The Visual Measurements of the Double Star STTA 127 AB

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Abstract: A team of students, a member of the faculty at The Evergreen State College and two amateur astronomers conducted separation and position angle measurements of the double star STTA 127 AB at the 2010 Oregon Star Party east of Prinville, Oregon. Percent differences between literature and observed values for separation and position angle were less than 1.5%. Field rotation could account for inaccuracy in the position angle due to a long drift time across the astrometric eyepiece. Position angle observations by two teams studying the same star system were carried out allowing the comparisons between alt-azimuth and equatorially mounted telescopes.

Introduction

A group of 14 students and their instructor from The Evergreen State College (TESC) in Olympia, Washington, participated in what may be the first scientific research on double stars at the nationally recognized Oregon Star Party (OSP), held from August 11-15, 2010. Some of the 14 students had just finished a summer research workshop at Pine Mountain Observatory (PMO) near Bend, Oregon, the previous weekend. All of the students at PMO were new to astrometric research at PMO and were ready to continue their double star observations at the OSP. The students were split into two teams, A and B.

Students Fisher, Hendrix, Pendergrass, Gilman, and Alduenda joined their instructor, Chamberlain, along with team leaders Frey and Estrada (Team A, Figure 1) in observing the optical double star, STTA 127 AB, in the constellation Draco. Team B from TESC, lead by Jo Johnson, studied the double star STF 1919. The alt-az telescope used for measure-

Figure 1: The Evergreen State College team. Front Row: Rebecca Chamberlain, Kristine Fisher, Thomas Frey. Back Row: Alex Hendrix, Cari Ann Pendergrass, Nathaniel Gilman, Chandra Alduenda, Chris Estrada

Table 1: Scale Constant Determination.

Star	Bess. epoch	Declin.	#Obs	AvDrift time(sec)	Std dev	Mean error	Scale constant
Dubhe	B2010.613	61.75°	17	85.87	0.52	0.13	10.19

ments by Team A was an 18” Obsession. The Celestron 12.5 mm illuminated astrometric eyepiece (graciously donated by Celestron to TESC) was calibrated and then separation and position angle measurements were taken. The data was analyzed and each student was assigned a topic to write up for the research paper.

Locale

The research was carried out at the 2010 Oregon Star Party (OSP), held each summer in the Ochoco National Forest about 35 miles east of Prineville, Oregon. The OSP was founded in 1987 and routinely has 700-800 astronomers in attendance. The elevation at OSP is about 5000 feet and is located at 44.2935° N and 120.1332° W. The surrounding area is notably high desert so the air is very dry, which resulted in excellent seeing and transparency. This year’s OSP was scheduled during the Perseid meteor shower allowing participants an exceptional opportunity to see this event under dark skies. And, since the New Moon appeared on August 10^{th}, the shower was very impressive.

Presentations

The OSP routinely has a series of presentations by amateur astronomers during the long weekend. The TESC double star research teams gave introductory presentations to the attendees on the nature of double stars, the history of double star observation, the required instrumentation, and how to measure separation and position angles with an astrometric eyepiece. This was followed by a presentation on data analysis and how to write an astronomical research paper. Following the observations and data reduction, the TESC students individually presented the results of their investigations and gave their personal views of their research experience.

Calibration of the Celestron Astrometric Eyepiece

The linear scale on the Celestron 12.5 mm astrometric eyepiece, divided into 60 equal divisions, must be calibrated for each telescope-eyepiece assembly to determine the scale constant in arc seconds per division. This has been described at length in other sources (Frey, 2008). The reference star Dubhe in Ursae Majoris was used for this calibration, because its declination lies within the recommended 50-75 degree range for calibration. The results are given in Table 1.

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Once the scale constant had been determined, the 18-inch Obsession telescope was two-star aligned and the tracking motors were engaged. Because several of the observers on the team were inexperienced in using the alt-az Newtonian telescope, a well-studied double star was chosen. The double star selected was STTA 127 AB in the constellation Draco, originally studied in 1844, then having a position angle of 68 degrees and separation of 71.2 arc seconds. The right ascension and declination of the primary star STTA 127 A is 13h 50m 59.4s and +68° 18m 55.6s, respectively. The most recent study published in the Washington Double Star (WDS) catalog was done in 1999, where the position angle was 63 degrees and the separation was 85.8 arc seconds. The primary and secondary stars had magnitudes of 6.5 and 8.3, respectively. The primary star is a K2IV, a red subgiant and the secondary (SAO 16200) is a G5 Sun-like star. The proper motion vectors, given in milli-arc second per year, for the primary and secondary stars are RA, -176; Dec.,-058 and RA, -095; Dec., +013, respectively (SIMBAD). Such divergent proper motions indicate this is probably an optical double star, although to determine the optical or binary nature of a double star with any certainty, it is important to collect and compile data over many years.

Separation Measurements of STTA 127 AB

The telescope was two-star aligned and the servo-motors engaged. The Celestron Micro Guide eyepiece was rotated until the central linear scale was parallel with the axis joining the two stars. The distances between the centers of the two stars was estimated to the nearest 0.1 divisions and recorded. Then, using the slow motion controls, the stars were shifted to a new location along the linear scale, a new measurement was made, and the process repeated many times. This method of moving the stars to new locations each time was employed to negate any bias

Table 2: Separation Measurements for STTA 127 AB

Double star	Bess. Epoch	Lit. Epoch	# Obs.	SD/ME	Obs. sep	Lit. sep	% difference
STTA 127 AB	B2010.613	1999	17	0.37/0.08	87.0	85.8	1.41%

Table 3: Position Angle Measurements for STTA 127 AB

Double star	Bess. Epoch	Lit. Epoch	# Obs.	SD/ME	Obs. PA	Lit. PA	% difference
STTA 127 AB	B2010.613	1999	17	1.32/0.31	61	63	-0.55%

error that might exist if the stars were continually kept and measured at the same division marks. This also removes systematic errors associated with optical aberrations across the field of view of the system. The results of the separation measurements for STTA 127 AB are shown in Table 2. The SD/ME are the standard deviation and standard error of the mean. The observed and literature separations are given in arc seconds. The percent difference is based on the difference from the most recent literature value.

Position Angle Measurements of STTA 127 AB

The determination of the position angle using the drift method with an alt-az telescope has been described at length in a previous paper (Frey, 2008). Briefly, it involves disengaging the servo-motors so the telescope becomes a "push Dob". The double star is aligned with the linear scale and adjusted manually so when it is released the primary star drifts through the central division (the 30th division) and continues to drift to the outer protractor scales. There are two potential flaws in this method. First, the primary star of the double star is allowed to drift across the middle 30 division mark on the linear scale. This proper drift alignment is difficult to do and usually takes several attempts to accomplish. Second, a parallax error can occur as the primary star crosses the outer protractor scale that can lead to an erroneous position angle. To circumvent these problems, many drift cycles are carried out and averaged to obtain the best mean measurement.

Due to field rotation, the eyepiece was continually adjusted so that the two stars remained aligned with the linear scale. Special effort was made to realign the stars parallel to the scale and the eyepiece was tightened snuggly in the draw tube. The results of the position angle measurements for STTA 127 AB are shown in Table 3. Position angles (PA) are given in degrees. The SD/ME are the standard deviation and standard error of the mean. The percent difference is based on the difference between the observed and the most recent literature values.

Cross Comparison of STTA 127 AB and STF 1919

Since the observed position angle for Team A was 2° less than the most recent literature value, Teams A and B agreed to check the data obtained by the opposite team. Team B, lead by Johnson, examined the double star STF 1919 as Team A was observing STTA 127 AB. Team B used a 6" Celestron NextStar Schmidt-Cassegrain on an equatorial mount; Team A was using an 18" Obsession, Newtonian telescope on an alt-az mount. Both teams used the same Celestron 12.5 mm Micro Guide eyepiece. Since we were making observations at the same time and the same site with completely different instruments, a brief comparison of one another's target would be interesting. We only compared the position angles, because the separation values for both teams were in agreement.

Table 4 shows the comparison of the data for STTA 127 AB. Team A's initial study with 17 observations was done on August 12, 2010 and was followed up the next night by a shorter second trial run simultaneously with Team B's observation of STTA 127 AB. The average position angle from the 17 and 6 observations taken by Team A are indicated and then

Table 4: Teams A&B Compare STTA 127 AB Position Angle

Team	Double Star	# Obs	Obs PA degs	Lit PA degs	SD/ME
A 1st trial	STTA 127 AB	17	60.7 (61)	63	1.3/0.31
A 2nd trial	STTA 127 AB	6	61.5 (62)	63	1.0/0.41
B	STTA 127 AB	5	63.0	63	1.0/0.4

Table 5: Teams A&B Compare STF 1919 Position Angle

Team	Double Star	# Obs	Obs PA degs	Lit PA degs	SD/ME
B	STF 1919	11	12.2	10	0.4/0.1
A	STF 1919	8	11.2	10	0.8/0.3

rounded to the nearest degree.

Table 5 shows the comparison of the data for STF 1919.

Results

For STTA 127 AB, Team B's observed position angle results corresponded exactly with the WDS literature value, where as Team A's values were less than the literature. Since the standard deviation and standard error of the mean statistics for both teams were very close to one another, the difference between the literature and observed position angle for Team A could be due to field rotation. This is a common phenomenon with alt-az mounted telescopes.

Argyle (2004) notes " The continual changing of the parallactic angle is known as field rotation and it is the main difficulty in measuring double stars with an alt-azimuth mounted telescope. The difficulty lies not so much in the fact that the orientation of the field is continually changing, but in the rate at which it is changing." For alt-azimuth telescopes the rate of field rotation reaches a maximum when the object is at the zenith and at a minimum when the object is on the prime vertical, e.g., when it is due east or due west. A point source like a star at the center of the field appears unchanged over time while the stars toward the edge of the field rotate around the center.

When Team A carried out the observation on the second night, the average drift time from the center mark to the outer protractor was 64 seconds. During this drift time, the field of view could have under gone enough field rotation to affect the position angle.

Further studies and verification on field rotation involving alt-az telescopes are being performed. The results of these inquiries will be valuable for all double star investigations with alt-az mounts. These studies will compare the mathematically calculated rotational change with the observed rotation for an alt-az telescope.

For STF 1919, the observed position angle for both teams was greater than the literature value. Unlike the 64 second drift time observed by Team A for STTA 127 AB, the drift time for STF 1919 with the Obsession alt-az telescope was only 25 seconds, which is only 0.4 of the longer drift time for STTA 127 AB and less chance for field rotation to occur. Team A's 8 observations were less precise than Team B's results indicated by a standard deviation of twice the amount. Yet the observed position angle of Team A was closer to the literature value. The observations of STF 1919 by teams A and B were done on consecutive nights. Environmental factors such as wind gusts (which were present) could have caused minor differences in measurements, yet not enough to generate outliers.

The students expressed satisfaction on completion of the project. They felt more relaxed in doing the research at the OSP after carrying out and completing two projects at PMO. Their motivation and interest was peaked at PMO and they were eager to do further observations at OSP. Their results were additionally impressive because of the six students on the team, only three had made previous measurements and three had never done astrometric measurements prior to OSP.

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