

# Astrometry of WDS 09000-4933

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**Abstract:** This research team conducted an astrometric measurement of the double star WDS 09000-4933 (HD 77321), with a Julian observation date of 2458591 (April 17, 2019). The observed separation was 9.056 arc seconds and the position angle was 307.530 degrees.

## Introduction

A research group of students from Paso Robles High School in the Astrometry Field Research Program (Figure 1) collaborated with the Institute for Student Astronomical Research (InStAR) to measure the separation and position angle of a double star. This team of four students specifically investigated double star WDS 09000-4933 (Figure 2). By observing, recording, and analyzing this double star, a contribution was made to the data collected in previous years in hopes of gaining a further understanding of the nature of binary stars. In order to do this, the observation of this double star system included documenting the measurements of the position angle in degrees, and the separation in arcseconds. This double star was chosen based on limitations of the ground based telescope, which can resolve stars down to about 5 arcseconds separation. Using Las Cumbres Observatory which has 0.4-meter telescopes in the northern and southern hemispheres allowed for selecting a star in the southern hemisphere.

The first published research of WDS 0900-4933 was in 1868 by J.M Gilliss (Gil 1868), with the last publication being in 2015. Gilliss initially discovered the double in 1852.

## Experiments and Procedures

Using Dave Rowe's Gaia WDS Catalog to select a system within the accessible parameters ( $> 0.5$  arcsecond separation,  $\Delta$  magnitude  $< 3$ ), research on double star 09000-4933 could commence. The Las Cumbres Observatory (LCO) granted telescope time, and 30 images were requested, 10 each at exposure times of

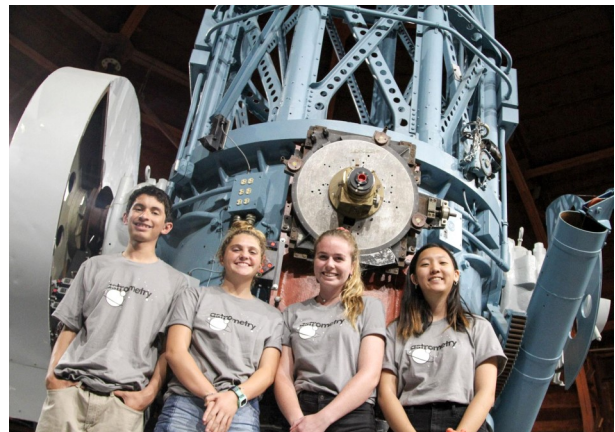


Figure 1: Image of Team Mizar with the 60" telescope at Mount Wilson Observatory, CA

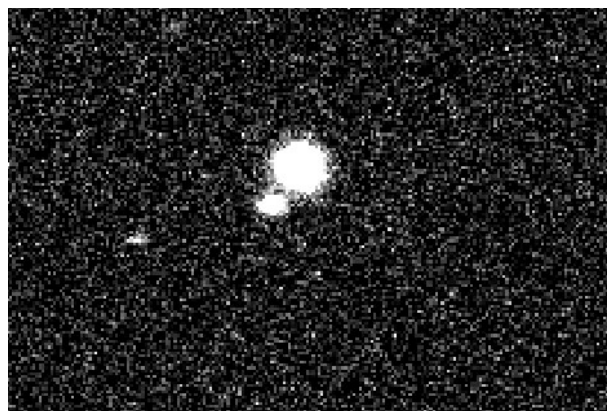


Figure 2: Image of WDS 0900-4933 (HD 77321) in AstroImageJ Software

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0.5, 1, and 2 seconds. The images were taken on a 0.4-m telescope located in Cerro Tololo in northern Chile. Along with these images, historical data was received on the star from Dr. Brian Mason with the US Naval Observatory.

The 30 images were analyzed using AstroImageJ (Collins. et al 2017) to measure each stars' right ascension (RA) and declination (DEC). Within the program, apertures of 4, 5, 6, and 7 were initially used to centroid the stars and determine precise RA and DEC values. After the collection of the data, it was determined that an aperture of 6 was best to eliminate variables and attain cleaner data. The average position angle and separation were then calculated using the observed RA and DEC from the AstroImageJ software.

### Results

Using AstroImageJ, the average position angle was calculated to be 307.530 and the average separation was 9.056 arc seconds. The data, including the averages of separation and position angle, are displayed in Table 1. The graph displayed in Figure 3 shows the data in relation to previous observations of the double star system. This graph was created using Richard Harshaw's Plotting Tool 3.10 (Harshaw personal communication).

### Discussion

The images analyzed by our student team show a separation of 9.056 arcseconds and a position angle of 307.530 degrees. Our measurements align well with the past observations (Table 3) of this double star as seen plotted in Figure 3. When using Richard Harshaw's Plotting Tool, which compiles data from the US Naval Observatory and the Gaia DR2 data file, we noticed that the parallax for the two stars are different but very close (Table 2). 1.23 milli-arcseconds and 1.14 milli-arcseconds are smaller than 5.00 and are at the limits of what the Gaia instrumentation can measure. The primary star has a distance of 813 parsecs and the secondary is at 877 parsecs. This puts a distance of about 64 parsecs between the two stars (over 200 light years), too far for them to be gravitationally bound. If we put the error (+ 0.02- 0.03 mas) into consideration the actual locations could be closer, the primary could be 1.198 mas and the secondary could be 1.173 mas. This separation is only 0.025 mas and is the minimum possible separation.

When plotting our data point alongside the historic measurements (Table 3), we noticed that the 1st measurement taken in 1852 showed a significant difference

Exposure Time (s)	0.5		1.0		2.0	
Image Number	Separation (arcsec)	Position Angle (deg)	Separation (arcsec)	Position Angle (deg)	Separation (arcsec)	Position Angle (deg)
1	9.065	307.630	9.105	307.975	9.130	307.782
2	9.104	307.469	8.963	307.961	9.031	308.023
3	9.084	307.606	9.102	307.573	9.077	307.714
4	8.942	307.149	9.079	308.188	9.093	307.689
5	9.044	306.982	9.040	307.434	9.075	307.813
6	8.986	307.126	9.027	307.896	8.877	305.953
7	9.059	307.203	9.072	308.185	9.166	306.691
8	9.058	307.558	9.018	307.261	-	-
9	9.119	307.394	9.075	307.995	-	-
<b>Mean Value</b>	9.051	307.346	9.054	307.830	9.064	307.381
<b>Standard Deviation</b>	0.056	0.238	0.046	0.330	0.093	0.761
<b>Standard Error</b>	0.019	0.079	0.015	0.110	0.035	0.288
			<b>Separation (arcsec)</b>		<b>Position Angle (DEG)</b>	
	<b>Total Mean Value</b>		9.056		307.530	
	<b>Mean Standard Deviation</b>		0.0628		0.503	
	<b>Mean Standard Error</b>		0.0126		0.101	

Table 1: Separation and Position Angle for 25 Images at Different Exposure Times on JD 2458591 (April 17, 2019)

**Astrometry of WDS 09000-4933**

	A Star Px, G2	B Star Px, G2	Wtd Distance	
Parallax	1.23	1.14	OVERLAP	-28
PXerr	0.02	0.03	RANGE	101
Err %	20%	3%	% O-LAP	-28%
MIN DIST	800	855		
<b>MEAN</b>	<b>813</b>	<b>877</b>	WTD PX	<b>1.18</b>
MAX DIST	826	901	WTD DIST	<b>847</b>
<b>AB SEP</b>	<b>250,260</b>	<b>270,018</b>	WTD SEP	<b>260,733</b>
Rad Vel	0.00	71.72	<b>NO OVERLAP</b>	
Radius	71.72	0.00		
Lumin	1,704.74	0.00		

Table 2: Distance (Parallax) Analysis (Plotting Tool 3.15)

from the rest of the points. Theta is 297.0 in 1852 and in less than 50 years it was measured to be 305.1. We suspect that the first measurement to be inaccurate due to limitations of the transit circle telescope used. We removed that data point from our graph (Figure 3).

**Conclusion**

The research group of students associated with Paso Robles High School made significant strides forward in the research and analysis of double star WDS 09000-4933. By collaborating with InStAR (Institute for Students Astronomical Research), they gathered further data on the double star system WDS 09000-4933. As measurements of the position angle and separation of the two stars were made, accuracy was judged

and confirmed. Our results are consistent with previous observations of the star system, and have added to the growing database of double star observations.

**Acknowledgements:**

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Year	Theta	Rho	X	Y	Adjustments		History	
					X <sub>p</sub>	New Theta	Made By	Type
1900.30	305.1	8.93	-7.30625	5.13480	-0.00191	305.09809	I_1905	Ma
1902.29	303.4	9.07	-7.57224	4.99286	-0.00192	303.39808	WFC1998	Pa
1903.12	310.1	9.33	-7.13692	6.00967	-0.00192	310.09808	WFC1998	Pa
1934.20	307.6	9.12	-7.22588	5.56452	-0.00200	307.59800	B_1935	Ma
1964.10	306.7	9.40	-7.53690	5.61768	-0.00208	306.69792	WFC1983	Pa
1987.191	307.0	9.23	-7.37161	5.55475	-0.00215	306.99785	Tob2005	Pu
1987.191	308.0	9.10	-7.17111	5.60252	-0.00215	307.99785	Bvd2003	Pa
1991.45	307.8	9.15	-7.23013	5.60810	-0.00216	307.79784	TYC2002	Ht
1998.987	306.4	9.09	-7.31669	5.39418	-0.00218	306.39782	UC_2013	Eu
2000.26	307.2	8.99	-7.16101	5.43535	-0.00218	307.19782	TMA2003	E2
2015.000	307.822	9.15	-7.22798	5.61088	-0.00222	307.81978	Kpp2018	Hg
2019.29	307.53	9.056	-7.18194	5.51670	-0.00223	307.52777	PRHS	C

Table 3: Past Measurement Data

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WDS Stars to select from and Rachel Freed for providing support and knowledge throughout our research of double star system 09000-4933.

**References**

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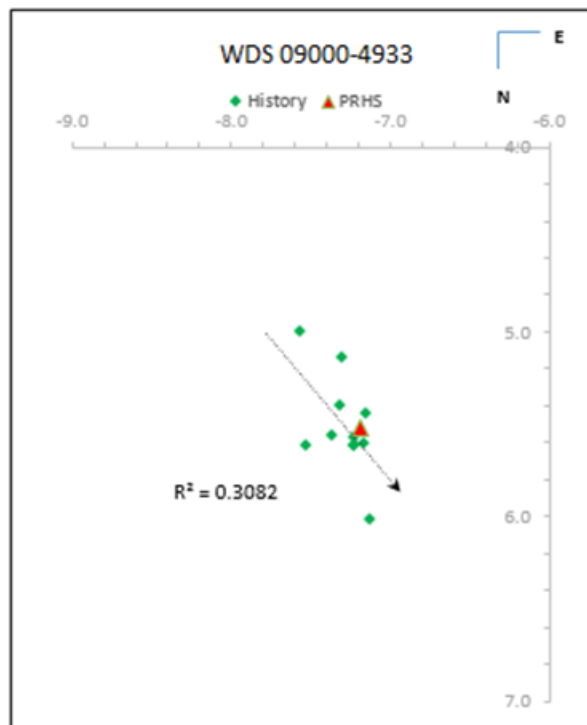


Figure 3. Our data (red triangle) compared with all historical data (green diamonds). X and Y Coordinates are in arc seconds. Downward arrow shows linear trend line of position.