Student Group Measurements of Visual Double Stars

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Abstract: Eight astronomy research seminar participants made visual measurements of double stars as a group project. A reflecting and a refracting telescope were used along with illuminated reticle eyepieces to measure the separation and position angles of known and neglected double stars. The group effort allowed students with a variety of expertise and talent to work together with synergetic effects. What we learned may apply to other group efforts.

Introduction and Hypothesis

As part of a research seminar at Cuesta College in the fall of 2007, we decided to observe visual double stars. Our expertise ranged from three observers with previous double star observations to two who had made other astronomical observations to three who had never used a telescope for quantitative measurements. Some of us were better at organizing and recording observational data while others were more experienced in writing and editing, so we hypothesized that working together as a group to gather and report on double star observations might have a synergetic effect.

The group's goals were to learn how to cooperatively: 1) operate the reflecting and refracting telescopes; 2) use the illuminated reticle eyepieces; 3) properly record and process data including statistical calculations; and 4) write and edit a scientific paper.

Equipment and Procedures

All observations were made at the Coombs Observatory in Atascadero, California. The authors divided into two groups, placing experienced observers in both groups. One group used a C-11 Celestron reflector on an equatorial mount with an illuminated Celestron 12.5mm Micro Guide eyepiece. The other viewed with an Astro-Physics six inch refractor, also on an equatorial mount with an illuminated Meade 12mm Astrometric eyepiece. Observations were made on two nights: September 26 and October 3, 2007.

To determine the scale factor for each eyepiece, the authors placed a bright star on the eastern-most division of the eyepiece's linear scale. The right ascension motor was then turned off. Using a digital stopwatch, read out to the nearest 0.01 seconds, the authors recorded the time taken for the star to drift from one end of the scale to the other. After finding the average drift time, the authors applied the scale factor equation:

$$z = \frac{15.0411t + \cos d}{D}$$

Where z is the scale factor in arc seconds per eyepiece division, 15.0411 is the arc seconds per seconds of time that the Earth rotates, t is the average time in seconds for the star to drift across the entire linear scale, d is the declination of the calibration star in degrees, and D is the number of divisions on the scale (60 for the Celestron eyepiece, 50 for the Meade eyepiece). A star with a declination between 60-75° was chosen to minimize timing errors when using the drift method (Argyle 2004).

Separations were determined by centering the primary star and rotating the eyepiece until the linear scale was aligned through the centers of both stars. The observers made multiple measurements of each double star. The number of divisions between the two stars was estimated and recorded to the nearest 0.1 divisions. The resulting average of several trials was multiplied by the scale factor, z, to obtain the separation in arc seconds.

Telescope	# of Obs.	Average Time (s)	St. Dev.	Mean Error	Scale Const. (as/div)
C-11	5	57.76	0.23	0.14	6.7
Astro-Physics	10	98.58	0.17	0.06	13.7

Table 1: Average drift times and scale constants for both telescopes

Position angles were determined using the drift method. The eyepiece was aligned in the same manner as the determination of the separation, above. The right ascension motor was then turned off to allow the primary star to drift to the protractor around the perimeter of the eyepiece, and its position when crossing the protractor was estimated and recorded to the nearest 0.5°. The position angle correction for the Celestron eyepiece was applied (Argyle 2004). This correction was not required for the Meade eyepiece. Multiple trials were recorded and averaged to produce the final position angle.

Session One: September 26, 2007 (B2007.736)

The first session was devoted to gaining experience in operating the equipment and making calibration and practice observations. None of the authors had used the telescopes at the Coombs Observatory before. It took several trials to become marginally proficient in using the setting circles and slow motion controls to properly position the double stars in the field of view.

Frey created a data form for each observer to record: 1) the scale constant drift times; 2) the separations in divisions on the linear scale; and 3) the position angle readings from the circular protractor. The data sheets also contained spaces for the observer to record the date, sky conditions, moon phase, stars to be measured, constellation, and the literature values for separation, position angle, and coordinates.

The first session was on a night with a full moon, so both groups observed only well known, bright double stars (with secondary stars brighter than magnitude 9.0). The scale factors for both telescopes were determined using the star Alpha Cephei with magnitude 2.45 and declination +62° 35′ 08.0″. The average drift times and derived scale constants of the two telescopes are shown in Table 1.

The C-11 group measured the double star Struve 2893 and the Astro-Physics group measured Alpha Cassiopeiae. The apparent magnitudes and coordinates of both well known double stars, according to the Washington Double Star (WDS) Catalog, are shown in Table 2. According to experienced double star observer Dave Arnold, Struve 2893 has a "relatively fixed" common proper motion while Alpha Cassiopeiae is an optical double.

The average observed separations and position angles with standard deviations and standard errors of the mean are shown in Table 3.

A comparison of the authors' observations with the WDS Catalog separation and position angle of these two double stars is shown in Table 4.

The observed separation of the C-11 group differed from the WDS catalog by approximately 0.4" and its position angle differed by 1.5°. The observed separation of Alpha Cassiopeiae with the Astro-Physics

Star	Pri. Mag./ Sec. Mag.	Right Ascension	Declination
Struve 2893	6.2/7.9	22h 12.9m	+73° 18m
Alpha Cas	2.2/8.8	00h 40.5m	+56° 32m

Table 2: Apparent magnitudes and coordinates of the two bright double stars

Telescope	Star	Obs. Sep.	St. Dev.	Mean Error	Obs. PA	St. Dev.	Mean Error
C-11	Struve 2893	29.2″	0.7	0.3	348.5°	2.1	1.0
Astro-Physics	Alpha Cas	69.2″	1.2	0.4	261.2°	4.6	1.4

Table 3: Observed separations and position angles with statistical calculations

Telescope	Star	Separation			Position Angle		
		# of Obs.	Obs. Sep.	Lit. Sep.	# of Obs.	Obs. PA	Lit. PA
C-11	Struve 2893	5	29.2″	28.8″	4	348.5°	347°
Astro-Physics	Alpha Cas	10	69.2″	68.1″	11	261.2°	282°

Table 4: Observed separations and position angles compared with WDS Catalog values of two well known double stars

telescope differed by 1.1”. All of these differences in measurement were close to the calculated standard error of the mean. However, the position angle of Alpha Cassiopeiae differed by over twenty degrees! This huge difference in position angle may be due to misalignments of the eyepiece because the dim secondary star could not clearly be seen prior to each drift.

Session Two: October 3, 2007 (B2007.755)

Session two occurred one week after session one during a third-quarter moon. Each group began the session by examining a known, bright double star to check the accuracy and precision of the techniques learned the previous week. The scale constants determined during the previous week were utilized.

Table 5 gives the data gathered on the second night for two well known double stars, Beta Cygni (Alberio) and 31 Cygni, along with their corresponding position angles. The observed separation of 31 Cygni is also given. The C-11 group did not measure the separation because they were very confident of their measurements in session one (less than 1% difference from the WDS catalog value). This procedure was performed to be sure proper instrumental techniques were being followed and that observations closely corresponded to recent literature values.

The standard deviation and mean error of the observed separation of 31 Cygni are stated as 0.0 arc seconds because the calculated values were far less than the estimated least significant digit (0.1 arc seconds). We attribute the greater precision of these measurements to the brighter magnitude and less difference in the magnitudes of both components as well as wider separations than the previous night’s observations. A comparison of observed separation for 31 Cygni and position angle of both double stars to literature values are shown in Table 6.

The Astro-Physics group then decided to attempt separation and position angle measurements of 56 Andromeda, a wide double star. The telescope was moved so the setting circles on the refractor were properly positioned for 56 Andromeda and its companion.

The literature values for the separation and position angles of 56 Andromeda are 200” and 298°, respectively. Observed values were very close to the separation cited in the literature but were significantly different for the position angle. Also the secondary seemed far too dim to be the secondary of 56 Andromeda. However, upon review of TheSky 6 star chart, it was determined that the double star the Astro-Physics group observed was actually adjacent to

Telescope	Star	# of Obs.	Obs. Sep.	St. Dev.	Mean Error	# of Obs.	Obs. PA	St. Dev.	Mean Error
C-11	Beta Cyg	NA	NA	NA	NA	7	53.3°	1.2	0.5
Astro-Physics	31 Cyg	3	107.9″	0.0	0.0	4	173.7°	1.0	0.5

Table 5: Measurements of two known bright double stars

Star	Obs. Sep.	Lit. Sep.	Obs. PA	Lit. PA
Beta Cygni	NA	34.7″	53.3°	54.2°
31 Cygni	107.9″	107″	173.7°	172.9°

Table 6: Comparison of observations to literature values for Beta Cygni and 31 Cygni

# of Obs.	Obs. Sep.	St. Dev.	Mean Error	Lit. Sep.	# of Obs.	Obs. PA	St. Dev.	Mean Error	Lit. PA
5	203.5″	0.2	0.1	203.4	3	244.3°	0.6	0.3	258°

Table 7: Observed separation and position angle of double star BU 1368 BD compared to WDS Catalog values of 2001

56 Andromeda. It was identified in the WDS Catalog as BU 1368 Bb. However, the WDS Catalog now refers to the double star as BU 1368 BD. Table 7 gives the observed data for the double star and compares these with the most recent WDS Catalog values of BU 1368 BD from 2001.

Conclusions and Recommendations

The group of observers found the project to be of significant educational value. Those who had little experience with telescopes learned how to operate them and use them. Others learned the proper methods of recording, analyzing, and reporting observations. All authors learned how to use illuminated reticle micrometers for measuring double stars.

During the first session, however, the full moon reduced the contrast between the double stars and the background sky. As a result, the secondary star of Alpha Cassiopeiae, which was significantly dimmer than the primary, was difficult to discern on the linear scale. The linear scale of the Meade Astrometric Eyepiece often covered the position of the secondary, so it is possible that the eyepiece was rotated in such a fashion that only the position of the secondary was revealed and thus the secondary was not properly oriented to get a proper position angle reading.

Also, working with unfamiliar equipment proved challenging. Members of both groups had trouble adjusting and reading the setting circles used to position the target double stars. Manipulation of the slow motion controls to position the double stars on the scale was also difficult because there was considerable backlash.

For future observations involving first time observers, we suggest that the owner or an experienced operator of the telescopes align the double stars and allow the students to estimate the separation and follow the drift patterns for measuring scale constants and position angles.

We recommend preparing star charts of the field of view in advance. A reviewer of this paper, Bob Buchheim, suggested that “with amateur equipment (whose polar alignment and setting circles are likely to be less than perfect), the use of a star chart of the field of view is absolutely required in order to be sure of the identification of the stars.” One does not want to spend the whole evening gathering data on a star system and then find out the next morning that it was the wrong one!

The overall experience of double star measurements by the research group was enlightening. Our hypothesis was confirmed since we learned, through a synergetic effect, a great deal about double stars themselves and the techniques required to quantify the parameters that describe them. We hope what we learned about group measurements will encourage others to observe double stars in similar educational settings.

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