Astrometric Measurements of the Neglected Visual Double Star ARY 54 AC

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Abstract: As part of a research seminar, high school and college students measured the separation and position angle of the neglected double star ARY 54 AC. They compared their results to past observations reported in the Washington Double Star Catalog. Then, with the help of an experienced double star observer, they determined that ARY 54 AC is an optical double star rather than a gravitationally bound binary system.

Introduction

This project was part of a physics research seminar offered by Cuesta College. The seminar had a diversity of members, with six Coast Union High School students, three Cuesta College students, two college professors, and one middle school volunteer. As suggested by Johnson (2008), visual double stars are excellent targets for student observers because they offer students exposure to basic Newtonian orbital dynamics, calculating precision and accuracy statistics, conducting a straight-forward vector analysis, and forming cooperative working groups, all the while making a modest contribution to science. Our objectives were to contribute measurements of separation and position angle for an infrequently observed double star and to determine if this star is an optical double or a gravitationally bound binary.

We chose ARY 54 AC because it was bright, widely separated, and appropriately positioned in the sky, yet was still among those listed in the "neglected double star" section of the Washington Double Star Catalog (2006). The catalog magnitudes of the primary and secondary stars are 8.1 and 8.9, respectively. The 2006 equatorial coordinates for the primary star are 18h 46m 12.2s in Right Ascension, and +44° 8m 8.3s in Declination.

Observations and Results

On September 4, 2008, members of the research seminar met at Coast Union High School in Cambria, California, to learn a procedure for calibrating astrometric eyepieces using the drift method (Teague, 2004). Observations were made with Frey's 18" Dobsonian telescope and a 12.5 mm Celestron Micro Guide Eyepiece. Although this hands-on experience was educational, we used the scale constant of 12.2 arc seconds per division determined by Frey (2008) in a previous seminar because we deemed it to be more precise.

On September 20, 2008 (B2008.722), Frey, B. Hodges, L. Hodges, Genet, and Johnson met at a Central Coast Astronomical Society observing session near Santa Margarita Lake, California. Frey operated his 18" telescope and instructed seminar member B. Hodges in a proper method of measuring a double star's separation (Teague, 2004). B. Hodges measured the separation of ARY 54 AC while Frey measured its position angle using a novel method he had previously

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Figure 1: Members of the research seminar met at Coast Union High School at the end of the semester to receive certificates of completion. Top row, left to right: Russell Genet, Casey Marlow, Nicole Anderson, Nathan Heaston, Brittany Powell, Annelisa Green, Clifford Mathieson, Vera Wallen, and Jolyon Johnson. Bottom row, left to right: Matthew Dowdy, Erick Vega, Logan Hodges, Bohdi Hodges, and Jonna Horn.

developed to account for field rotation that is associated with alt-az mounted telescopes (Frey, 2008).

On September 25, 2008 (B2008.735), the research seminar members met at Coast Union High School to make additional measurements of the separation of the same neglected star, ARY 54 AC. Frey again measured its position angle. Table 1 shows, for both separation and position angle measurements, the number of observations as well as their average, standard deviations, and standard errors of the mean.

Analysis

Table 2 shows our recent measurements of the separation and position angle for ARY 54 AC as compared to the previously reported (2003) Washington Double Star Catalog values.

ARY 54 AC is reported in the Washington Double Star Catalog as having nine previous observations between 1893 and 2003. The first reported separation was 75.9" while the last was 75.2". The separation measurements made by the authors differ from the 2003 value by +1.7". However, the estimated standard deviation of the authors' observations was 2.9" which was far greater than this difference. Thus our value for the separation is not significantly different from the 2003 value. The somewhat large standard deviation of 2.9" (3.8%) was not unexpected because most observers were making their first quantitative measurements.

	Separation	Position Angle
Number of Observations	25	14
Average	76.9″	46.7°
Standard Deviation	2.9″	0.8°
Standard Error Of the Mean	0.7″	0.5°

Table 1: Observational Results of ARY 54 AC Sept 4-25, 2008

	Observed (2008)	Literature (2003)
Separation	76.9 ± 2.9″	75.2″
Position Angle	46.7 ± 0.8°	48°

Table 2: Comparisons Between Observations and Catalog Values

The first reported position angle was 47° (1893) while the last was 48° (2003). The 2003 observation was 1.3° larger than our 2008 position angle. A reviewer pointed out that the position angle appears to have been less in 1893 and 2008 then in 2003. Although the difference between 2003 and 2008 was about 1.6 times greater than the estimated standard deviation of 0.8° for our observations, this difference was not large enough to be significant at the 95% confidence level. Therefore, we do not claim that the position angle has decreased based on our observations.

To help determine if ARY 54 AC is a gravitationally bound binary system or, conversely, an unaffiliated optical double, Arnold analyzed the proper motion vectors, parallax, and spectral types of both stars. The proper motion values—the two dimensional motion through space—of the components can help make this determination because, while common proper motion is not a sufficient condition, it is a necessary condition for a visual double star to be in a binary system (Arnold, 2009). The specific proper motion values as reported in the Washington Double Star Catalog (2006) are (in milli-arc seconds per year) RA +2.15, Dec +12.68 for the primary star, and RA +6, Dec +7 for the secondary star.

One standard, which is commonly applied, is that a difference of more than about 10% between the respective proper motion values probably indicates that a given double star is an optical pair and is not bound by gravity. By simply comparing the above values, it can be calculated that the directions of the proper motion vectors, of the "A" and "C" components, have diverged by approximately 30°. The percentage difference of the length of the vector of the "C" component, relative to that of the "A" component, is 28%. The authors believe that, based on our vector analysis, ARY 54 AC is most likely an optical double because the values of the proper motion vector for the "A" component, in right ascension and declination, reveal too much divergence from the values of the "C" component.

Finally, the trigonometric parallax value of the "A" component is 3.7 milliarcseconds (which equates to a distance of 890 light years), while that of the "C" component is 28 milliarcseconds (which equates to a distance of 116 light years), about 7.7 times less (Hipparcos). Furthermore, the spectral type for the "A" component is A5, while that for "C" is K5 (Hipparcos). The large distance between the two stars probably explains why both components have similar apparent magnitudes (8.1 for the primary and 8.9 for the secondary), yet the primary is much more massive than the secondary.

Conclusions

The authors concluded that the difference between the 2003 separation and position angle measurements with respect to the results of this project were not significant at the 95% confidence level. The authors also concluded that ARY 54 AC is an optical double star rather than a binary star based on the 28% difference in proper motion vectors and the 24.3 milliarcsecond difference in trigonometric parallax.

Acknowledgments

The authors thank Coast Union High School instructor Jonna Horn for helping organize the seminar, for the use of her classroom, and for transporting students to special meetings at alternative locations. The authors also thank Coast Union High School instructor Lucinda Wilson for helping the students observe and reduce the data and for attending several meetings. The authors thank Vera Wallen, the retired Coast Union School District Superintendent, for helping organize this seminar. The authors thank the Central Coast Astronomical Society for inviting the students to present their scientific research at an astronomical symposium. The authors thank the United States Naval Observatory for the use of the Washington Double Star Catalog during this project. Lastly, the authors thank Bob Buchheim, Tom Smith, and Morgan Spangle for their helpful reviews and suggestions.

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