Astrometric Measurements of the Double Star System WDS 14126+4512 (DQ Boo)

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Abstract

We present new observations of the double star system WDS 14126+4512 STF 1815 (DQ Boo). The separation is $8.96 \pm 0.06''$ and the position angle is $150.537° \pm 0.28°$. This measurement, combined with both historical data and distances determined using Gaia DR3, indicates that DQ Boo is unlikely to be a binary system.

Introduction

WDS 14126+4512 STF 1815 (DQ Boo) was identified as a double star by Fredrich Georg Wilhelm Struve (1793–1864). Struve was a prolific double-star observer, publishing four catalogs of double stars between 1822 and 1852 (Tenn, 2013). His second catalog included 3,112 systems, over 2,500 of which were newly identified (Tenn, 2013); 2,343 of these new systems were discovered by Struve himself with the 9-inch refractor at Dorpat Observatory in modern Tartu, Estonia, where he served as director from 1815–1839 (Batten, 1977).

There are 30 historical observations on record. The earliest, from 1830, indicated a position angle of 155.0° and angular separation of 9. arcsec (Herschel, 1833). The most recent observations from 2021 showed a position angle of 150.51° and separation 8.95 arcsec (Matson et al., 2024). The Washington Double Star Catalog classifies DQ Boo as a physical system, meaning the stars are near one another in space, but may not be gravitationally bound. Our measurements, combined with data from GAIA Data Release 3 (DR3) and the historical data, indicate that DQ Boo is unlikely to be a binary system.

Equipment and Procedure

DQ Boo was selected by utilizing the selection tool available through Stelle Doppie (Sordiglioni, 2024). Based on the capabilities of the Las Cumbres Observatory (LCO; Brown et al. 2013) global telescope network, we searched for double stars that were between 5 and 10 arcseconds apart, with primary magnitude less than 11, and a difference in magnitude no greater than 3. The latter criteria prevents the primary star from washing out the secondary star in the image.

The primary star in the DQ Boo system is a K0 class star with an apparent magnitude of 9.58. The secondary star's magnitude is 10.92. Crucially, the difference between the two stars' magnitudes is small enough to observe and resolve both with a telescope image.

Observations and Measurements

We observed DQ Boo by taking a series of ten images remotely using the LCO Observation Portal by entering the desired right ascension, declination, filter, and exposure length. The LCO network then assigned the observation to a telescope fitting our needs. An example image from LCO is provided in Figure 1, below.

Figure 1: *An example image of WDS 14126+4512 STF 1815 (DQ Boo) taken by the LCO telescope system. Also shown is the measurement output from AstroImageJ.*

Specifically, our images were taken with a 2.0-second exposure, using the Bessel-V filter on an 0.4-meter telescope at McDonald Observatory of the University of Texas at Austin. The BANZAI processing pipeline was used to process all images (Brown et al. 2013). The separation, position angle, and magnitude difference between the two stars were measured using AstroImageJ (Collins et al. 2017) and are shown in Table 1, below.

Observation Number	Separation [Arcseconds]	Position Angle [Degree]	Delta Magnitude
1	8.89	150.48	1.19
2	8.97	150.39	1.24
3	8.99	150.92	1.22
4	8.94	150.32	1.19
5	8.89	150.09	1.19
6	8.90	150.29	1.20
7	8.97	150.74	1.20
8	9.04	150.77	1.16
9	8.94	150.48	1.25
10	9.07	150.89	1.19

Table 1: *Measurements of separation, position angle, and delta magnitude of DQ Boo, from AstroImageJ.*

Results

We report the basic statistical parameters of the observations in Table 2.

Parameters	Separation [Arcseconds]	Position Angle [Degree]	Delta Magnitude
Mean	8.96	150.54	1.20
Standard Deviation	0.06	0.28	0.03

Table 2: *Statistics of the Measurements for DQ Boo.*

Discussion

Our results of 8.96″ for separation and 150.537° for position angle are largely in agreement with recent observations of DQ Boo. However, when all data are considered, it appears that DQ Boo is not a binary system.

Our measurement, along with the historical data for the system, are plotted in Figure 2 using Plot Tool 3.19, based in Microsoft Excel (Harshaw, 2020). The points show the position of the secondary star, with the primary star located at the origin (not shown). There is no clear pattern to the data points. A gravitationally bound binary system is expected to show a parabolic trajectory, while a proper motion pair should appear as a straight line. Neither is a good match to the data.

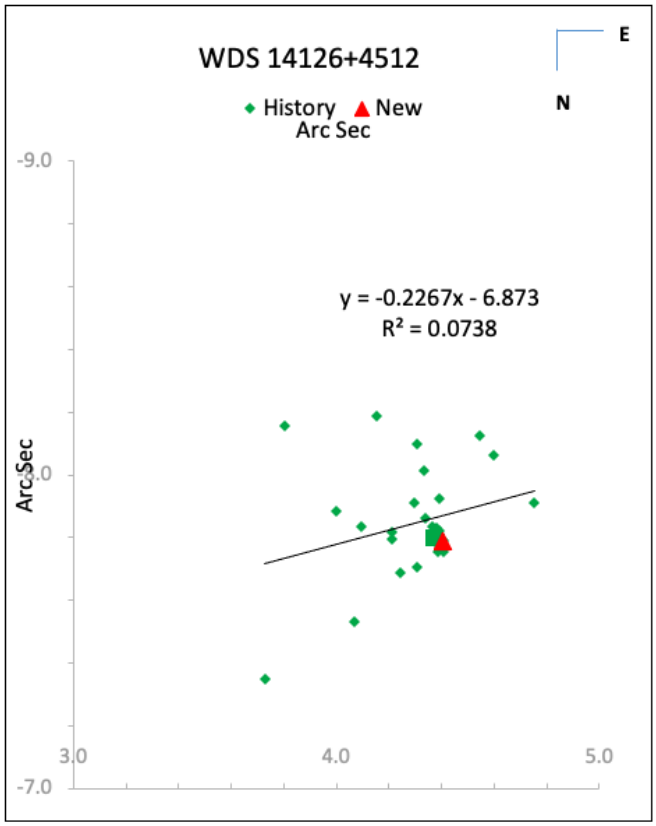

***Figure 2**: Historical data for DQ Boo system plotted using Plot Tool 3.19 (Harshaw 2020), including the parameters of a linear fit, which is clearly very poor. Historical data are shown as green diamonds, while our new measurement is a red triangle.*

To further investigate, we consider astrometric data from Gaia Data Release 3 (DR3; Gaia Collaboration et al. 2023). The stellar parallaxes and proper motions for the DQ Boo system are shown in Table 3.

Measurement	Primary Star	Secondary Star
Parallax	6.9511 mas	6.5065 mas
Parallax Error	0.0127 mas	0.1779 mas
Proper Motion in Right Ascension	-31.378 mas/yr	-27.699 mas/yr
Proper Motion in Right Ascension Error	0.011 mas/yr	0.150 mas/yr
Proper Motion in Declination	30.769 mas/yr	33.534 mas/yr
Proper Motion in Declination Error	0.013 mas/yr	0.175 mas/yr

Table 3: *Gaia DR3 Data (Gaia Collaboration et al. 2023)*

We also consider the separation between the stars based on the Gaia DR3 stellar parallaxes. The distances to the two stars of 143.86 $\pm$ 0.26 pc and 153.69 $\pm$ 4.20 pc indicate a separation of 9.82 ± 4.21 pc. For two stars to be gravitationally bound, they should generally be within about 60,000 AU $\approx$ 0.3 pc. The separation of the stars in DQ Boo is thus well outside the range for a binary system.

Conclusions

Our new astrometric measurements for DQ Boo, combined with the historical measurements and Gaia DR3, show neither a parabolic orbital relationship nor the linear relationship expected for a proper motion pair. It is unlikely that DQ Boo is a binary system.

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