# Comparison of Data on Iota Boötes Using Different Telescope Mounts in 2009 and 2010 by the St. Mary's School Astronomy Club

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**Abstract**: Teachers and students from St. Mary's School in Medford, Oregon attended the 2009 and 2010 Astronomy Research Workshop at Pine Mountain Observatory in Oregon. They compared the accuracy of their double star observations on an Alt-Az and equatorial telescope mount using the star Iota Bootes. Our results showed no significant difference between the use of either mount.

## Introduction

A double star is defined by two different categories: binary systems, in which stars are close enough relative to each other in space to have significant gravitational interactions; and optical double stars, which are gravitationally unrelated stars that only appear to be near each other when viewed from Earth. Data collection over several centuries is necessary to determine in which category a double star belongs. This is accomplished through detailed measurements of separation and position angles that are used to determine the status of the system. We present our visual measurements of the double star Iota Bootes as part of our process toward becoming accurate and efficient double star observers.

This project is a continuation of initial studies carried out at the Pine Mountain Observatory Summer Science Research Workshop in 2009. At that time a small group from the St. Mary's Astronomy Club (Figure 1) worked towards and accomplished the composition of a paper on the neglected double star ARY 52 (Frey, et. al., 2009). It was the

**Figure 1**: St. Mary's Astronomy Club 2010: Back Row left to right: Emma Dauterman, Corey Cattanach, Chris Ladue, Cody Holliday, Trenton Hoyle, Will Oursler, Conor Keating, Nolan Peard, Ryan Gasik, Guo Zihan, Qiu Hongxiang, Jacob Robino, Conrad Stout, Peter Schwartz, Ross Robino, Tom Hilton. Front Row left to right: Holly Bensel, Monika Ruppe, Dashton Peccia, Emii Pahl. Not Pictured: Fred Muller, Anne Oursler, Dave Scimeca, Trevor Thorndike

goal of this group to master techniques in the observation of double stars and to use this information in their further research with their astronomy club which is based on the campus of St. Mary's School in Medford, Oregon. Afterwards, sixteen assorted high school and middle school students learned how to take data on double stars and how to write a proper research paper. Data was collected on the campus track which is located at [42.3° N latitude, 122.8° W longitude] at an elevation of 1380 feet above sea level. Viewing conditions on the track are relatively bright but low magnitude double stars are still clearly visible in our telescope.

After several weeks of data collection on known double stars, and comparing our results with those published in the Washington Double Star Catalog (Mason, 2009), the club was ready to study a "neglected" double star. A neglected double star is one that has not been observed extensively or recently. Unfortunately, fall and winter in Southern Oregon can be unpredictable. The fall and winter seasons of the 2009/2010 academic year were cloudy and rainy. The club was unable to take the telescope out until July and August of 2010. In July the telescope mount was converted from Alt-Az to equatorial using a wedge. It was discovered that with the new mount came new challenges. These challenges included unfamiliarity with the new mount and hence difficulty in aligning the telescope.

Before measurements could be obtained on the neglected stars, the group needed to be certain they could obtain results of an equal or better quality to those achieved when the mount was in Alt-Az configuration. Therefore, data was collected on Iota Bootes, one of the double stars which the club had gathered data on in the fall of 2009 at St. Mary's School. This new data was taken during the 2010 Pine Mountain Observatory Summer Science Research Workshop. Pine Mountain Observatory is located at [43.8° N latitude, 120.9° W longitude] at an elevation of 6500 feet above sea level near Bend, Oregon. The dry, desert-like climate and dark skies make for excellent viewing.

## Hypothesis

It was hypothesized that the switch from the Alt-Az telescope mount to the equatorial mount would not result in any significant differences in the data as long as the telescope operators were experienced with the new setup. However, the researchers were not experienced with the setup, consequently it was speculated that the measurements might not be as accurate as those made while the telescope was in the more familiar Alt-Az configuration.

**Figure 2**: Setting up the telescope at St. Mary's School, 2009. Left to right: Monika Ruppe, Fred Muller, Will Oursler, Misha Zavalzowski, Ryan Randall, Ryan Gasik.

## Equipment

The St. Mary's Astronomy Club uses a Meade 10" LX200 Schmidt-Cassegrain telescope which was generously donated by Fred Muller in 2007 (Figure 2). In both the 2009 and 2010 observing seasons a 12.5mm Celestron Micro Guide astrometric eyepiece was used. The telescope mount was converted from an Alt-Az configuration to an equatorial configuration in the July of 2010, leading to a few changes in the method of operation. These changes in operation are specific to the position angle and will be described in detail later in the paper.

## Calibration

The first step in observing double stars is to calibrate the linear scale on the astrometric eyepiece in units of arc seconds per division. Argyle (p. 152) suggests using a reference star of medium brightness at a declination between 60o and 75o to avoid timing errors. If the star is below 60o then the field drift is too slow, and above 75o is too fast to allow accurate timing. Therefore, the club used Mizar, at 59o 52.379' declination, because it was easily visible and close to the recommended range. The time component is measured by placing the calibration star on the eastern edge of the linear scale and allowing it to drift in right ascension to the other side of the scale. This drift is timed using a stopwatch to the nearest .01 seconds. To reduce random errors, many trials were made by different individuals from the club. The average of all these trials was used to determine the scale constant (Z) for the telescope eyepiece system.

$$Z = \frac{T_{ave}\,15.0411\cos(RS)}{D}$$

where $Z$ is the scale constant (in arc seconds per division), *Tave* is the average drift time, 15.0411 is the arc seconds per second of the Earth's rotation at the celestial equator, cos(*RS*) is the cosine of the reference star's declination, and $D$ is the number of division on the linear scale. This is 60 divisions for our Celestron eyepiece.

The reference star used in the calculation, Mizar, had an average drift time of 47.64 s (standard deviation of 0.31s. and mean error of 0.10 s). This resulted in a scale constant of 6.85 arc seconds per division. We used this value during the 2010 Pine Mountain Workshop. We were confident of this value since we repeatedly obtained similar results on multiple nights at St. Mary's School during the fall of 2009. The scale constant data are summarized in Table 1.

## Separation and Position Angle Measurement of Iota Bootes

Iota Bootes was chosen for this project because it is an extensively studied double star with known separation and position angle measurements. Hazy sky conditions in Medford, OR made this star system ideal because the magnitudes of the two stars (4.9, 7.5) were bright enough to allow effective observations. It is located at a right ascension of 14h 16.5', and a declination of 51° 19.25'. The Washington Double Star Catalog cited the separation and position angle as 38.7 arc seconds and 34° respectively (WDS, 2009). Our results are for measurements of Iota Bootes are shown in Table 2.

The separation between the primary and secondary star is found by aligning the two with the linear scale and estimating the distance between them to the nearest 0.1 division. The pair of stars are moved across the scale periodically to reduce bias between measurements. The average of these measurements is multiplied by the scale constant to obtain the separation in arc seconds (Argyle, p. 152).

The students took twelve separation measurements in 2009 at St. Mary's School and made nine separation measurements during the Pine Mountain Workshop in 2010. As mentioned earlier, the difference in operation between 2009 and 2010 was in the acquisition of the position angle. In the Alt-Az arrangement the students used a method described by Frey (2008) and taught to St. Mary's participants at the 2009 Pine Mountain Workshop (Frey, et al., 2009). The astrometric eyepiece is rotated until the stars are aligned with the linear scale. The scope is manually moved using the right ascension and the declination control knobs to allow the primary star to drift through the mid mark on the linear scale and move outward to a circular protractor scale, where the position angle is observed and recorded to the nearest 0.5° (Argyle, p. 153). In the equatorial configuration the primary star was placed at the center

**Table 1**: Data used in the Excel spreadsheet calculation of the scale constant for a 10" LX200 Schmidt-Cassegrain telescope.

| Eyepiece | Star | Besselian Epoch | Declination | #Obs | AveDriftTime (Sec) | Std Dev | Mean Error | Scale Constant |
|---|---|---|---|---|---|---|---|---|
| Celestron Astro Reticule | Mizar | 2011.57 | 54 55' 51" | 10 | 47.64 | 0.31 | 0.1 | 6.85 |

**Table 2**: Comparison of Separation and Position Angles of Iota Bootes in 2009 and 2010.

| Double Star | Identifier | Besselian Epoch | Lit. Epoch | #Obs. | SD/ME | Obs. Sep. | Lit. Sep. | % Difference | Type of Mount |
|---|---|---|---|---|---|---|---|---|---|
| Iota Bootes (2009) | 14162+5122 | 2004.09 | 2009 | 11 | 0.304/0.092 | 35.6 | 34 | 6.32 | Alt-Az |
| Iota Bootes (2010) | 14162+5122 | 2010.06 | 2009 | 9 | 0.870/0.290 | 37.1 | 34 | 2.37 | Equatorial |
| **Double Star** | **Identifier** | **Besselian Epoch** | **Lit. Epoch** | **#Obs** | **SD/ME** | **Obs. PA** | **Lit. PA** | **% Difference** | **Type of Mount** |
| Iota Bootes (2009) | 14162+5122 | 2004.09 | 2009 | 15 | 1.24/0.32 | 32 | 38.7 | 3.63 | Alt-Az |
| Iota Bootes (2010) | 14162+5122 | 2010.06 | 2009 | 8 | 2.44/0.70 | 32 | 38.7 | 3.93 | Equatorial |

of the linear scale using the telescope hand controller keypad and the eyepiece rotated so that the double star aligned with the linear scale. The Right Ascension motor was then deactivated. The position angle was determined by observing which degree marking the primary star crossed on the outer protractor scale and rounding to the nearest 0.5°. Once the star crossed the protractor scale the motor was turned on and the procedure was repeated with the reticule rotated 180° approximately every five trials to reduce bias.

## Conclusions and New Directions

The students' separation and position angle measurements when using the Alt-Az telescope mount were similar to their measurements using the equatorial mount. The percent error of the position angle was 3.63% in 2009 and 3.93% in 2010. In 2010 there were four outliers due to inexperienced operators. The percent error of the separation distance was 6.32% in 2009 and 2.37% in 2010. The error was less the result of the mount and more the result of operator error and lack of familiarity with the telescope configuration. The club will need to practice with the equatorial mount so that the alignment and other procedures yield more precision and accuracy.

In addition to improving our operational skills over the summer of 2011, the club plans to add photometry of double and triple star systems to our skill set.


# Acknowledgements

The St. Mary's Astronomy Club would like to thank Russell Genet, Research Scholar in Residence at California Polytechnic State University, for providing the workshop that gave us the experience to learn about double stars. We would also like to thank Thomas Frey for his guidance and support. We want to thank the Pine Mountain Observatory for making the observatory available for workshops. We thank Fred Muller for donating the telescope and Dave Scimeca for donating technical expertise his time. Acknowledgement is also directed to the faculty and staff at St. Mary's School for providing facilities and financial support to the astronomy club.


## References


*Observing and Measuring Visual Double Stars*, Argyle, Robert., Springer, London, 2004.

Frey, Thomas G., October 2008, *Journal of Double Star Observations*, 3(2), p. 59-65.

Frey, Thomas G., October 2009, *Journal of Double Star Observations*, 5(4), p. 212-216.

Mason, Brian. The Washington Double Star Catalog. July 2009. Astronomy Department, U.S. Naval Observatory. http://ad.usno.navy.mil/wds/wds.html.



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