstroImageJ to determine if these stars are physical pairs. The plots we created of historical data, obtained from the US naval observatory, combined with the Gaia data indicate that none of the systems are physical.

Introduction

We set out to research the star system WDS 07204+2344 (Figure 1). Furthermore, the neighborhood of this system is rich, with three other star systems within the same field of view: WDS 07204+2399, WDS 07204+2353, and WDS 07205+2340. In this paper, we provide new measurements for these systems as well. For the star system WDS 07204+2344, there are 12 data points, including ours; the earliest was recorded in 1892, and the most recent in 2021. The earliest observation of each of the other star systems was recorded in 1954. The goal of our research was to determine if these systems are physical.

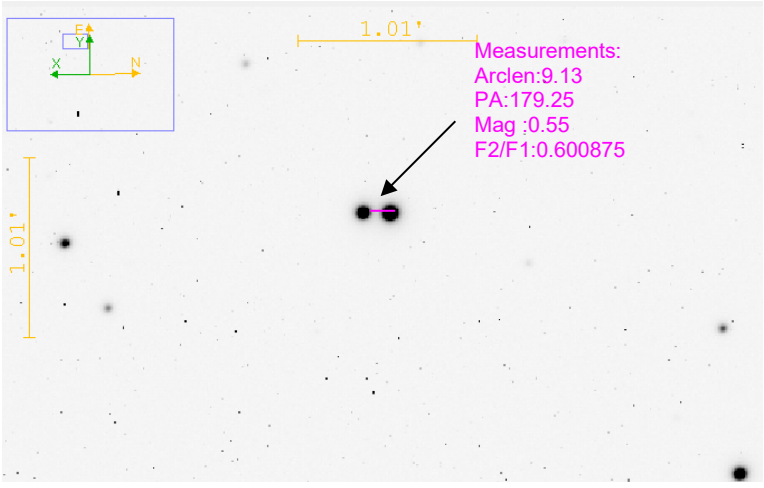

Figure 1: Star system WDS 07204+2344, shown with measurements taken in AstroImageJ.

Methods

We requested images of the star system WDS 07204+2344 from the Las Cumbres Telescope Network. The telescope at the observatory has a diameter of 0.4 meters and a sloan r' filter was used while taking the photos. We received 10 images, which were taken on March 17, 2022. The images had an exposure time of 5 seconds and were binned 1 x 1. After we received the photos, we used AstroImageJ (Collins, 2017) to verify that they were not overexposed. Two photos were deemed unusable because the stars had trailed and their measurements were removed. We then used AstroImageJ software to determine the rho and theta measurements for all four systems in each image.

Star		Rho (Arc Seconds)	Theta (Degrees)
WDS 07204+2339	Mean	9.22	181.80
	Std. Dev	0.045	0.41
	Std. Error	0.02	0.15
WDS 07205+2340	Mean	7.73	59.07
	Std. Dev	0.03	0.36
	Std. Error	0.01	0.13
WDS 07204+2353	Mean	10.54	116.44
	Std. Dev	0.037	0.244
	Std. Error	0.01	0.09
WDS07204+2344	Mean	9.23	177.81
	Std. Dev	0.04	0.31
	Std. Error	0.02	0.11

Table 1: Our measurements for each system in the area around WDS 07204+23454.

Results

Table 1 shows the mean, standard deviation, and standard error of the measurements for these 4 systems. The standard error is very low, which indicates that our measurements are likely quite precise.

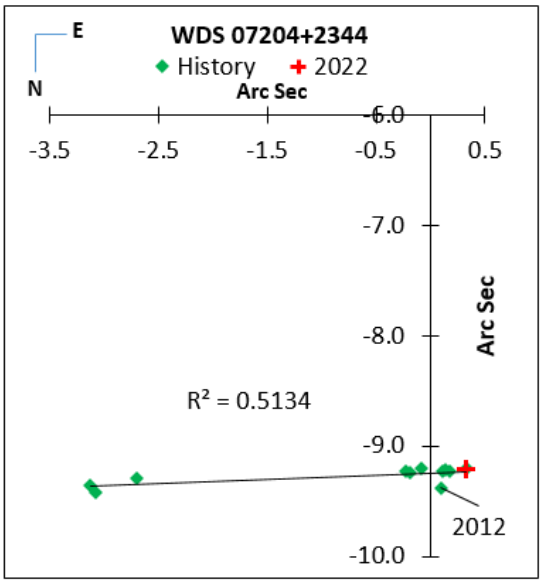

Figure 2: Plot of the historical data next to our measurement for WDS07204+2344. The measurements from 1909 and 1954 appeared to be outliers and are not shown. The 2012 measurement also appears to be a bit of an outlier, as the rho for that measurement is quite a bit larger than the measurements before or after. If this point is removed, the r-squared value improves to 0.86. The data appears to be linear, suggesting that the stars are not physically associated.

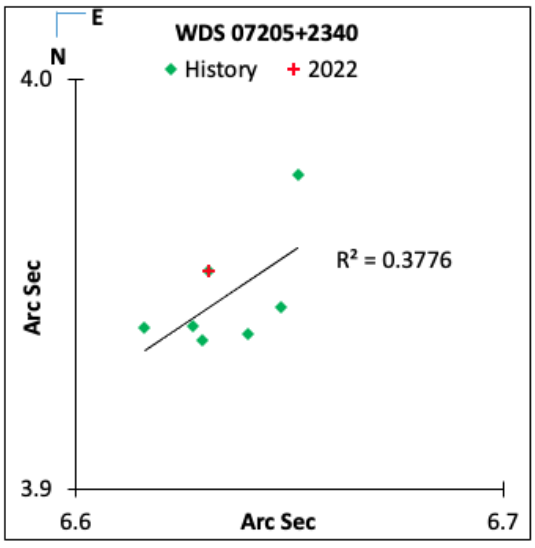

Figure 3: The graph of the historical data next to our data(WDS 07205+2340), with the 1909 and 1954 outliers removed. Unfortunately, the motion of the stars in this system is too small to draw any conclusions about the physicality of the system. The measurements themselves are also scattered, which suggests that neither a linear nor a polynomial fit are appropriate for the system.

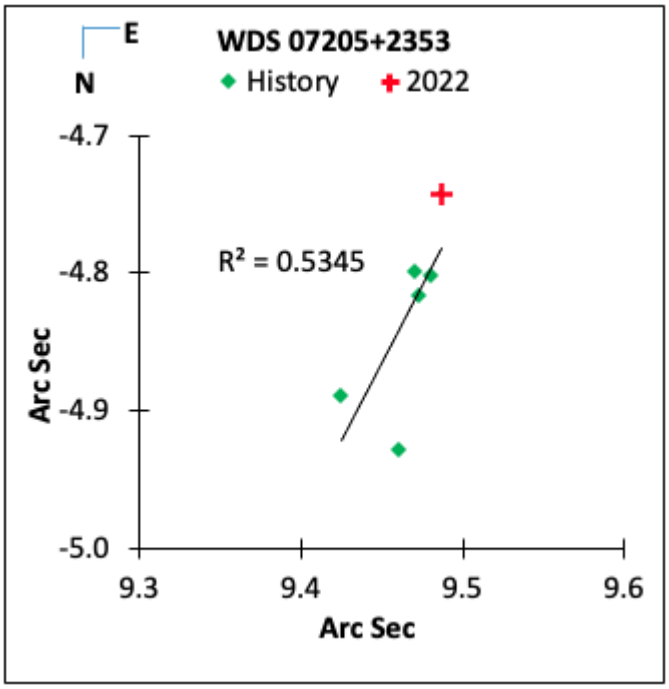

Figure 4: The graph of the historical data next to our data for WDS 07204+2353, with the 1909, 1954, outliers removed. An apparent outlier from 2010 has also been removed. A linear fit is shown, although with only 0.2" of movement over 24 years, it is difficult to assess the accuracy of this fit.

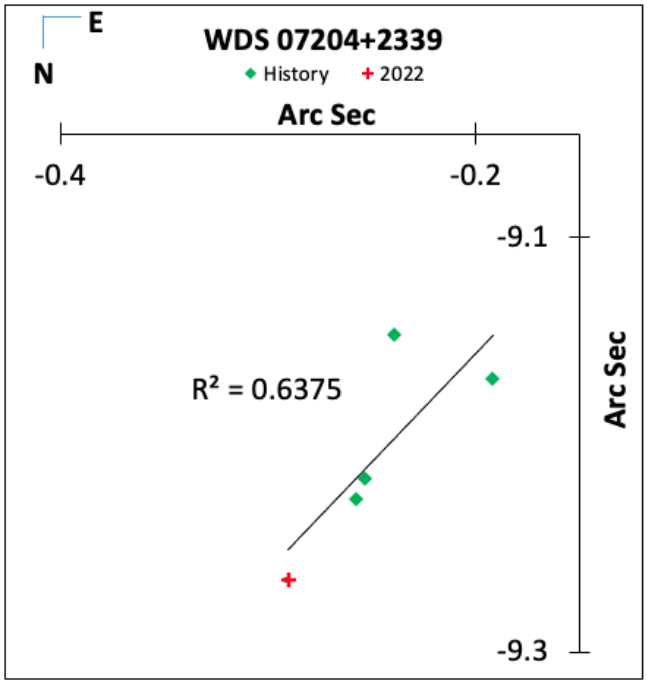

Figure 5: A plot of the data for WDS 07204+2339. We have removed the outliers from 1909, 1954, and an additional one from 2001. The remaining points cover a period of 24 years, and appear to show linear motion over the course of that time frame.

Discussion

To investigate how our measurements fit in with past observations of these systems, we requested historical data for them from the US Naval Observatory (Matson, 2022). There are 12 historical measurements for WDS 07204+2344, 8 for WDS 07205+2340, 9 for WDS 07204+2353, and 7 for WDS 07204+2339.We have plotted these measurements for each of these systems using Harshaw's Plot Tool (Harshaw, 2020), and have shown them together with our new measurements. These plots are shown in Figures 2-5. In each of these plots, we have omitted the data points from 1909 and 1954 because they are apparent outliers. The measurements from 1909 are from the discoverer of these pairs, M. A. Pourteau, who made the measurements from photographic plates that were taken as part of the Carte du Ciel project (Pourteau, 1933). Perhaps the errors in these measurements are due to some problem with the photographic plate used, or by the "computer" who measured the positions of the stars on the plate. The 1954 measurements were obtained by using a "home-made measuring machine" on prints of the Palomar Sky Survey (Gellera, 1982). Some systematic offsets must have been at work with this method since we find that the measurements from this work are discrepant in every system we examined. Figure 2 shows the motion of WDS07204+2344, and there appear to be two outliers: one in 1909 and another in 1954. These years also show outliers for the other systems in Figures 3-5, suggesting that there was a systematic error with the observations produced in these years. If we omit these two potentially spurious measurements, our new measurement and the other historical measurements show that the motion of WDS 07204+2344 appears to be linear, implying that the B component is not physically associated with the A component.

Figure 3 shows the motion of WDS 07205+2340, and again we see that the observations from 1909 and 1954 seem inconsistent with the others. With these points omitted the remaining data points appear to show a curve, which could be suggestive of orbital motion. However our new measurement isn't where it would be expected if the stars were in fact physical, which makes it difficult to say from the ground-based astrometry alone whether or not this pair is physical. As for WDS 07204+2353 (Figure 4), the 2010 observation as well as those from 1909 and 1954 seem inconsistent with the others. The remaining data points, together with our new observation, are suggestive of linear motion, which would mean that this pair is also unphysical. Finally, Figure 5 shows the historical measurements and our new observation for WDS07204+2339. Again the 1909 and 1954 measurements seem inconsistent with the remaining observations. If these discrepant measurements are not considered, then the remaining points, together with our new measurement, seem consistent with linear motion. This would suggest that this system is not physical.

To further explore the motions of these systems, we requested the Gaia data (Gaia Collaboration et al. 2020) for them, which is shown in Table 3. For the system WDS 07204+2344, we can see that the parallax values are very different, with the two systems being at least 200 pc apart.

Additionally, their proper motion values are dissimilar. This suggests that the components are not physically associated. One way to assess the "goodness" of the Gaia measurements is with the reduced unit weight error (RUWE). For well-behaved measurements, the RUWE should be near 1.00 (Lindegren, 2021). However, the RUWE value for the B component of this system is quite large, so one cannot place too much value on the measurements for this star. Still, the Gaia data together with the linear motion seen with the historical measurements suggest that these components are not physically associated.

In the case of WDS 07205+2340, we also see that the parallax and proper motions of the two components are dissimilar. The two stars are at least 200 pc apart, and in the case of this system the RUWE values for both components are close to 1.00, suggesting a high confidence in the accuracy of these measurements. For the system WDS 07204+2353, the RUWE values for both components are close to 1.00, and we again see that the parallax and proper motion values indicate that the system is not physical. Finally, for WDS 07204+2339 we see a similar story. The parallax measurements yield distances that are quite dissimilar, suggesting that the system is not physical. The confidence in these measurements is also good, as they both have an RUWE value quite close to 1.00. In summary, our new observations, together with the historical measurements and the parallax and proper motion data from Gaia, lead us to conclude that none of the systems observed in this work are physical.

Star (WDS)	Component	Parallax (mas)	Distance (pc)	RA Proper Motion (mas/year)	Dec Proper Motion (mas/year)	RUWE
07204+2344	**A**	3.78±0.014	264 - 266	-24.961±0.017	-13.901±0.013	0.852
	B	1.63±0.47	476 - 862	0.991±0.528	-12.263±0.417	10.92
07205+2340	**A**	4.17±0.016	239 - 241	-4.392±0.019	-3.106±0.016	0.919
	B	0.21±0.022	4310 - 5320	-1.167±0.025	-2.28±0.023	1.102
07204+2353	**A**	0.92±0.02	1063 - 1111	-4.89±0.021	-6.771±0.017	1.053
	B	0.42±0.02	2500 - 2273	-2.127±0.021	-1.54±0.017	0.928
07204+2339	**A**	0.53±0.02	1960 - 1818	0.402±0.029	-1.329±0.024	0.912
	B	1.12±0.02	877 - 910	-2.597±0.032	-7.154±0.027	0.995

Table 3: Gaia EDR3 measurements for WDS 07204+2344, 07205+2340, 07204+2353, and 07204+2339.

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