Visual Astrometry of 35 Cassiopeiae

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Abstract: As part of an astronomy research seminar, high school students met with an experienced observer to learn astrometric techniques and measure the separation and position angle of the double star 35 Cassiopeiae which they found to have a separation of 59.0″ and a position angle of 345°. Proper motion vectors suggest this double star is optical rather than binary.

Introduction

Known since antiquity, the constellation Cassiopeia is easily recognized due to its characteristic W shape. The double star 35 Cassiopeiae has magnitudes of 6.3 and 8.6. Both stars are blue in color. It was first measured by James South in 1782, at which time the reported position angle was 355° and the separation was 50″ (Mason 2012). Those values are significantly different from the most recent observation (WDS 2010) of 342° and 56.3″.

Other identifiers for 35 Cassiopeiae include HD 8003, HIP 6312, SAO 11712, TYC 4038-622.1, and WDS 01211+6439A. Its precise coordinates, as given by the Washington Double Star Catalog, are (J2000) 01h 21m 05.27s +64° 39m 29.3s.

The goals of this project were to: 1) learn the necessary techniques to conduct this research, 2) measure the position angle and separation of 35 Cassiopeiae, 3) compare our observations with previous observations, and 4) consider whether or not this double star might be a gravitationally bound binary based on its proper motions.

Figure 1: from the left—Krystyn Michaud, Sarah Thomas, Garrett Moore, Triston Perez, Oksana Moscoso, and Russell Genet outside the classroom at Arroyo Grande High School.

Observations

The observations were made using a Celestron model CPC 1100 telescope. This alt-az telescope was computerized and motorized, and was fitted with a Celestron 12.5 mm Micro Guide eyepiece. The telescope is of Schmidt-Cassegrain design with an aperture of 11

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inches. All observations were made in Santa Margarita, California on 11 November 2012 (B2012.865) beginning at 7pm Pacific Standard Time.

Following the procedure suggested by Teague (2012), the Micro Guide eyepiece was oriented with the celestial coordinate system using the primary star of 35 Cassiopeiae. Once the orientation was completed, ten drift time measurements were made, with an average value of 70.95 seconds, and a standard deviation of 4.96 seconds. That average was used to calculate the scale constant using the formula:

$$Z = [\ 15.0411 * t * \cos(\delta)\ ] / D$$

where Z is the scale constant in arc seconds per division, 15.0411 is the rotation rate of Earth in arc seconds per second, t is the average drift time of the calibration star in seconds, δ is the declination of the calibration star (64.65°), and D is the number of divisions on the linear scale (60). The resulting scale constant was 7.6 arc seconds per division.

The primary star was then placed on the linear scale, and eight separation measurements were taken and reported to the nearest division. The primary star was relocated and advanced on the linear scale prior to each measurement. The average value was 7.8 divisions with a standard deviation of 0.46 divisions and a standard error of the mean of 0.16 divisions. The average value was used to calculate the angular separation of 59.9″.

The position angle measurements were made by aligning both stars on the linear scale with the primary star at the middle, 30^{th} division, disabling the telescope's tracking feature, and allowing the stars to drift to the circular scales with the Earth's rotation. The crossing point of the primary star at the outer scale was approximated to the nearest degree. Following each measurement, the tracking feature was enabled and the process repeated. Eight position angle measurements were taken without any rotation of the eyepiece, which resulted in an average value of 345.3^{o}, a standard deviation of 1.8°, and a standard error of the mean of 0.6°.

Comparison with Previous Observations and Analysis

Shown in Table 1 are several previous observations from 1782 to 2012 as well as our current (2012) measurement. Our separation measurement was 2″ greater than three recent observations, while our position angle measurement was 3° greater. These differences might be reduced in future observations if separation observations were not rounded off to the nearest division, and the eyepiece was rotated 180° between each position angle measurement to reduce the effects of eyepiece alignment error as well as the effects of field rotation during observation when using an alt-azimuth telescope.

One goal of this project was to determine if the double star 35 Cassiopeiae might be a physically bound binary system by considering the proper motions of the two stars. Binary stars have very similar proper motion vectors, the two dimensional motion of stars through

Figure 2: The observing team with the Celestron telescope used to make the observations (from left): Joseph Carro, Garrett Moore, Sarah Thomas, and Triston Perez.

Table 1: Past observations of 35 Cassiopeiae compared to the results of the present study.

Reference	Separation (")	Position Angle (°)
WDS (Mason+ 2007) 1782	50.0	355
WDS (Mason+ 2007) 1824	55.0	353
WDS (Mason+ 2007) 1967	55.5	344
O A G (Comellas 1980)	55.0	345
Herschel 500 Catalog	57.0	342
Hipparcos (from SKY X)	57.0	342
WDS (Mason+ 2007) 2010	56.3	342
Present Study (2012)	59.0	345

space. The proper motion of the primary star (SAO 11712) is 59.75 milliarcseconds per year in right ascension and -22.83 mas/yr in declination (SIMBAD 2012). The proper motion of the secondary star (SAO 11709) is -5.30 in right ascension and -9.50 in declination (SIMBAD 2012). These sizable differences in both proper motion magnitude and direction suggest that 35 Cassiopeiae is probably an optical double and not a binary system (Arnold 2010).

Conclusions

The students measured the position angle and separation of the double star 35 Cassiopeiae. In making the observations, the students learned the necessary techniques to conduct astrometric research of double stars. Our accuracy could have been improved if we had rotated the eyepiece between position angle observations. Finally, we concluded that this double is not likely binary due to the sizeable difference between its proper motion vectors.

Acknowledgments

The authors thank Orion Observatory for the use of its facilities. The authors also thank Brian Mason and the United States Naval Observatory for past observations. Finally, thanks go to Tom Frey and Vera Wallen for their critical reviews of this paper.

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