Analysis of Eight Double Star Systems

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Abstract

Our class measured eight double stars and assessed the probability of a gravitational relationship for each system. All targets for this study are pairs whose stars have similar brightness and a separation between 5 and 20". The measurements were performed using between eight and ten images per system provided by the Las Cumbres Observatory Global Telescope Network's 0.4m robotic telescopes in early 2021. The measurements made were then compared with historical data for each of the system and data from the Gaia mission's third data release. While seven of the eight systems measured exhibited common proper motion, the data suggests that only one system (STT 547AB, which has a solved orbit) is definitely a binary system. However, this conclusion does not necessarily rule out the possibility of a physical relationship between stars of some of the other examined pairs.

1. Introduction

All double star pairs for this study have similar brightness (delta magnitude < 3) and a separation between 5 and 20″. The stars in each system also have similar parallax and proper motion (PM). Similarity of proper motion is measured with a proper motion ratio, rPM, which is the magnitude of the proper motion difference vector divided by the magnitude of the longer of the two stars' proper motion vectors (Harshaw, 2016). Of the eight stars studied, seven have common proper motion (rPM < 0.2) and the eighth has similar proper motion (rPM < 0.4). One particularly interesting system is STT 547 AB, which has two solved orbits with very different orbital parameters. STT 547 AB is close in the sky to several other stars, all of which were originally designated as part of the system. One of these companions, STT 547 AF, also has a solved orbit with a long period of 830 centuries. All three of the orbits on file in the Washington Double Star (WDS) catalog for this system are shown in Figure 1.

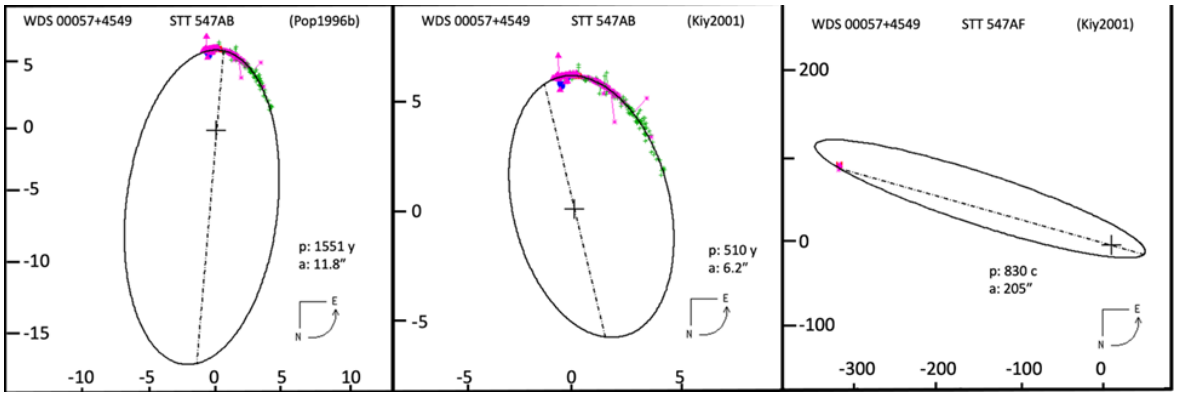


Figure 1. Raw CCD Images of WDS 06412-4021 (HJ 5443) with the Bessel V filter with an exposure of 1.5 Seconds

2. Equipment and Methods

For all stars in this study, images were taken using 0.4 meter aperture robotic telescopes from the Las Cumbres Observatory (LCO) Global Telescope network. The cameras use in the LCO's 0.4 meter telescopes are SBIG STL-6303s, with a 29.2' by 19.5' field of view, and a pixel scale of 0.57" per pixel. The filters used were either clear or PanSTARRS-W.

3. Data

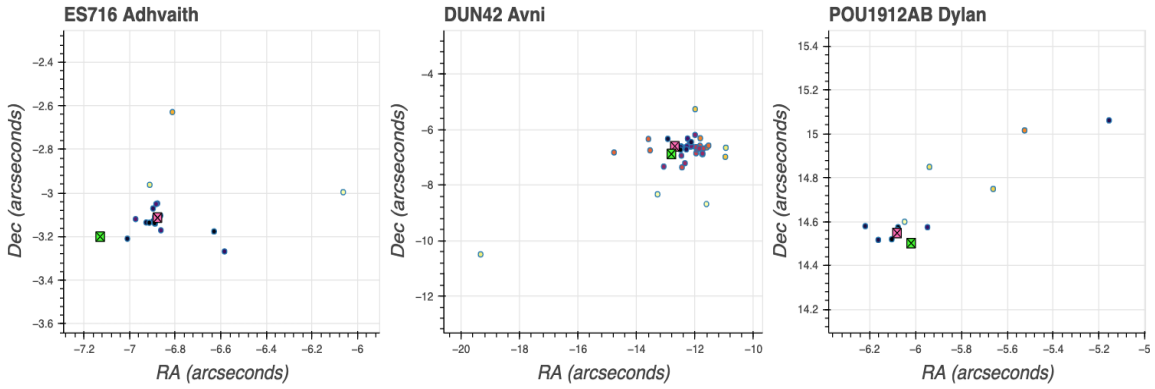
Table 1 shows the parallax and PM of each star from Gaia Early Data Release 3 (EDR3), along with the rPM computed from those values. The position angle (PA) and separation of each system was measured in AstroImageJ and is listed in Table 2. Historical measurements of each system were requested through the U.S. Naval Observatory and are plotted in Figure 2. The historical measurements are colored according to date, with darker points being more recent. Each student's measurement is a green square, Gaia EDR3 measurements are a pink square, and the plots are labeled with the name of the system and the name of the student who made the measurement

System	Parallax Primary (mas)	Parallax Secondary (mas)	PM Primary (RA, Dec) mas/yr	PM Secondary (RA, Dec) mas/yr	rPM
DUN 42	24.4775	22.7501	23.62±0.154, 108.653±0.17	11.069±0.437, 107.302±0.577	0.114
DON 537 A,BC	2.2982	2.779	11.207±0.020, -4.237±0.013	11.293±0.074, -4.560±0.059	0.196
UC 102	11.6507	11.7004	22.491±0.033, -81.077±0.031	22.971±0.035, -79.116±0.031	0.023
STT 547	86.8003	86.8206	888.479±0.023, -154.0±0.020	846.013±0.03, -162.831±0.024	0.186
POIJ 1912AB	122.1088	122.0035	3.033±0.018, -9.314±0.016	3.595±0.024, -8.938±0.021	0.192
KR 29AB	5.5862	5.6094	-15.356±0.013, -29.352±0.012	-15.420±0.012, -30.691±0.011	0.058
ES716	1.9949	2.2185	-1.589±0.044, -6.885±0.038	-0.912±0.038, -8.265±0.031	0.185
COO159	68.6052	68.5820	89.305±0.029, -26.183±0.023	84.945±0.027, -62.672±0.025	0.392

Table 1. Parallax and Proper Motion (PM) from Gaia EDR3, along with the Proper Motion ratio (rPM)

System	Date	Number of Images	Position Angle (°)	Standard Error	Separation (")	Standard Error
DUN 42	2021.02	10	298.253	0.116	14.539	0.027
DON 537 A,BC	2021.02	8	76.824	1.111	15.195	0.606
UC 102	2021.02	10	59.170	0.006	19.917	0.002
STT 547	2021.06	9	190.599	0.203	5.937	0.039
POIJ 1912AB	2021.02	10	202.541	0.043	15.701	0.008
KR 29AB	2021.02	9	355.956	0.105	6.357	0.006
ES716	2021.07	10	294.174	1.172	7.815	0.144
COO159	2021.02	12	113.432	0.026	9.340	0.005

Table 2. Measurements of eight double stars made in January 2021



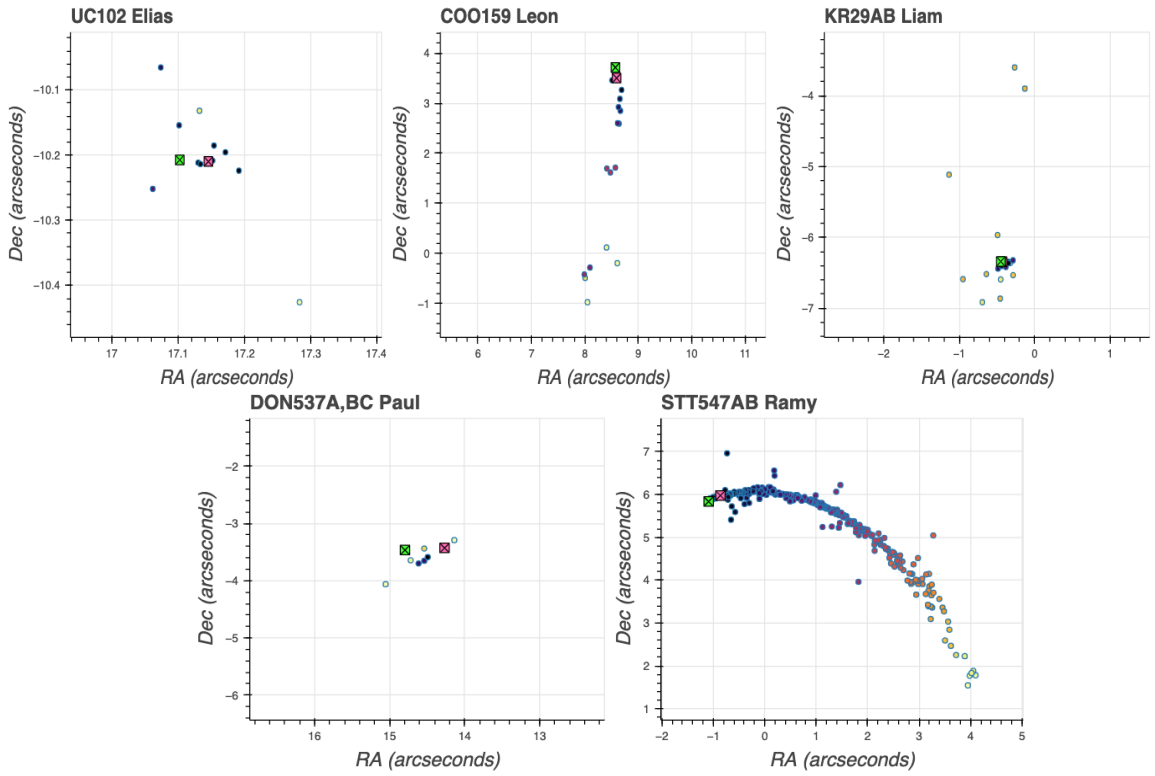


Figure 2. Measurements of each system plotted (and marked with a green square) with Gaia EDR3 data (pink square) and previous historical data, with more recent measurements being darker

4. Discussion

Common proper motion and similar parallax are indicators that a double star system may have a physical relationship, but more evidence is needed to confirm that a given system is binary. The plots in Figure 2 convert past PA and separation measurements to RA and Dec in order to form a graph of the system's behavior over time, with darker measurements being more recent. Often, the scatter in historical data for wide pairs obscures any obvious trend in the motion of the secondary star relative to the primary. However, systems that have clear and consistent relative motion will show a trend in color. Systems that do not have clear relative motion over time will have points that are more scattered in color, because the stars' relative motion is smaller than the error in the measurements.

The only system with a preexisting orbital solution is the aforementioned STT 547 AB, and it is the only system that shows evidence of an arc over time based on the historical data. Plots for the other systems have an insufficient number of total measurements, too much noise, or a pattern that is too ambiguous to definitively claim that they are gravitationally bound. That said, these plots do not necessarily rule out the possibility of a physical relationship, since their rPMs are low. The pair with the least similar parallax and PM is COO 159, which has rPM 0.392. The colored patten in its historical data plot indicates that this pair is likely to have a linear solution.

5. Conclusions

Our Eight double star systems were measured to evaluate the possibility of a physical or gravitational relationship in each one. Continued measurement of these systems is important in identifying trends that emerge over long time periods, such as long period orbits in systems with multiple stars. Continued measurement can also decrease the inherent uncertainty in orbital solutions inferred from a short arc, such as the two very different solutions listed STT 547AB. Of all the systems analyzed, the data suggest that

only STT 547AB is binary, but this does not rule out the possibility of a physical relationship in the other pairs presented here.

6. Acknowledgments

This research was made possible by the Washington Double Star catalog maintained by the U.S. Naval Observatory, the Stelledoppie catalog maintained by Gianluca Sordiglioni, Astrometry.net, and AstroImageJ software which was written by Karen Collins and John Kielkopf. This work has also made use of data from the European Space Agency (ESA) mission Gaia (https:// www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC, https://www.cosmos.esa.int/web /gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement.

This work makes use of observations taken by the 0.4m telescopes of Las Cumbres Observatory Global Telescope Network.

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