

# Refuting S 825AB System Classification through Astrometry and Gaia Satellite Data

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**Abstract:** A student-led team of researchers studied double star S 825AB (WDS 23100+3651). Analysis of ten CCD images obtained by the Sierra Research Observatory yielded an average position angle of  $318.37^\circ$  and an average separation of  $67.38''$ . Comparing these results to published findings in the Washington Double Star Catalog and measurements taken from the European Space Agency's Gaia astrometry satellite, the team concluded that S 825AB is not a binary system.

## Introduction

The term “double star” refers to any two stars that appear near to each other from the perspective of Earth. Although the stars may appear to be in close proximity, the components of the systems may actually be separated by great distances. The distance and masses of the components in three-dimensional space determines whether the system is a binary system, an optical double, or a common proper motion pair. A true binary system contains two stars that are physically bound and orbit around a common gravitational center. This is in contrast to optical double and common proper motion systems which are chance optical alignments but the component stars are not orbiting one another. Through repeated observations of these systems, taking place over many years, the nature of the stellar relationship can be determined.

A team of students from several institutions studied the suspected binary star system S 825AB (listed as WDS 23100+3651 in the Washington Double Star Catalog) by collecting new images and combining the data with past observations. S 825AB has been previously proposed as a binary system due to past findings suggesting the stars are gravitationally bound (Figure 1).

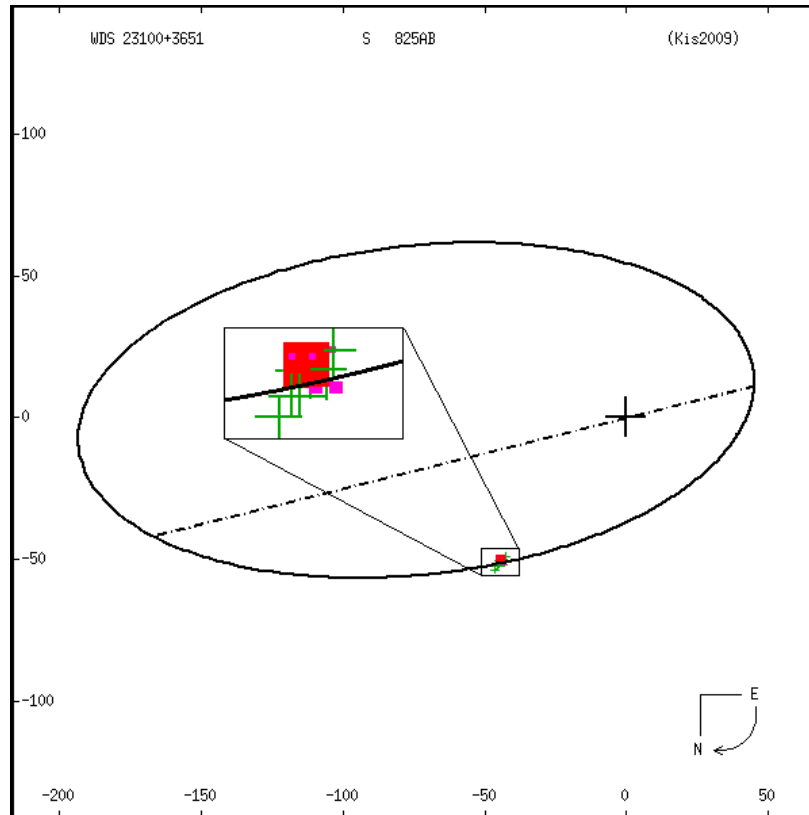
The proposed orbit, however, did not coincide with recent observations. Data collected by the Gaia satellite from the European Space Agency (ESA) provides strong evidence that S 825AB is not a binary system. The purpose of this study was to make a new observation to determine the nature of S 825AB as a binary.

## Procedures and Instrumentation

Previous data was collected on S 825AB from both the Washington Double Star Catalog (WDS) via the United States Naval Observatory and the Gaia Satellite Observations database from the European Space Agency. New data was obtained through Sierra Remote Observatory in California using a PlaneWave Instruments CDK217 Astrograph telescope and Apogee F16 KAF-16803 CCD camera. Instrument specifications are listed in Table 1. Ten images were captured and compiled on June 30, 2017 in order to measure current system positions.

The collected images were analyzed using AstroImageJ, a public domain image processing program based on the ImageJ software developed by the National Institutes of Health (Collins et al., 2017). AstroImageJ has the option to use “centroid apertures” within its measuring tools that automatically sets the

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*Figure 1. An orbital plot containing 38 previous observations of S 825AB provided by U.S. Naval Observatory.*

cursor to the center of the identified stars. This option reduces the human error involved in measuring the separation and position angle between the component stars. With the *Plate Solve* feature, the identity of the stars was confirmed and compass directions oriented via the online database [astrometry.net](http://astrometry.net), thus further validating the measurements.

**Data and Results**

Previous data was collected and compared from both the Washington Double Star Catalog and the Gaia Catalog. Of particular importance is the description of

the proper motions of the individual stars in the double star system from the Gaia Satellite (Table 2). The data collected from Sierra Remote Observatory is displayed with data from each captured image (Table 3) and resulted in a combined position angle of  $318.37 \pm 0.005^\circ$  and a separation of  $67.38 \pm 0.01''$ .

**Discussion**

The results of this study combined with previous data demonstrate a nearly linear change in position between the two stars (Figure 2). Possible explanations of

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*Table 1: Summary of Equipment Utilized with Specifications.*

Equipment	Specifications
Telescope	CDK17 OTA, IRF90 integrated rotator/focuser
Telescope mount	A200 mount with Sitech controller
Camera	Apogee F16M KAF-16803 based camera with filter wheel
Software	STI 1.4.2 mount interface, PWI 3.3.3 focuser/rotator interface, PWA 1.09 automation software, MaxIm DL Pro 5 camera interface, TeamViewer 12, Google Drive, db3.2.1 version AstroImageJ

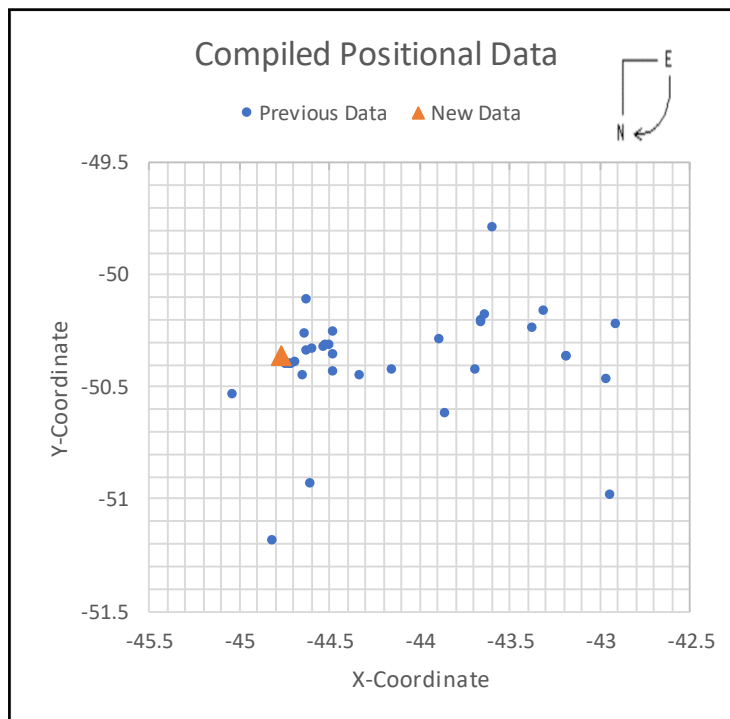
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**Table 2:** Selected data obtained from the ESA’s Gaia astrometry satellite describing the location and movements of each component of the double star S 825AB

Right Ascension (degree)	Declination (degree)	Parallax (milliarcsec)	Proper Motion RA (milliarcsec/year)	Proper Motion DE (milliarcsec /year)
347.5108173664	+36.8482827887	3.26	14.712	-2.267
347.4952824410	+36.8622777008	1.56	4.290	-0.004

**Table 3.** Separation and position angle measurements from CCD images taken in this study including average value, standard deviation, and standard error of the mean.

Observation	Position Angle (degrees)	Separation (arc seconds)
1	318.36	67.42
2	318.39	67.40
3	318.38	67.41
4	318.37	67.30
5	318.36	67.46
6	318.35	67.37
7	318.39	67.33
8	318.39	67.36
9	318.38	67.38
10	318.35	67.41
<b>Mean</b>	318.37	67.38
<b>Std. Deviation</b>	0.02	0.05
<b>SE Mean</b>	0.005	0.01



**Figure 2.** A compilation of new and previous data plotted on a Cartesian Coordinate system for comparison (excluding statistical outliers).

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these results are that the system exhibits an orbit with a prolonged period or that the components are not gravitationally-bound. Large differences in parallax and proper motion are reported in the Gaia catalog data set, suggesting that the components of the system are chance optical alignments rather than a gravitationally bound binary system.

### Conclusion

This student-led study has successfully introduced several undergraduate researchers to the field of astrometry. The results show definitely that the double star S 825AB is not a binary system but rather an optical motion double star. The component stars move in a similar direction; however, it can be inferred that with the passage of time, the differences in proper motions will cause the pair's separation to widen.

### Acknowledgements

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Washington Double Star Catalog maintained at the U.S. Naval Observatory.

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VizieR catalogue access tool, CDS, Strasbourg, France. The original description of the VizieR service was published in A&AS 143, 23

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