

Astrometric Observations of WDS Neglected Binary Stars

Stephen J. Williams¹, John W. Wilson¹, Melissa Hursey^{1,2}, and Saida M. Caballero-Nieves¹

1. Dept. of Physics & Astronomy, Georgia State University, Atlanta, GA 30303

2. Dept. of Middle-Secondary Education and Instructional Technology, Georgia State University, Atlanta, GA 30303

Abstract: We present observations of 10 fields of stars from the Washington Double Star Catalog Neglected Doubles List, resulting in measures for 33 double or multiple stars. This research was a class project as part of the science teacher curriculum at Georgia State University. The data were gathered with the 31-inch telescope at Lowell Observatory's Anderson Mesa.

Introduction

The observation of visual binary stars may lead to orbits for such systems, and in some cases, ultimately to the measurement of one of the most fundamental properties of stars, their masses. The knowledge of the mass of a star, at virtually any point in its lifetime, can be used to constrain theories concerning the past, present, and future of the star.

Observations and Analysis

All observations were made on the night of 2009 Feb 7 (Universal Time) with the 31-inch telescope at Lowell Observatory's Anderson Mesa. These data were taken with the NASACam CCD, a 2048 by 2048 pixel array with a field of view of approximately 17 arcminutes on a side. All observations were taken with a Bessel V filter. Because we were only interested in the pixel locations and relative fluxes (counts) of each object, data were not processed and raw images were used in subsequent analyses. Digitized Sky Survey (DSS) images were used as finding charts for field identification with a field of 15 arcminutes on a side. Exposure times ranged from 15 seconds to 60 seconds depending on the brightness of the main target for each field.

Image orientation was determined for each image using the astrometric positions of field stars from the US Naval Observatory's Image and Catalog Archive

(<http://www.nofs.navy.mil/data/fchpix/>). Utilizing field stars with known pixel positions and equatorial coordinates, the IRAF routine "ccmap" in the "imcoords" package was used to solve for the orientation of each image and the pixel scale in arcseconds per pixel. Next, the IRAF package "qphot" was used to determine the instrumental magnitude of the target stars, and their precise pixel locations. From these pixel coordinates and the pixel scale, the position angle (θ) and angular separation (ρ) were calculated for each star in the system relative to the particular companion star's location via trigonometry.

Due to inclement weather, no standard star fields were observed, so all brightness measurements from "qphot" were forced to be left as instrumental magnitudes. Thus, only delta magnitudes are listed in the "Results" section below.

Results

All the data presented in Table 1 were taken on a single night so $N=1$ for all observations. The epoch of observation for all data is 2009.104 in fractional Besselian years.

(Continued on page 17)

Astrometric Observations of WDS Neglected Binary Stars

Table 1: Measurements of neglected double stars. Our separation and position angle measurements are in the columns labeled "our θ " and "our ρ ", respectively. All measurements are epoch 2009.104. Bold-faced and italicized objects were the main targets in each field. Others were serendipitous targets also in the fields.

WDS name	first	last	$\theta(1^{\text{st}})$	last	$\rho(1^{\text{st}})$	last	our θ	our ρ	delta mag
04480+5307	1831	1983	130	131	20.0	28.4	139	29.0	0.2
04484+6411	1832	2007	165	164	12.0	14.0	164	13.5	1.2
04495+3914	1832	1998	311	332	8.0	9.1	332	9.2	1.9
04497+3920	1984	2007	223	223	30.2	30.2	223	30.1	0.9
05067+5121	1903	2006	139	135	4.2	5.1	135	5.1	0.4
05161+3632AB	1895	2007	109	113	24.8	25.1	294	25.0	<0.1
05161+3632AC	1895	2007	261	260	25.0	25.8	78	25.7	0.6
05161+3632CD	1998	2007	198	198	13.0	13.1	198	12.8	2.4
05165+3635AB	1895	2008	147	123	23.2	21.3	122	21.2	1.9
05165+3635AC	1998	2007	295	296	20.9	21.1	298	20.8	4.4
05231+3802	1895	2007	88	89	25.6	27.0	268	26.2	0.3
05234+3802	2007	2007	296	296	9.9	9.9	116	9.8	<0.1
05227+3755	1985	2007	83	123	9.2	11.1	303	11.2	0.2
05227+3758	2007	2007	78	78	16.6	16.6	78	16.6	2.2
05234+3758	2007	2007	82	82	15.7	15.7	82	15.9	0.7
05236+3803AB	2007	2007	324	324	11.0	11.0	143	10.7	0.2
05236+3803AC	2007	2007	178	178	14.5	14.5	177	14.5	0.7
05278+3446	1938	1940	113	121	6.8	6.5	114	6.2	0.4
05284+3546AB	1895	2007	186	187	25.1	25.4	187	24.9	0.3
05284+3546AC	1895	2007	207	209	17.8	18.0	209	17.9	1.0
05284+3546BD	2007	2007	199	199	10.4	10.4	199	10.2	0.3
05284+3545	1895	2007	17	20	9.8	10.3	19	10.2	0.3
05284+3549AB	1895	2007	288	288	12.2	11.5	288	11.4	0.2
05284+3549AC	1895	2007	358	359	15.2	15.4	359	15.3	1.3
05288+3547AB	1985	2007	106	108	23.6	23.4	108	23.2	0.7
05288+3547AC	1895	2007	50	50	24.7	24.9	50	24.8	2.6
05288+3547BC	1895	2007	352	353	22.7	23.3	352	23.2	1.9
05288+3547BD	1998	2007	133	133	16.0	16.1	134	15.9	2.7
05288+3546	1985	2007	295	292	17.5	19.0	292	18.9	2.2
05380+3643	1895	2007	195	196	19.0	17.0	197	17.4	0.6

Astrometric Observations of WDS Neglected Binary Stars

Discussion

WDS 04480+5307 STF 586

Also listed as BD+52 882 in the Simbad Astronomical database (<http://simbad.u-strasbg.fr/simbad/>). The measurements listed in Table 1 are not that different from historical measurements. The image for this object is shown in Figure 1.

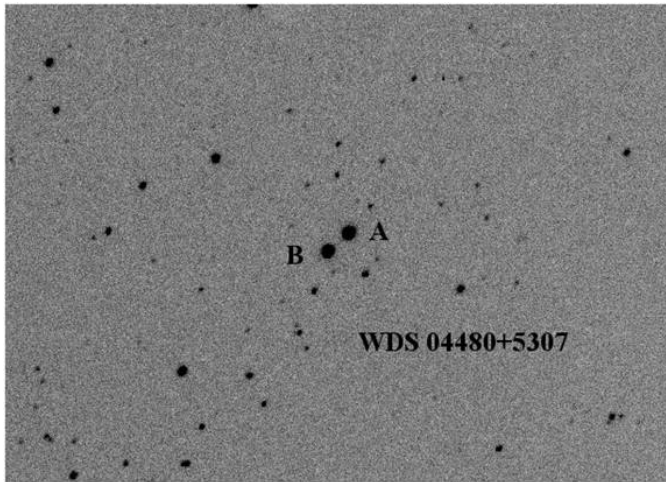


Figure 1: WDS 04480+5307 with North up and East to the left. This image is 8 arcminutes by 11.3 arcminutes.

WDS 04484+4611 HJ 2239

Measurements show no significant change in either position or angle from previous observations. The corresponding image is shown in Figure 2.

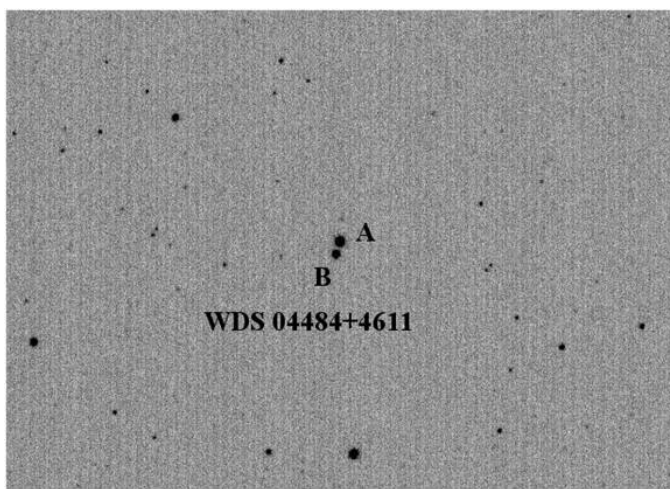


Figure 2: WDS 04484+4611 with North up and East to the left. The image is 8 x 11.3 arcminutes.

WDS 04495+3914 STF 594

Also listed as HD 276957 and HD 276957B in Simbad. Again, measurements from the image shown in Figure 3 show no difference between the most recent data (1998) and our data. The second object in the field of view that is also in the WDS is cross-listed as HD276951 and WDS 04497+3920. Analysis reveals numbers similar to the archival data.

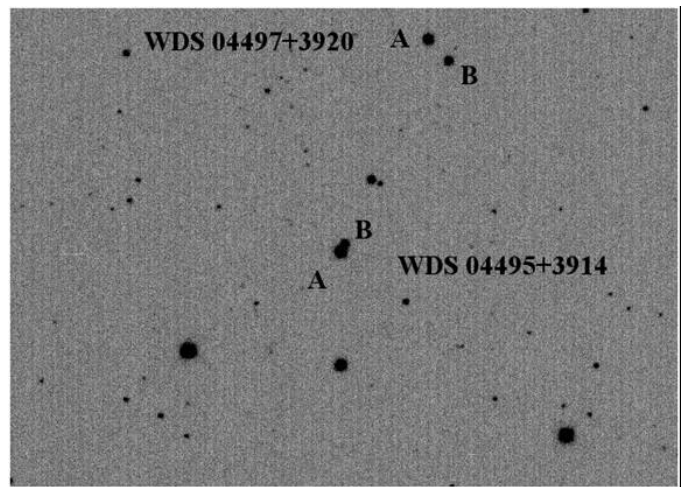


Figure 3: WDS 04495+3914 in the center with North up and East to the left. WDS 04497+3920 and components are marked near the top of the image, which is 8 x 11.3 arcminutes.

WDS 05067+5121 SMA 47

All historical data are essentially similar to the measurements made here on the image shown in Figure 4.

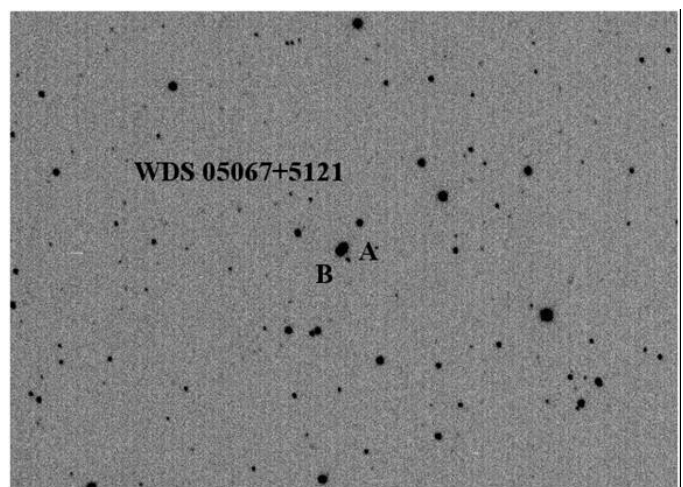


Figure 4: WDS 05067+5121 with North up and East to the left. The image is 8 x 11.3 arcminutes. The primary and secondary are very close together but not yet overlapping.

Astrometric Observations of WDS Neglected Binary Stars

WDS 05161+3632 SEI 132AB

The magnitudes of the primary and secondary are given in the WDS as 12.9 and 12.8 respectively. The data show the archival identification of the brighter star to be inconsistent, thus the measurements shown in Table 1 have a 180 degree difference. The two stars have less than a 0.1 magnitude difference in measurements from the data in Figure 5. Interestingly enough, star C in this four star entry is brighter than star B, and thus also brighter than star A. This is the cause for the 180 degree difference in each of these measurements in Table 1. The positions for each pair appear not to have changed, at least within the measurement uncertainty in our data.

As a bonus on this particular field, WDS 05165+3635 is nearby and is included in this analysis. The measurements for this pair were not significantly different than those listed in the WDS.

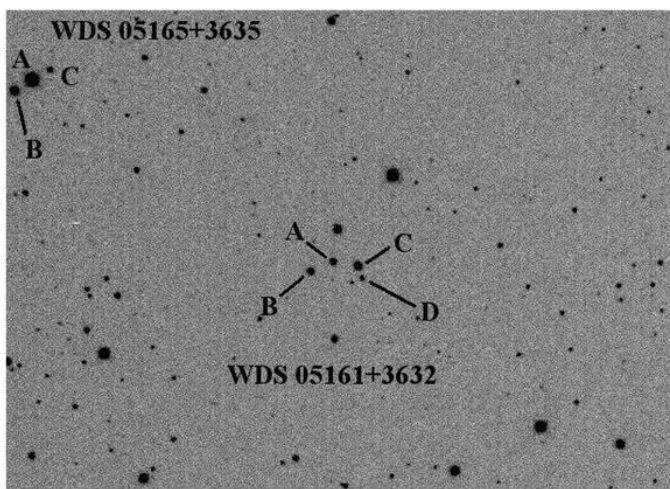


Figure 5: WDS05161+3632 at center with North up and East to the left. The top left shows WDS 05165+3635 with labels. The image is 8 x 11.3 arcminutes.

WDS 05231+3802 SEI 225

This object is also listed as CCDM J05232+3802A and B in SIMBAD. The magnitudes of the primary and secondary are given in the WDS as 12.5 and 13.0 respectively. In the SIMBAD Astronomical Database, the V magnitudes are 10.0 and 10.5 respectively. The measurements based on Figure 6 for these data give a delta magnitude in the Bessel V-band of 0.3. Aside from the 180 degree ambiguity, owing to the switch in identification of the brighter (thus, primary) star, there

seems to be little change in the values of separation and position.

The second serendipitous target is WDS 05234+3802. This is listed in the WDS as having the secondary (B component) brighter than the primary (A component), but the position angle measurement does not reflect this. Aside from this 180 degree difference, all else appears similar to previous measurements for this target.

The next target also on the field is WDS 05227+3755. Again, the primary and secondary stars are reversed according to the data used in this analysis, so the position angle differs by 180 degrees. Given the change in separation between the first and last measurements, perhaps there is some evidence of a different proper motion between the two components?

Following these, the next target in the field is WDS 05227+3758. This shows no real difference between the measurements here and those conducted in 2007, except in the difference in magnitudes.

The next target is WDS 05236+3803, containing three stars, Star A is actually fainter than star B, and this is shown in the 180 difference in position angle in Table 1. Other values corresponding to this system show no significant differences compared to those listed in the WDS.

All these stars could not fit on one figure, so Figures 6a and 6b show all of the systems for which measurements were made.

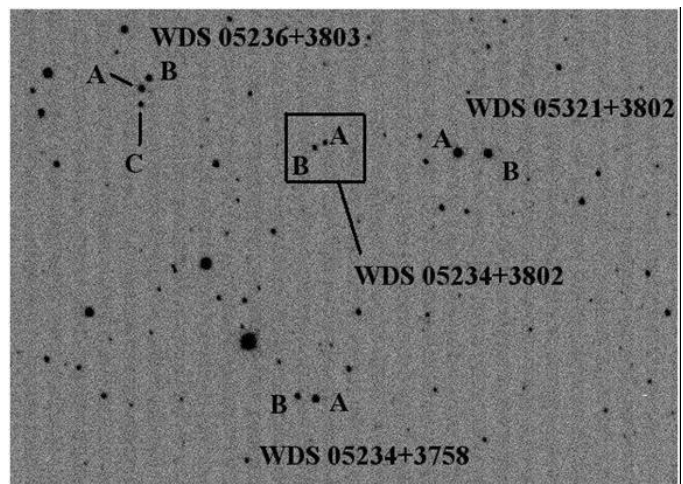


Figure 6a: The first part of the field where WDS 05231+3802 was the main target with North up and East to the left. Each system and its components are labeled. The image is 8 x 11.3 arcminutes.

Astrometric Observations of WDS Neglected Binary Stars

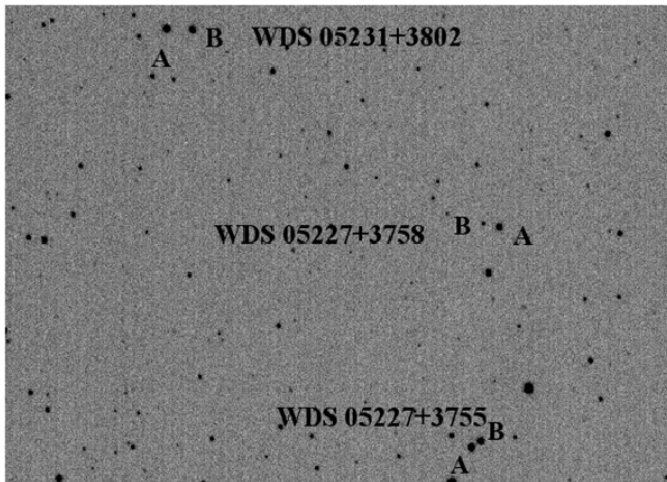


Figure 6b: A different field showing WDS 05231+3802 and two of the other systems measured and listed in Table 1. This image is 8 x 11.3 arcminutes.

WDS 05278+3446 MLB 1039

Again, no real change is seen in the measurements between these data and previous work. There are several other WDS objects in Figure 7, but all have separations lower than what can be measured from these data.

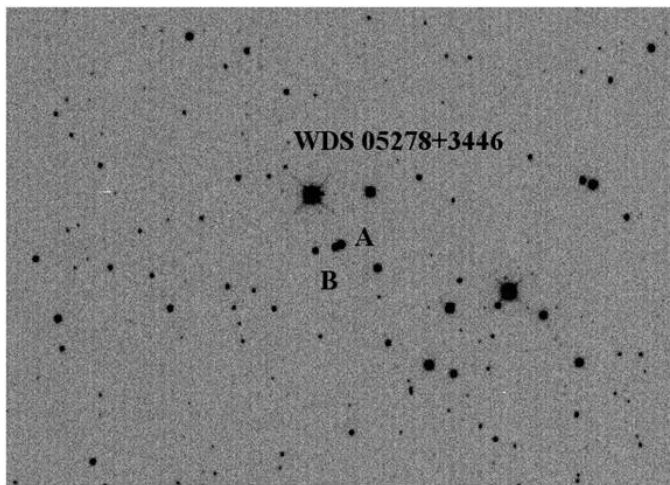


Figure 7 - WDS 05278+3446 with North up and East to the left. The image is 8 x 11.3 arcminutes.

WDS 05284+3546 SEI 277AB

There are two WDS systems in the field of view for this object. The identifications overlap somewhat. We have measured separations and position angles for WDS 05284+3546 AB, AC, and BD (also a separate listing under the name WDS 05284+3545). The second

system is WDS 05284+3549, for which we have measured AB and AC. See Figure 8 for the precise locations of each component in the field of view. None of these measures are significantly different than those given in the WDS catalog.

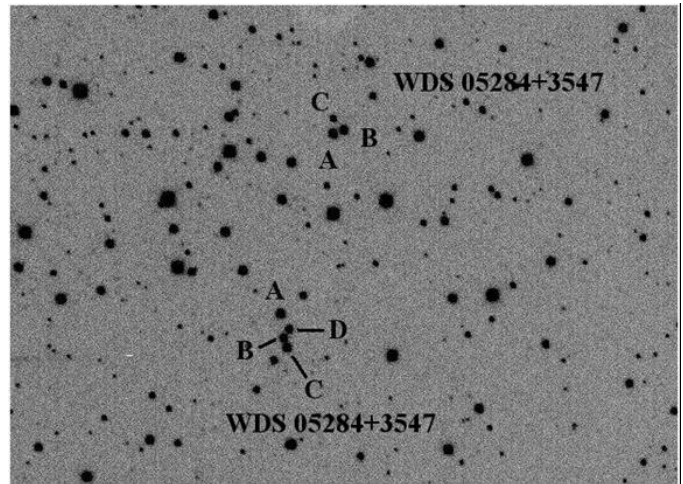


Figure 8: Components of WDS 05284+3546 with labels on the bottom. The components of WDS 05284+3547 with labels are shown at the top. North is up and East is to the left in this image spanning 8 x 11.3 arcminutes.

WDS 05288+3547

This frame also had two systems in the field of view. The first family of systems is WDS 05288+3547, containing a total of four stars. The second is just one pair of stars, listed in the catalog as WDS 05288+3546. See Figure 9 for proper identifications. Again, no major differences are seen between historical measurements and the values derived in this work.

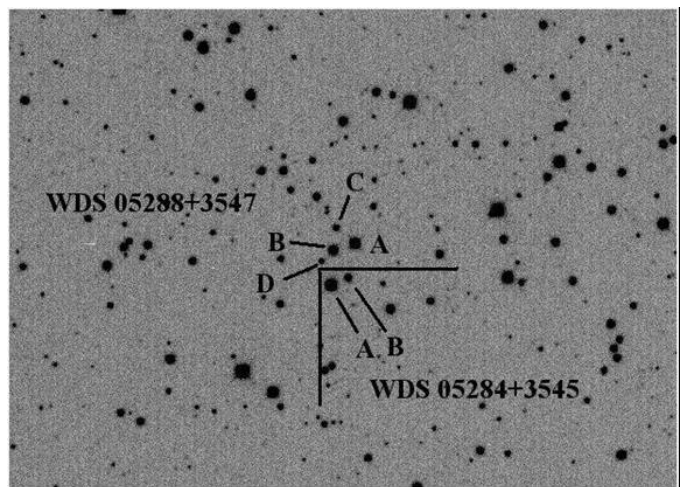


Figure 9: WDS 05288+3547 in the center of the frame with labels. North is up and East to the left. Also shown are the two components of WDS 05284+3545. This image is 8 x 11.3 arcminutes.

Astrometric Observations of WDS Neglected Binary Stars

WDS 05380+3643 SEI 358

In the WDS the primary and secondary are listed with the same magnitudes of 10.5 each. This analysis shows the difference in magnitude to be 0.6 in the V-band. This could cause a 180 degree ambiguity in the future, but here the same primary is used as past observers, and once again there is not a large difference between new measurements and those listed in the WDS.

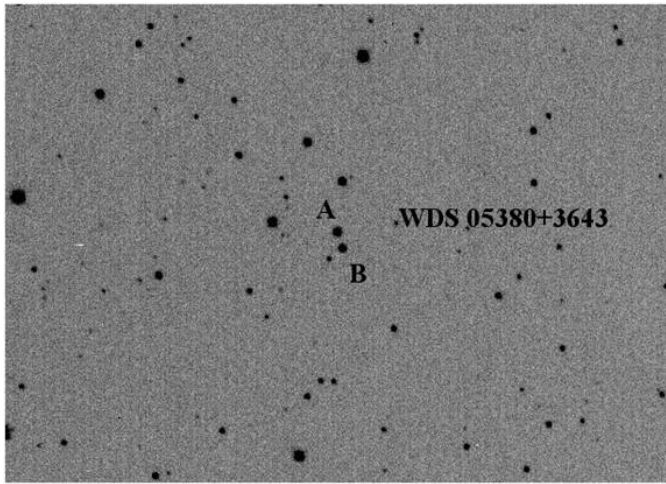


Figure 10: WDS 05380+3643 with North up and East to the left. The image is 8 x 11.3 arcminutes in size.

Acknowledgements

This research has made use of the USNOFS Image and Catalogue Archive operated by the United States Naval Observatory, Flagstaff Station (<http://www.nofs.navy.mil/data/fchpix>). This research has made use of the SIMBAD database, operated at CDS, Strasbourg, France. This research has also made use of IRAF. IRAF is distributed by the National Optical Astronomy Observatory, which is operated by the Association of Universities for Research in Astronomy, Inc., under cooperative agreement with the National Science Foundation. The Second Palomar Observatory Sky Survey (POSS-II) was made by the California Institute of Technology with funds from the National Science Foundation, the National Geographic Society, the Sloan Foundation, the Samuel Oschin Foundation, and the Eastman Kodak Corporation.

We would also like to thank the staff of Lowell Observatory, and in particular Brian Skiff, for making these observations possible.

