New measurements of WDS 00005+5902 AB, WDS 01487+3306, and WDS 05205+3654

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Abstract

We report new measurements of separation and position angle for the systems WDS 00005+5902 AB, WDS 01487+3306, and WDS 05205+3654. For all of these systems, we made new measurements of separation and position angle and compared these to historical measurements. Additionally, we gathered proper motion and parallax for these systems from the Gaia DR3 database. It is unlikely that the WDS 00005+5902 AB system is physical, as the stars are separated by over 600 pc, although some of the Gaia data is of low confidence. None of the 8 stars in the WDS 05205+3654 system appear to be physical, as they are found at very different distances from one another. WDS 01487+3306 is a nearby (~35 pc) high proper system that is well observed, although its components are not physical.

1. Introduction

Observations over a long timeline are useful in examining whether or not visual binaries are in fact physical. For this study, we set out to add observations to the baselines of stars in 3 systems: WDS 00005+5902AB, WDS 05205+3654, and WDS 01487+3306. We selected these systems because they were at the appropriate declination to be visible during Fall 2024 at the telescope used for this project, which was the Great Basin Observatory. The stars in these systems were sufficiently separated to be resolved in the images acquired with this telescope, but were close enough to be resolved in the same image. Additionally, they were of the appropriate brightness to be observed with an exposure time of less than 4 minutes to prevent trailing of the stars on the image. Furthermore, these systems were selected because it has been at least 10 years since they were last observed.

The system WDS 05205+3654 consists of a group of 8 stars within 1 arcminute of each other. The separation and position angle of the A and B components have 8 observations in the Washington Double Star Catalog, the first of which dates to 1895 with the most recent dating to 2015. There are also 8 measurements for the A and C components, however their first observation dates to 1982, with the most recent again dating to 2015. Measurements of both the AD and AE components first began in 2000 with 7 measurements apiece until 2015. The DF and FG components have only 4 observations between 2000 and 2015. The FH component has only 2 observations: one in 2000 and another in 2007.

We also observed the primary and secondary components of WDS 00005+5902, although the A and C components of this system were too closely spaced (~5") for us to resolve. The first recorded observation of this system is from 1910, with a total of 9 observations, including the most recent in 2015. The final system we observed was WDS 01487+3306. This pair has long been recognized as a common proper motion pair (Giclas et al. 1961), with a separation of 20" at the time of its first observation in 1959. It has been observed an additional 20 times, with the last observation dating to 2015, when the separation was found to be 20.2".

2. Equipment and Methods

We observed these stars with the Great Basin Observatory, which is located inside Great Basin National Park, Nevada. This observatory is the first and only research-grade telescope inside a national park, and is managed by Great Basin National Park, the Great Basin National Park Foundation, the University of Nevada-Reno, and Southern Utah University. This observatory consists of a 28-inch CDK700 Planewave telescope with a focal ratio of f/6.5. The SBIG STX 16803 camera used with this telescope delivers a 27"x27" field of view, with a plate scale of 0.4 arcsec per pixel. Ten images of WDS 05205+3654 were taken on October 3rd, 2024 through a *Sloan* r filter with a 2 x 2 binning and an exposure time of 300 seconds. A finder chart for this system is shown in Figure 1. We also acquired ten images of the other two star systems using the same filter on October 3rd and 4th, with an exposure time of 240 seconds.

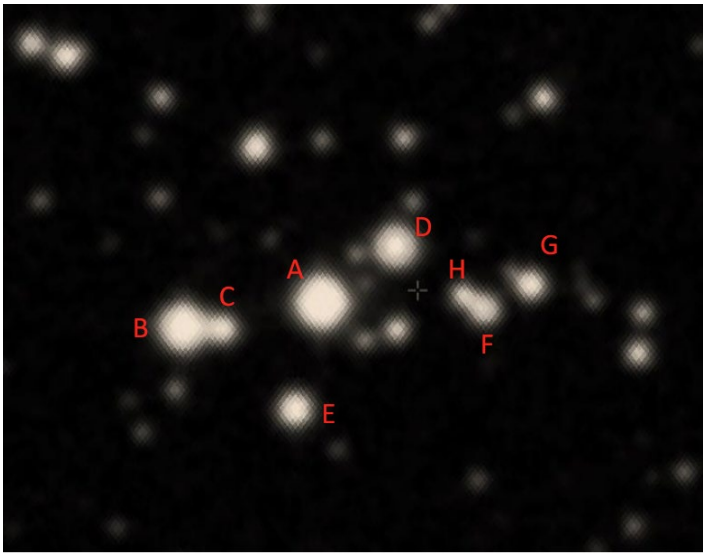

Figure 1: Finder chart for stars in WDS 05205+3654

The image astrometry was acquired with the use of http://nova.astrometry.net/ (Lang 2010). AstroImageJ (Collins et al. 2017) was used to apply the dark, bias, and flat-field frames to the light frames. We reviewed seeing profiles of each star to confirm that they were not overexposed. We also used AstroImageJ to obtain measurements of separation (theta) and position angle (PA) for each pair. Changing the size of the Region of Interest (ROI) aperture produces slight differences in the resulting measured separation and position angle. We therefore used the aperture setting that produced the smallest combined error for both separation and position angle. Historical data for each system was requested from the Washington Double Star Catalogue, (Matson, 2024), and plots of our data and the historical measurements were created using Plot Tool (Harshaw, 2020).

3. Data

The results of our measurements of each pair of stars, including the mean and standard deviation for each of the 10 images, are recorded in Table 1.

Table 1. Measurements of separation and position angle.

WDS Identifier	Separation (ρ)" (Error)	PosAng (θ)° (error)
00005+5902 STI 3079 AB	14.51 (0.02)	123.21 (0.5)
01487+3306 GIC 26 AB	20.26 (0.02)	228.8 (0.04)
05205+3654 SEI 197 AB	26.02 (0.01)	99.8 (0.10)
05205+3654 TOB 27 AC	19.08 (0.10)	104.3 (0.26)
05205+3654 BKO 206 AD	17.05 (0.03)	307.9 (0.06)
05205+365 4BKO 206 AE	20.47 (0.02)	166.1 (0.03)
05205+3654 BKO 206 DF	19.74 (0.04)	235.1 (0.09)
05205+3654 BKO 206 FG	9.91 (0.03)	295.2 (0.31)
05205+3654 BKO 206 FH	3.73 (0.19)	58.5 (1.90)

4. Discussion

We used the historical data together with our new measurements to produce plots of the positions of the stars over time as these plots are helpful in looking for evidence of orbital motion. Plots of greatest interest are included here, while others are discussed without being shown because they exhibit little (<1") motion over their baseline of observation. To further investigate the nature of the star's motions, we retrieved parallax and proper motion information from the Gaia DR3 (Gaia Collaboration et al. 2016b, 2023j), which is shown in Table 2.

An important part of determining whether a system is physical or not is comparing the star's motions through space. Stars that are physical should have similar velocity vectors pointing in roughly the same direction, while large differences in the directions of their velocities indicate that the stars are not physical. Harshaw 2016 suggested a method for comparing how much of one star's velocity lies in the direction of the other star using proper motions. However, this method relies on the 2-D projection of the star's velocities on the plane of the sky. A better approach would be to include radial velocities in the analysis, as done in the space velocity vectors approach (Nugent, 2025). Unfortunately, only 4 of the stars in the systems under consideration in this work have measured radial velocities (see Table 2), so the space velocity vector method can only be applied to the DF components of the system. The Harshaw 2016 method is therefore used for the other components, despite its limitations.

00005+5902 AB

This system shows very little motion (<1") over the last 115 years, which complicates interpretation. Furthermore there are some inconsistencies in the historical measurements, which makes understanding the motion even more difficult, since a line fitted to the data has an R^2 value of just 0.25. Because there has been so little motion over the last century, we turned to Gaia data to see if parallax and proper motion measurements can shed some light on this pair (Table 2). We have also included in Table 2 a distance column which presents a range of distances to a star that is derived from the measured parallaxes and the associated parallax errors. In this table we see that the Gaia parallax for the primary in this system is 0.8

mas, while that of the secondary is 1.4 mas, and the parallax errors of these stars show no overlap. These differences in parallax translate to a distance between the stars of ~600 pc, which would indicate that they are not physical. However when we examine the RUWE, which is an indicator of the reliability of Gaia data (Lindegren 2018), the situation may not be so clear. For well-behaved measurements, we would expect an RUWE near 1, but for the primary star it is 2.54, suggesting that the Gaia data for this star has a low confidence. An elevated RUWE could be the result of a number of factors, and a forthcoming Gaia data release will change how the RUWE is calculated. Until that revision, it is difficult to draw a conclusion based on parallax. Finally, the proper motions also present a muddled picture. The space velocity vectors approach can be used to compare the motions of the stars through space, however this method requires the radial velocity of each star, and the B component of this system has no radial velocity in the Gaia database or Simbad, therefore this method cannot be used. Despite the uncertainties that result from a high RUWE and the inability to compare the space velocity vectors, the observations we do have suggest that these components are not physical, although further observations are necessary to determine their true nature.

Table 2: Gaia Measurements

Component	Parallax (mas)	Distance (pc)	RA Proper Motion (mas/year)	Dec Proper Motion (mas/year)	Radial Vel (km/s)	RUWE
00005+5902 A	0.791± 0.030	1219 - 1316	2.84 ± 0.030	-1.03 ± 0.028	-47.95 ± 14.12	2.54
00005+5902 B	1.432± 0.013	692 - 705	5.55 ± 0.012	-1.01 ± 0.012		1.01
01487+3306 A	27.912± 0.030	35.8 - 35.9	281.55 ± 0.030	-28.60 ± 0.030		1.46
01487+3306 B	28.067 ± 0.020	35.6 - 35.65	275.65 ± 0.020	-28.32 ± 0.020	37.17 ± 1.29	1.29
05205+3654 A	0.8856 ± 0.017	1108 -1150	-0.15 ± 0.019	-4.69 ± 0.013		1.06
05205+3654 B	0.4972 ± 0.0142	1955 - 2070	1.63 ± 0.017	-0.75 ± 0.012		1.02
05205+3654 C	0.9592 ± 0.362	757 - 1675	0.92 ± 0.416	0.02 ± 0.295		9.71
05205+3654 D	0.4961± 0.0223	1929 - 2111	0.90 ± 0.026	1.08 ± 0.019	2.37 ± 2.09	1.37
05205+3654 E	1.093± 0.032	889 - 942	1.04 ± 0.037	-12.92 ± 0.026		1.13
05205+3654 F	0.168± 0.034	4961 - 7457	1.09 ± 0.038	-1.85 ± 0.027	-58.73 ± 8.33	1.04
05205+3654 G	0.684± 0.039	1384 - 1551	-4.59 ± 0.045	-2.07 ± 0.031		0.96
05205+3654 H	0.459± 0.071	1887 - 2580	1.06 ± 0.080	-3.43 ± 0.057		1.06

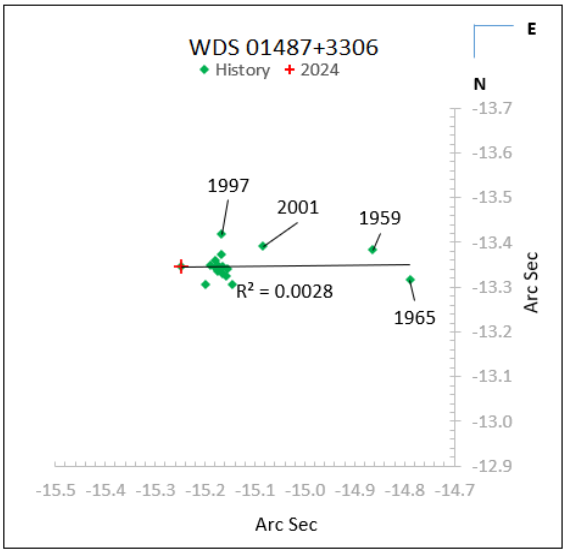

Figure 2: Plot of historical (in green) and recent observation (in red) of WDS 01487+3306.

01487+3306 AB

This system of M dwarfs (Weis 1991) is widely separated, at about 20", and has long been recognized as a common proper motion pair (Giclas et al. 1961). It has observations going back to 1959, as shown in Figure 2, which also shows that the system has exhibited very little change in separation (<0.5") since that time. A number of the observations are outliers, which reduces the R^2 value and lowers confidence in the linear fit shown in the figure. Despite the somewhat inconsistent nature of the historical observations, the Gaia data show that the pair are quite close to Earth, with the primary star having a distance of 35.827 ± 0.0643 parsecs, and the secondary having a distance of 35.629 ± 0.0430 parsecs. These parallax measurements indicate that the pair is not physical, as the mean separation between them is ~40840 AU. Their high proper motion could indicate that these are halo stars that are plunging through the disk, and spectra to determine a metallicity would be helpful in determining their origin.

05205+3654 AB

We now turn our attention to the 8 stars in the WDS02205+3654 system. For the AB components, our observation correlates well with the historical data. This system shows very little movement, about 0.25 arcsec, over a time span of 130 years. Such a small change in separation is well within the expected measurement error, which means we cannot say that motion has been observed for this pair. The measurement from 2007 seems to be an outlier, and with it removed the R^2 improves from 0.53 to 0.82, although with such a small change over that time frame this has little meaning. Looking at the Gaia measurements, the measured parallaxes are near 1 mas, and for the primary indicate a distance of ~1,100 pc, while the secondary is much more distant, at ~2,000 pc. The RUWE for both stars is quite good, indicating high confidence in the Gaia data.

05205+3654 AC

This pair has a shorter baseline of observations than the AB components, with the first observation dating to 1982. The C component is very faint and lies close to the B component, which complicates the centroiding process, and as a result we report a large error for this pair. Nevertheless in Figure 3 we see that the C component seems to have a linear path, with a good R^2 value of 0.95. However, we don't know the error for the initial measurement from 1982, so this must be interpreted with some caution. The parallax data from Gaia is not very helpful with this pair, as the RUWE for the C component is quite poor, at 9.71. This means that the measured parallax and therefore the distance to the C component has a very large range, from ~750 - 1,700 pc. This large range overlaps the A component, which could indicate that these two stars lie at a similar distance from Earth. The proper motion of the C component is quite different from that of the A component, but is also accompanied by very large errors of measurement. As with the AB stars, a comparison using the space velocity vectors approach is not possible for this system due to a lack of measured radial velocities, but the Harshaw method gives a value of 1.00, indicating that this pair does not have similar proper motions. Based on all of this, we tentatively conclude that the AC components are not physical, although further observations are certainly necessary in this case.

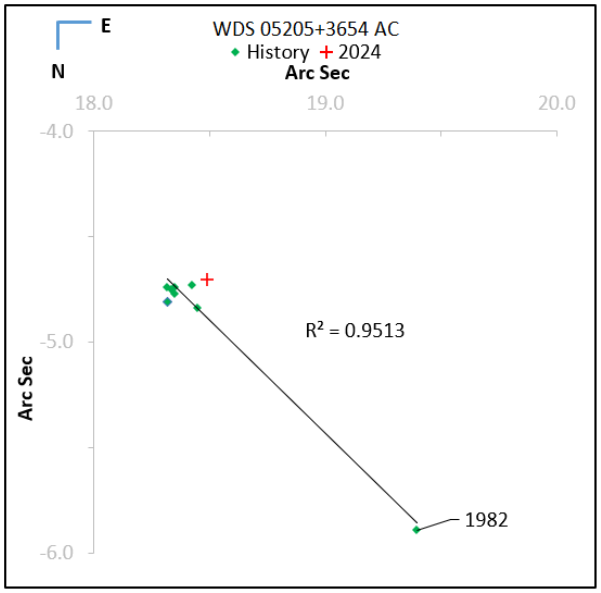

Figure 3. Plot of historical (in green) and recent observation (in red) of WDS 05205+3654 AC.

05205+3654 AD

This pair does not have a long history of observation, as the first record dates only to 2000. The data are somewhat scattered, with a poor R^2 of only 0.5, with less than 0.25" of motion being observed over the past quarter century. The secondary has a parallax of 0.5 mas, which compared to the primary's parallax of ~0.9 mas indicates that these two stars are separated by about 800pc. This would indicate that the stars are not physical, which is confirmed by their proper motion, which is in opposite directions in both axes. The D component has a Gaia radial velocity, but the A component does not, so a 3-D comparison of their velocity vectors cannot be made. However the 2-D approach gives a value of 1.23 for this pair, further suggesting that they are not physical.

05205+3654AE

The historical and new measurements of this system are shown in Figure 4. There are no apparent outliers, and the observations follow a chronological progression from the first observation to our new one. Despite this linear motion, it is less than 0.25" in 24 years, which has very little meaning. The Gaia data are helpful for this pair, as the measured parallaxes indicate that these stars are quite far apart. The A component is at a distance of 1129±21 pc, and the E component is at 915±26 pc.

05205+3654 DF

The F component is very near the H component, which complicates measurement. Consequently, we report a somewhat elevated error for this system, with the result that our measurement is very much an outlier compared to past measurements. The baseline of observation for this pair only spans 25 years, with the first observation dating to 2000. The parallax measurements from Gaia are quite different, suggesting that this pair is separated by ~4,000 pc. This is the only pair for which we have measured radial velocities, which allows us to use the 3-D approach to compare the angles between the stars' velocities. This yields $\nu = 111°$, indicating that the stars have different space motion. Clearly this pair is not physical.

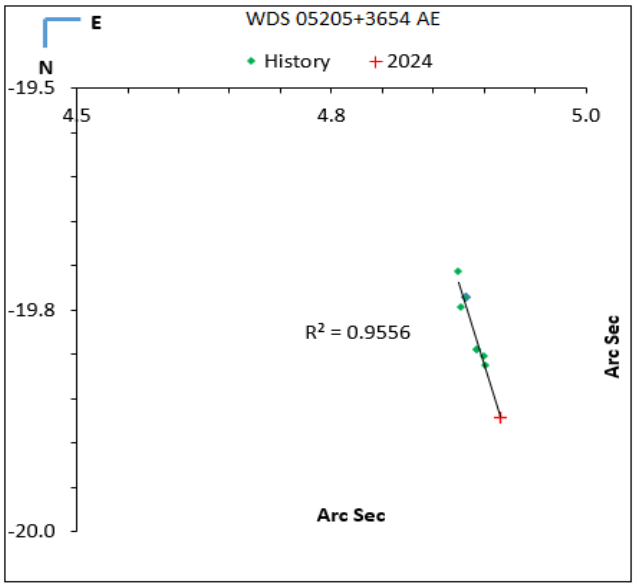

Figure 4: Plot of historical (in green) and recent observation (in red) of WDS 05205+3654AE.

05205+3654 FG

This pair only has 4 observations recorded in the past 25 years, and in that time the observed motion is quite small, at 0.25 arcsec. The measurement from 2007 appears to be an outlier, although with such a small amount of apparent motion it is difficult to say for sure. As noted above, the proximity of the F component to the H component complicates measurement. The Gaia data suggest that this pair is not physical, as the parallax measurements show that these stars are separated by ~ 4,500 pc.

05205+3654 FH

This star only has two historical measurements, the first of which dates to 2000. The other measurement is from 2007, and our new measurement falls between these two. The difference in position angle between the two historical measurements is more than 10 degrees, while our new measurement lies closer to the original, as we report a new position angle of 58.5 degrees. The Gaia data indicate that this is an optical double, and the stars are not physical, as they are separated by ~700 pc.

5. Conclusions

Although the 8 stars of the WDS 05205+3654 system appear close together in the sky, we find that none of these stars are physical. However the errors on the parallax measurement of the C component are quite large, and its RUWE is quite poor, so we cannot rule out the possibility that it may be physically associated with the A component. The components of the WDS 00005+5902 system don't appear to be physical, despite the fact that they have similar proper motions. Finally, although the components of WDS 01487+3306 have similar proper motions, their mean separation of ~40,800AU clearly indicates that they are not physical. Their rapid motion through the disk of the Milky Way may suggest that they are halo stars that are plunging through the disk, although a knowledge of their metallicity would be helpful in confirming this.

Acknowledgements

This project was made possible thanks to a partnership with Southern Utah University and the Great Basin Observatory. We would like to thank those who operate the GBO, as well as the helpful comments from the anonymous referee. This research made use of AstroImageJ, Astrometry.net, and the Washington Double Star Catalog maintained by the U.S. Naval Observatory. This work has made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

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