Exploring Binary Stars – Fundamental Systems in Astronomy: Observation of HD 80460

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Abstract

We report the measurement of the position angle and separation for the double star system HD 80460. We made use of a 0.4m telescope from Las Cumbres Observatory (LCOGT) and a DeltaRho 350 + QHY600 camera. An analysis was made with the historical data from the Washington Double Star (WDS) catalog. A search was made with SIMBAD for spectral type, parallax, and proper motion for the double star.

1. Introduction

Double star systems have captured the attention of astronomers, scientists, and amateurs due to their peculiar formation and relative brightness and colors (e.g. Palencia et al. 2017). These double stars are fundamental to our understanding of the universe as they allow a way to determine the mass of the stars. The Stellarium planetarium allowed us to locate the constellations visible from our location and finally choose the double star to study. We used Stelle Doppie platform, to select the double star for our study. This program facilitates the selection of a double stars from the Washington Double Star (WDS) catalog.

To select the double star, we considered an apparent magnitude between $9 < m < 11$ and $\Delta m < 3$. We selected HD 80460 which is in the majestic constellation of Ursa Major (basic properties are shown in Table 1). Figure 1 shows an image of the system from the Digitized Sky Survey taken from Stelle Doppie.

Table 1. HD 80460 coordinate and apparent magnitudes of the stars.

Double star name	RA (2000.0)	DEC (2000.0)	m_1	m_2
HD80460	$09^h22^m35.60^s$	+62° 50’ 35.5”	10.04	10.30

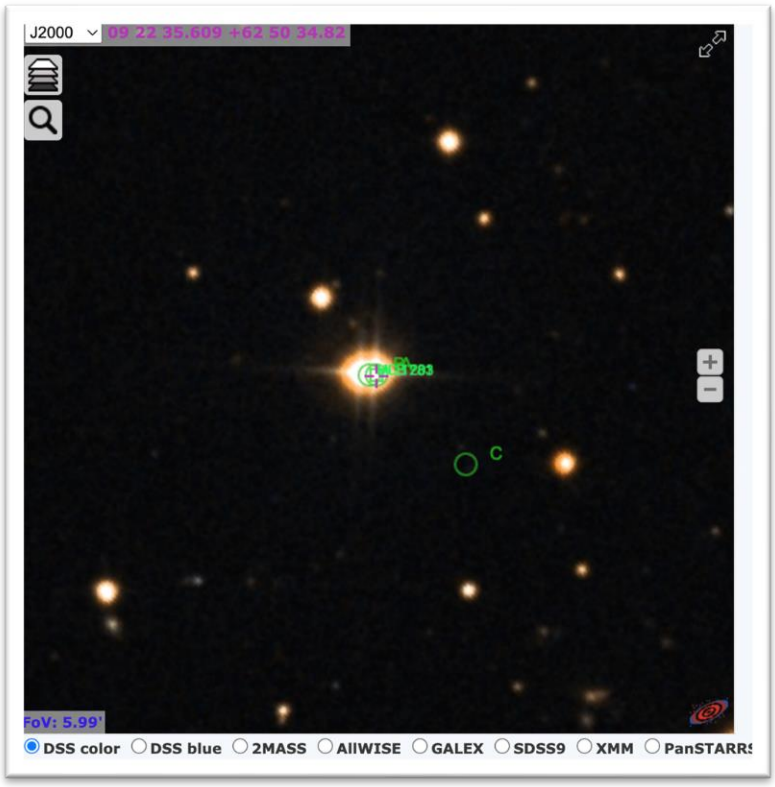


Figure 1: Image of HD 80460 from the Digitized Sky Survey (DSS)

2. Equipment and Methods

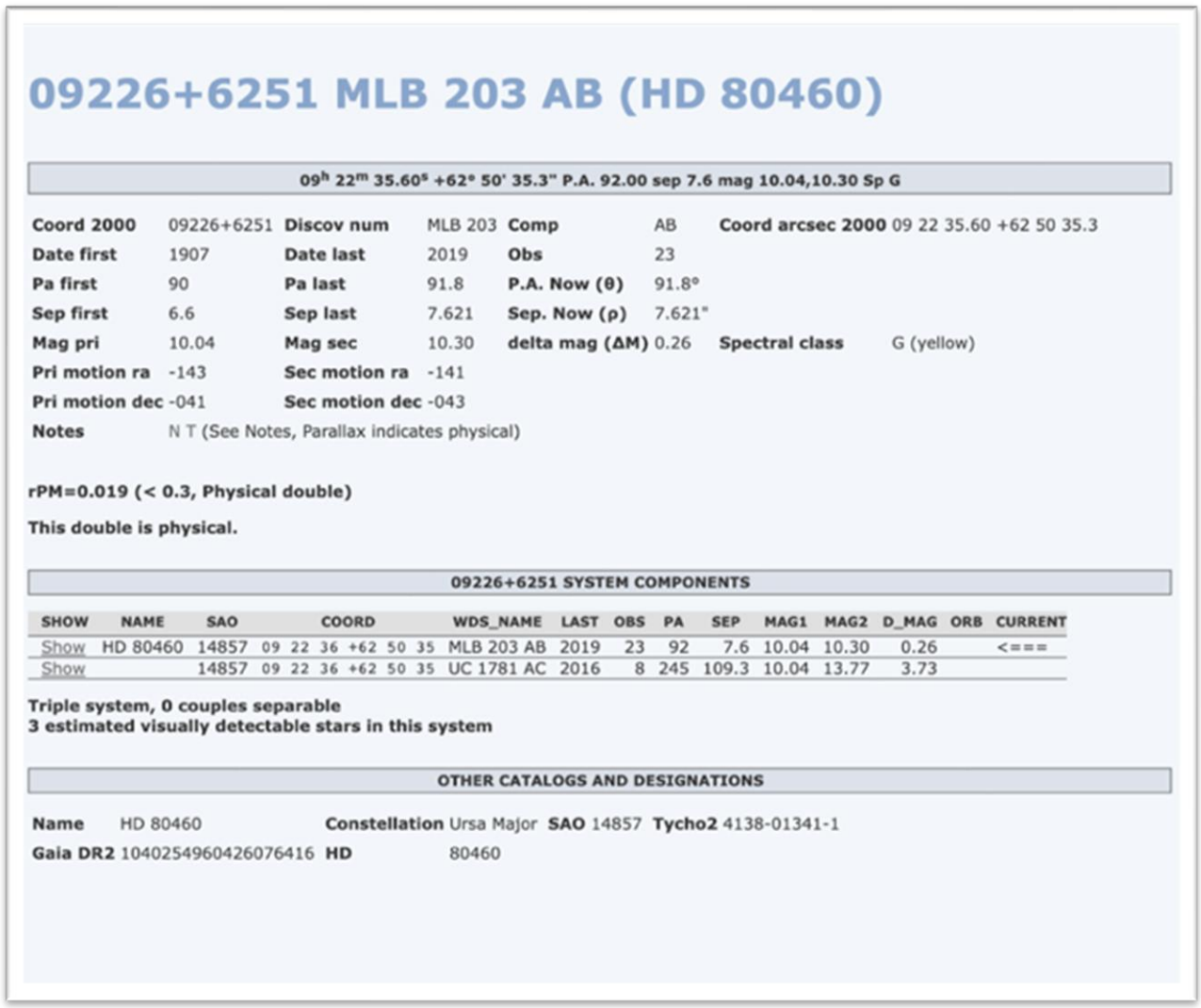
We used the following software for our research:

Stellarium:

Stellarium is a planetarium simulation program that offers an immersive experience for desktop computer users. With its advanced calculations, it can accurately determine the positions of celestial bodies such as the Sun, Moon, planets, constellations, and stars. Thanks to the Stellarium platform, we were able to locate the constellations visible from our location and ultimately choose our HD 80460 double star (Zotti, G., Wolf, A. 2022).

Stelle Doppie:

Stelle Doppie is a database with information from the renowned Washington Double Star Catalog and seamlessly integrates it with data from other credible astronomical sources. The platform's unique integration of data from multiple sources makes it a comprehensive and dependable resource for studying double stars. For our research we selected WDS 09226+6251 MLB 203 AB (HD 80460). Figure 2 shows a screenshot of data from Stelle Doppie.



09226+6251 MLB 203 AB (HD 80460)

09h 22m 35.60s +62° 50' 35.3" P.A. 92.00 sep 7.6 mag 10.04,10.30 Sp G

Coord 2000	09226+6251	**Discov num**	MLB 203	**Comp**	AB	**Coord arcsec 2000**	09 22 35.60 +62 50 35.3
Date first	1907	**Date last**	2019	**Obs**	23		
Pa first	90	**Pa last**	91.8	**P.A. Now (θ)**	91.8°		
Sep first	6.6	**Sep last**	7.621	**Sep. Now (ρ)**	7.621"		
Mag pri	10.04	**Mag sec**	10.30	**delta mag (ΔM)**	0.26	**Spectral class**	G (yellow)
Pri motion ra	-143	**Sec motion ra**	-141				
Pri motion dec	-041	**Sec motion dec**	-043				
Notes	N T (See Notes, Parallax indicates physical)						

rPM=0.019 (< 0.3, Physical double)

This double is physical.

09226+6251 SYSTEM COMPONENTS

SHOW	NAME	SAO	COORD	WDS_NAME	LAST	OBS	PA	SEP	MAG1	MAG2	D_MAG	ORB	CURRENT
Show	HD 80460	14857	09 22 36 +62 50 35	MLB 203 AB	2019	23	92	7.6	10.04	10.30	0.26		<===
Show		14857	09 22 36 +62 50 35	UC 1781 AC	2016	8	245	109.3	10.04	13.77	3.73		

Triple system, 0 couples separable
3 estimated visually detectable stars in this system

OTHER CATALOGS AND DESIGNATIONS

Name HD 80460 **Constellation** Ursa Major **SAO** 14857 **Tycho2** 4138-01341-1
Gaia DR2 1040254960426076416 **HD** 80460

Figure 2: Screenshot of the Stelle Doppie system with the information of the binary star system chosen

LCOGT

LCOGT is a global network of robotic telescopes that enables researchers to access celestial objects from different locations on Earth. We used the observing portal to submit or observation requirements. We selected the 0.4m telescope with the DeltaRho 350 + QHY600 camera (Bessell-V filter and exposure time).

AstroImageJ:

AstroImageJ is a platform that offers a specialized display environment and tools tailored for the display of astronomy specific images, as well as for the calibration and reduction of astronomy specific image data. The AstroImageJ platform was used to measure the Position Angle (PA) and Separation (SEP) of HD 80460. Figure 4 shows an example of measurements with AstroImageJ.

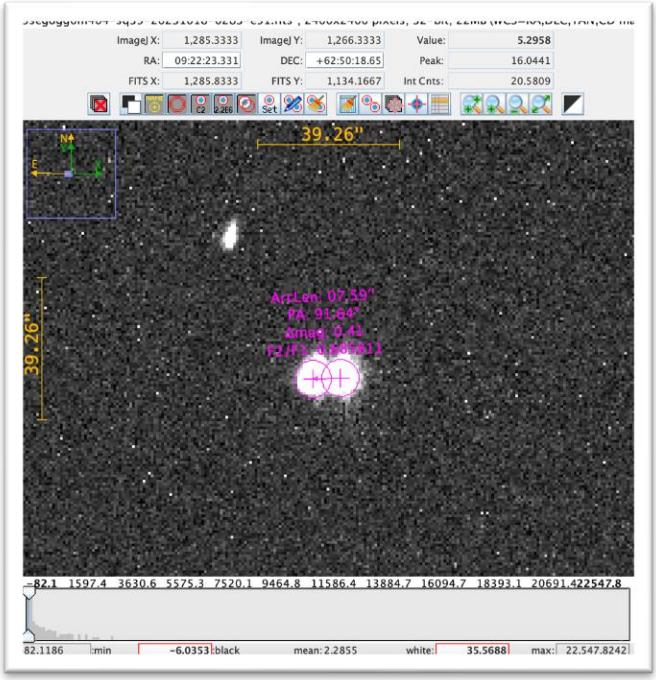


Figure 4: Example of AstroImageJ measurement of HD 80460 Double star Sep=07.59", PA=91.64°

SIMBAD:

SIMBAD is an astronomical database that provides information on astronomical objects beyond our solar system. It is maintained by the Centre de Données astronomiques de Strasbourg (CDS) in France.
In a search in SIMBAD, the names of the two stars of HD 80460 were found. The primary star is called HD80460A, and the secondary star is called HD80460B. According to this Platform, the primary star is a High Proper Motion Star, has a parallax of 12.3238 [0.013] mas and its spectral type was not found. Regarding the second star, it was found that its parallax is 12.3432 [0.0136] mas and its spectral type is K0 but classified D quality.

Gaia:

The Gaia archive encompasses derived data such as positions, parallaxes, proper motions, radial velocities, and luminosity measurements (Gaia Collaboration et al. 2016). We used the Gaia platform to identify the names of our double star, in addition to the parallax, spectral type, RA and DEC.

3. Data

Table 2 shows the date, exposure time (s), PA (degrees) and SEP (arcmin). These images were taken with a 0.4m telescope from LCOGT (Fall 2023, Bessell-V filter).

Table 2: Data of double star HD 80460 observed with LCOGT.

Date	Exp time (s)	PA (deg)	SEP (arcmin)
oct.19.2023	5	91.90	0.04
oct.19.2023	1	91.94	0.13
oct.19.2023	0.5	92.10	0.13

oct.19.2023	1	92.10	0.13
oct.19.2023	5	91.64	0.13
oct.19.2023	5	91.15	0.12
oct.19.2023	2	91.72	0.39
oct.19.2023	1	91.81	0.11
oct.19.2023	1	90.23	0.12
oct.19.2023	1	92.98	0.13
Average:		91.8	0.14
Standard deviation:		0.7	0.09

4. Discussion

The stars are close to each other. Of the ten observations that were made, the average PA is 91.8° with a standard deviation is 0.7°. The average SEP is 0.14 arcmin and its standard deviation is 0.09 arcmin. The historical data is presented in Table 3. Observations were found from the year 1907 to 2019. The first column presents the date on which the observation was made, the second column shows the PA, the third column shows the SEP, the fourth column shows the telescope aperture (m), the fifth column shows the number of nights of the observation, the sixth column shows the RA in arcsec, and the last column shows the DEC in arcsec. This table was used to plot the orbit in a Cartesian graph. For the x axis we calculated: Sep × sin (PA) and for the y axis we calculated: -Sep × cos (PA). We searched SIMBAD and found HD 80460A doesn't have a spectral type. The name of the secondary star is HD 80460B and have a K0 spectral type. The parallax of the principal star HD 80460A is 12.3238 [0.013] mas, and for HD80460B is 12.3432 [0.0136] mas. In Table 4, we presented the data retrieved from Gaia DR3 for both stars, HD80460A and HD80460B. The first column lists the name of each star, the second column shows its parallax along with the corresponding error, the third column displays the right ascension, and the fourth column indicates the declination. Moving forward, the fifth column represents the proper motion in the right ascension with its error, the sixth column conveys the proper motion in declination with its error, and the final column outlines the distance in parsecs in arcseconds.

Table 3: Historical Data for HD 80460 from the WDS Database

Date	PA (degrees)	Sep (arcsec)	Telescope aperture (m)	Number of nights	RA (arcsec)	DEC (arcsec)
1907.22	90.4	6.558	0.3	l	6.56	0.05
1907.72	88.8	7.0	0.3	2	6.10	-0.15
1908.22	89.3	8.633	0.3	1	8.63	-0.11
1921.22	88.5	7.23	0.6	2	7.23	-0.19
1930.15	96.8	7.046	0.2	1	6.10	0.83
1957.18	92.4	7.143	0.2	1	7.14	0.30
1974.274	90.717	7.522	0.7	5	7.52	0.09
1981.309	91.045	7.521	0.7	1	7.52	0.14
1984.231	90.880	7.501	0.7	1	7.50	0.12
1985.00	90.5	7.20	0.5	2	7.20	0.06
1986.193	90.966	7.522	0.7	6	7.52	0.13
1986.981	91.146	7.513	0.7	1	7.51	0.15
1989.233	91.157	7.572	0.7	2	7.57	0.15

1991.62	91	7.574	0.3	1	7.57	0.13
1999.05	91	7.56	1.3	1	7.56	0.13
2003.274	91.4	7.582	0.2	7	7.58	0.19
2012.256	91.7	7.61	0.7	2	7.61	0.23
2013.067	91.71	7.561	0.2	5	7.56	0.23
2014.097	91.59	7.597	0.2	10	7.59	0.21
2015.0	91.60	7.726	1	1	7.72	0.22
2015.101	91.64	7.597	0.2	10	7.59	0.22
2015.5	91.64	7.6147	1	1	7.61	0.22
2016.0	91.3	7.58	1	1	7.58	0.17
2019.120	91.8	7.621	0.7	1	7.62	0.24

In Figure 5 we show the historical data plotted in a Cartesian coordinate system with RA (arcseconds) in the x axis and Dec (arcseconds) in the y axis. The blue line is a second order polynomial fit (R^2= 0.04). The blue dots are the historical data, and the red dot is our new measurement for HD 80460.

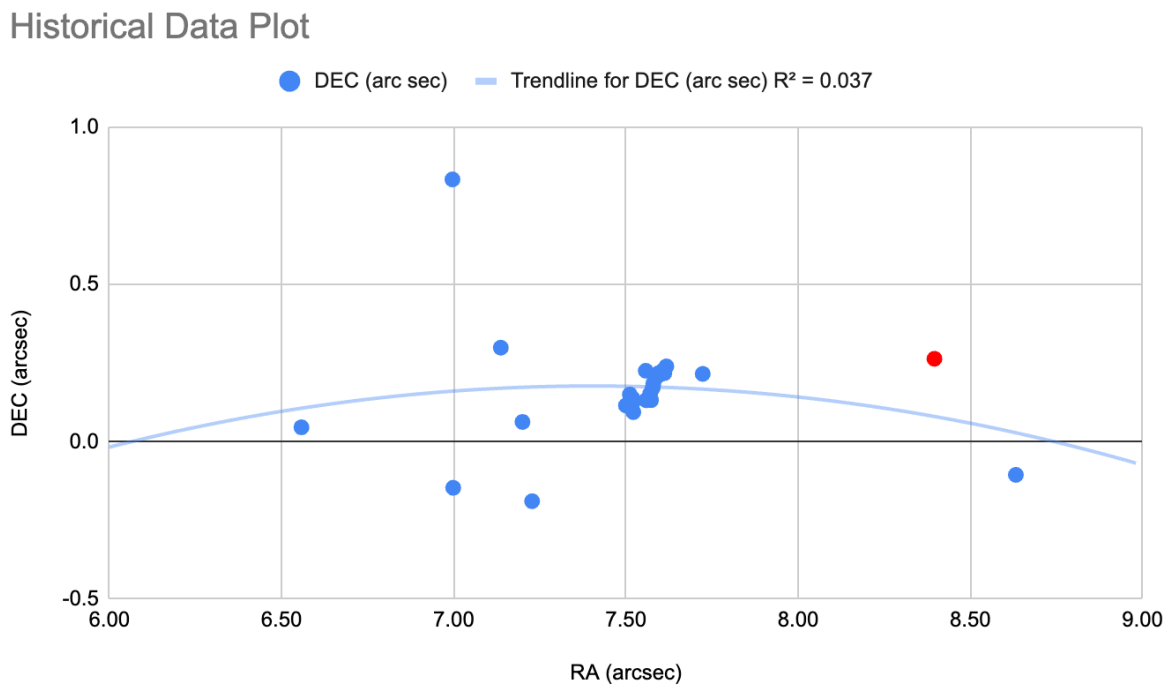


Figure 5: Shows the historical data plotted in a Cartesian coordinate system with RA (arcseconds) in the x axis and Dec (arcseconds) in the y axis. The blue line is a second order polynomial fit. The blue dots are the historical data, and the red dot is our new measurement for HD 80460

Table 4: Gaia DR3 measurements of the System HD80460A and HD80460B.

Double star name	Parallax [error] mas	RA (2000.0)	DEC (2000.0)	pmRA[error]	pmDE [error]	Dist (parsec)	Dist (lightyears)

HD80460A	12.32 [0.013]	$09^h22^m35.60^s$	+62° 50' 35.34"	-142.92 [0.011]	-40.92[0.012]	80.84	263.53
HD80460B	12.34 [0.014]	$09^h22^m36.70^s$	+62° 50' 35.17"	-140.84[0.011]	-43.53[0.013]	80.72	263.21

5. Conclusions

Binary star systems, where two stars orbit a common center of mass, offer insights into various aspects of astrophysics. Observations of double stars at various stages provide important data to validate and improve theoretical models, improving our understanding of the birth, life, and fate of stars. The motion of binaries within galaxies can provide information about mass distribution, contributing to our understanding of dark matter and the overall structure of galaxies.

In conclusion, with our observations and the historical data, we were able to observe that the values we made were similar to the values of the historical data. We used Stelle Doppie, which informed us that this system was physical. This is why the Gaia DR3 platform was used to observe the relationship that both stars showed, since, according to our graph, the value was too low to identify them as a physical pair. The data obtained from Gaia DR3 is consistent with the system being a physical system. The proper motions of the stars are similar indicating that the stars are moving together in space. In addition, the distance values of each star are very similar (< 1 ly difference). This is an interesting system that would benefit from more observations that would help establish its orbit and clarify its true nature.

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