Unique Stellar Dynamics of ES1144

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Abstract

This investigation selected a double star system: ES1144 (also known as HD67007A and HD67007B), which is an eclipsing binary and member of a quadruple star system. We report on our observations and measurements of position angle and separation using images taken with Las Cumbres Observatory telescopes. We found a separation of 6.7 arcsec and a position angle of 337°. We conclude that more observations will be required to establish the orbit of the system.

1. Introduction

An eclipsing binary is a double star system in which one star periodically eclipses the other from our vantage point on Earth. They are important in astronomy because they can allow the determination of the stars' masses, sizes, and orbits through the analysis of their light curves during these eclipses (e.g. Fraknoi, et al., 2022, p.596).

Our choice of a star system was made by using Stelle Doppie program and using its filters. We searched for double star systems with apparent magnitude $9 < m < 11$, $\Delta m \lesssim 3$, separation $5 < SEP < 10$ arcseconds, and with < 25 previous observations made. We selected for our study the double star system ES1144 (see Table 1). It is listed in Stelle Doppie as a member of a quadruple system of stars.

Table 1. Data of ES1144

HD67007	Magnitude (Stelledoppie)	Magnitude (SIMBAD)	Spectral type
Primary	10.20	9.7	G5
Secondary	10.27	10.20	G5

2. Equipment and Methods

The observations of the system HD67007 were obtained using Las Cumbres Observatory robotic telescopes (LCOGT). We used the: 0m4 SCICAM QHY600 camera, Mode Central 30x30 and Bessell V filter. We tried different exposure times to determine which time gave the best image. These exposure times being: 0.2s, 0.5s and 1.0s. We selected 0.2 seconds as the best exposure time.

3. Data

Table 2 presents our measurements of position angle and separation made using AstroImageJ. Column 1 is the exposure time (s), column 2 is the Separation (SEP) in arcsecs, column 3 is position angle (PA) in degrees.

Table 2. Observational data of ES1144.

Exposure Time (s)	SEP (arcsec)	PA (deg)
0.200	6.8	335
0.201	6.9	338
0.201	7.0	342
0.200	7.0	336
0.200	6.4	333
0.200	6.4	335
0.199	6.5	337
0.199	6.4	338

Table 3 presents the average separation (SEP) in arcsecs, the average position angle (PA) in degrees and their respective standard deviations and standard errors of the mean.

Table 3. Average, Standard Deviation and SEM of the positions of ES1144.

	SEP (arcsecs)	PA (degrees)
Average	6.7	337
Standard Deviation	0.3	3
SEM	0.09	0.9

4. Discussion

Table 4 shows the historical data obtained from the United States Naval Observatory. Column 1 is the date, column 2 is the position angle (PA) (degrees), column 3 is separation (SEP) (arcsec), column 4 is the position angle (radians), column 5, 6 are the distance from the primary to the secondary in the RA and DEC direction (delta-RA (arcsecs), delta-DEC (arcsec)). The system has been observed from 1897-1989.

Table 4. Historic Data and position of ES1144.

Date	PA (degrees)	SEP (arcsecs)	PA (radians)	delta-RA (arcsecs)	delta-DEC(arcsecs)
1897.98	338.5	6.57	5.907939518	-2.40791306	-6.112843422
1902.96	325.1	6.16	5.674065398	-3.52441858	-5.052135555
1912.24	337.8	7.63	5.895722213	-2.882925203	-7.064392562
1914.31	336.6	6.49	5.874778262	-2.57748981	-5.956227521
1915.9	331.2	6.55	5.780530483	-3.155486565	-5.739808754
1920	341.9	6.61	5.967280713	-2.0535712	-6.282908986
1930.05	335.6	6.45	5.85732497	-2.664523572	-5.873909612
1938.26	336.8	6.52	5.878268921	-2.568501251	-5.992762412
1958.09	335.0	7.71	5.846852994	-3.258386798	-6.987633038
1979.99	335.0	6.50	5.846852994	-2.747018701	-5.891000616
1989.02	336.7	6.53	5.876523591	-2.582912132	-5.99745487
2024.25	336.82	6.78	5.878617987	-2.668750698	-6.23266955

A linear fit was made to the data of delta-DEC vs delta-RA and obtained a value of $R^2 = 0.034$ which represents low correlation. We also made a second order polynomial fit to the data of delta-DEC vs delta RA and obtained a value of $R^2 = 0.092$ a value also close to 0.

Table 5 shows some properties of HD 67007A,B found in the SIMBAD database.

Table 5. Data from Gaia DR3 of ES1144 (HD 67007A,B) obtained using SIMBAD.

Star Name	Parallax (mas)	Parallax Error (mas)	Proper motion RA (mas/yr)	Error of proper motion RA (mas/yr)	Proper motion DE (mas/yr)	Error of Proper motion DE (mas/yr)	Dist (pc)
HD67007A	6.8405	0.0171	-11.083	0.017	-23.235	0.014	145.3158
HD67007B	6.8015	0.0192	-12.129	0.020	-24.455	0.016	145.9470

5. Conclusions

We measured a separation SEP= 6.7 $\pm$ 0.3 arcsec and a PA= 337$\pm$ 3 degrees for ES1144. Stelle Doppie indicates that ES1144 (HD 67007) is a physical pair. Our plot of the historical data contains 12 observation points. With this amount of points, we are not able to trace a curvature for this system. Our search with the SIMBAD database resulted in measurements from Gaia DR3 for parallax and proper motion for the stars of the system. The difference in proper motion between the two stars is ≈ 0.002 arcsec/yr. The values of proper motion are consistent with a physical pair. The distance to the stars is approximately 479 light years. Since this pair of stars is part of a quadruple system it seems a very interesting system to continue to study. HD 67007A (TIC 99135781) and HD67007B (TIC 99135783) can be found in the TESS eclipsing binary catalog live database version (https://tessebs.villanova.edu) listed with a period of ~3 days (Prsa, A., et al. 2022).

Acknowledgements

References

(2022) Astronomy 2e (A. Fraknoi, D. Morrison, and S.C. Wolff, Ed.) Openstax (https://openstax.org/details/books/astronomy-2e)

Prsa, A., et al. (2022) TESS Eclipsing Binary Stars. I. Short-cadence Observations of 4584 Eclipsing Binaries in Sectors 1-26, The Astrophysical Journal Supplement Series, 258(1), 16-22.