Comparison of Visual Data Collection Techniques on Mizar: The Barlow Lens

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Abstract: Since turning their eyes to the heavens and gazing at the celestial bodies therein, mankind has been restricted and limited in his knowledge of the cosmos by the resolving power of first, the naked-eye, and later, the telescope. It has been the goal of astronomers worldwide to create larger and more powerful telescopes with higher resolving capabilities. Such large telescopes are not an option, however, for amateur astronomers and as such they must rely on other instruments and tools to achieve greater precision. One of these tools is the Barlow lens, used to increase the magnification power of a telescope by increasing its focal length. This magnification can assist in precision and accuracy of observations, especially when measuring the angular separation. Continuing their previous work in double star research (Bensel, Peard, Peccia, Scimeca, et al.), a contingent from St. Mary's School in Medford, Oregon compared the usage of a 2X Barlow lens with their usual telescope configuration and discuss the advantages and disadvantages they experienced with each.

Introduction

Double stars are defined into the following two separate categories: binary systems, in which the stars are close enough relative to each other to have significant gravitational interactions; and optical double stars, which are gravitationally unrelated stars that appear to be near each other when viewed from earth. Data collection and analysis 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 of the stellar components within the system and the subsequent analysis of those measurements. The authors compared visual measurements of the known double star, Mizar, as part of a process to discover an accurate and practical method for double star observation and research.

Figure 1: St. Mary's School Participants in the 2011 Pine Mountain Workshop. From left to right: Fred Muller, Holly Bensel, Dave Scimeca, Robert Bensel, Dashton Peccia, and Nolan Peard

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This project is in continuation of the initial studies carried out at the Pine Mountain Observatory Summer Science Research Workshop in 2009. During 2011, the authors (Figure 1) continued the visual aspect of double star research and added to their skill set by comparing the use of a 2X Barlow lens with their typical setup. It was the goal of this group to master the visual observing techniques on double stars and compare our visual data, with and without the additional 2X Barlow lens, with previously published data. The location for these observations, Pine Mountain Observatory, is positioned at 43.8 N latitude and 120.9 degrees W longitude at an elevation of 6500 feet above sea level near Bend, Oregon. The dry, desert-like climate and dark skies in that area make for excellent viewing.

Hypothesis

Due to adverse weather conditions and resulting vibrations in the telescope, it was thought that the visual data gathered in standard setup, sans Barlow lens, would provide more accurate results when compared to the published results in the WDS Catalog (2010) than the data taken with the augmenting 2X Barlow lens. Although it was initially believed that the use of a 2X Barlow lens might allow more accurate measurements of the separation of Mizar, blustery conditions caused severe field vibration reducing the precision and possibly the accuracy of the observations.

Equipment

The group used a Meade 10" LX200 Schmidt-Cassegrain telescope, generously donated by Fred Muller in 2007. In the 2011 observing season a 12.5mm Celestron Micro Guide astrometric eyepiece was used in addition to a 2X Barlow lens. The telescope was converted from Alt-Az to equatorial mode in 2010 through the use of a wedge bought with donations.

Calibration of the Celestron Astrometric Eyepiece

The first step in observing double stars is to calibrate the linear scale on the astrometric eyepiece in units of arcseconds per division. Argyle (p. 152) suggests using a reference star of medium brightness at a declination between 60° and 75° to avoid timing errors. If the star is below 60° then the field drift is too slow, and above 75° is too fast to allow accurate timing. Therefore, the club used Mizar, at 54° 55.51' declination because it was easily visible and near 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 opposite side of the scale. The field 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) is defined as follows:

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

where Z is the scale constant (in arc seconds per division), T_{ave} is the average drift time, 15.0411 is the arc seconds per second of the Earth's rotation at the celestial equator, $\cos\delta_{RS}$ is the cosine of the reference star's declination, and D is the number of divisions on the linear scale which, for our Celestron eyepiece, is 60 divisions. Because two different telescope setups were being used, the scale constant had to be measured both with and without the 2X Barlow lens. The data used in the calculations for each scale constant is discussed below.

The reference star used in the calculation, Mizar, had an average drift time of 47.64 seconds (standard deviation of 0.31s and mean error of 0.01s) with a standard setup and 20.42 seconds (standard deviation of 0.24s and mean error of 0.08s) when the 2X Barlow lens was introduced. This resulted in a scale constant of 6.85 and 2.93 arc seconds per division with and without the Barlow lens, respectively. Data for the scale constant determination using the Celestron Micro Guide eyepiece both with and without the additional Barlow lens is shown in Table 1 below.

Separation Measurement of Mizar

The separation angle between adjacent stars is determined by aligning the primary and secondary star along the linear scale and measuring the distance between them to the nearest 0.1 division. The pair of stars is reallocated across the scale to decrease bias between trials. This value is then multiplied by the scale constant (Z) to obtain the separation angle in arc seconds (Argyle p. 152).

Mizar was chosen for this project because it is an extensively studied double star with known separation and position angle measurements. It was also easily located in the night sky at Right Ascension 13h 23.6', declination 54° 55.31'. The Washington Double Star (WDS) Catalog (2011) cited the separation dis-

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Table 1: Measurements for scale constant determination (using Mizar) without and with the Barlow lens.

	Epoch (B1900)	#Obs	Time (sec)	STDEV	Mean Error	Scale Const. (a.s. per div.)
w/out Barlow	2011.57	10	47.64	0.31	0.01	6.85
with Barlow	2011.57	10	20.42	0.24	0.08	2.93

Table 2. Separation angle measurements of Mizar (STF1744) without and with the Barlow lens.

	Epoch (B1900)	Lit. Epoch	#Obs	SD/ME	Obs. Sep.	Lit. Sep.	% Error
w/out Barlow	2011.56	2011	10	0.44/0.14	14.59	14.7	~0.75%
with Barlow	2011.56	2011	10	0.42/0.13	15.25	14.7	~3.72%

Table 3: Position angle measurements of Mizar (STF1744) without and with the Barlow Lens.

	Epoch (B1900)	Lit. Epoch	#Obs	SD/ME	Obs. PA	Lit. PA	% Error
w/out Barlow	2011.56	2011	5	0.61/0.27	152	152	~0.0%
With Barlow	2011.56	2011	10	1.79/0.57	153.9	152	~1.25%

tance and position angle as 14.7 arc seconds and 152° respectively. The results of separation angle measurements of Mizar using the Celestron eyepiece without and with the additional Barlow lens are shown in Table 2.

Position Angle Measurement of Mizar:

In the equatorial arrangement, the primary star was placed at the center of the linear scale using the telescope controller keypad, the eyepiece rotated so that the double star was aligned with the linear scale. The Right Ascension motor was then deactivated and the position angle determined by observing which degree marking the primary star crossed on the outer protractor scale, rounding to the nearest 0.5°. Once the star crossed the protractor scale, the tracking motor was reactivated, the star brought back to center, and the procedure repeated with the reticule rotated 180 degrees every five trials to reduce operator bias. The results of position angle measurements of Mizar using the Celestron eyepiece without and with the additional Barlow lens are shown in Table 3.

Conclusions and New Directions:

In measuring the position and separation angles of the primary components of Mizar, a quadruple star system, the authors discovered that measurements acquired without the use of a 2X Barlow lens were more accurate, when compared to literature values in the WDS, than those made with the Barlow lens. Specifically, there was a 2.97% increase in error when the Barlow lens was used in measuring the separation angle and a 1.25% increase in error for measuring the position angle (Tables 3, 4, 5, 6). The authors believe that this unexpected increase in error was a result of a higher propensity toward field vibration, resulting from air flux and occasional jostling by the operators, while using the 2X Barlow lens. Although a higher level of precision and accuracy was expected, extreme care must be taken to eliminate vibrations else the use of a Barlow lens may be nullified. The authors recommend that a Barlow lens will be most useful on very still, clear nights with an established procedure and experienced operators. Lacking those parameters, the relatively equivalent level of accuracy and precision can be achieved without any augmenting optics such as the Barlow lens.

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