Analysis of Visual Double Stars

Thanh Tran[1], Holly Bensel [2], Paige Birmingham[1], Yifan He[1], Kieran Rooney,[1] Yuqi Shi[1], Ruiyang You[1]

(1) Students and (2) Teacher at St. Mary's School, 816 Black Oak Dr., Medford, Oregon 97504 www.smschool.us

Introduction

Visual double stars are either a gravitationally bound binary or an apparent binary when the stars are actually at different distances from Earth. We find the right ascension (RA) and declination (DEC) and calculate the separation distance rho (ρ) and the position angle phi (ϕ).

Background

The St. Mary's School Astronomy Club is working towards measuring positions and angles of relatively unstudied visual binary stars, called "neglected double stars". We analyzed the double stars Epsilon Lyrae (Double Double), Alberio, Mizar, Zeta Lyrae, and Sheliak using a 10" Meade Lx 200 equipped with a Canon DSLR Camera and a 12.5" CDK PlaneWave telescope from Dr. Sean Curry. In addition, we used astrometry.net and SAOImage DS9 program to measure RA and DEC on known double stars before attempting measurements on neglected double stars. To check our results, we compared the calculations with the data from Washington Double Star Catalog (Mason, 2016). By analyzing these double stars, we have added to the understanding of these double stars and built up our own data analysis skills. Our next project will be to study 'neglected visual double stars,' lesser studied double stars with fainter magnitudes.

References

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Frey, et al., 2009, *Visual Measurements of the Neglected Double Star ARY 52 at the Pine Mountain Observatory Summer Science Research Workshop 2009.*

Mason, et al., 2016, *The Washington Double Star Catalog.*

Schrader, B, 2009, *Visual Measurements of Double Stars with a NexStar 6 SE at the Pine Mountain Observatory Summer Research Workshop 2009.*

Tanguay, R, 2006, *Observing Double Stars for Fun and Science,* **Sky and Telescope.**

Observations

Acquired images from 10"Meade lx200 telescope and 12.5" PlaneWave CDK telescope

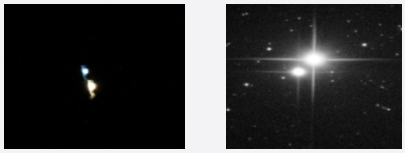

Figure 1. Alberio measured on Meade telescope (left) and on CDK Plane Wave telescope (right).

Figure 2. Epsilon Lyrae (Double Double) taken from Meade telescope and CDK telescope (top left and right), and Mizar and Zeta Lyrae are taken from Meade telescope and CDK telescope respectively (bottom left and right).

Methods

- Used astrometry.net to convert JPEG and PNG images to FITS file images.
- Uploaded to SAOImage DS9 to analyze each double star pair for RA and DEC data in the FITS images.
- Followed the procedure outlined in Buchheim (2007) to determine ρ and ϕ values:

$$\rho = \sqrt{(\Delta a * cos\delta_1)^2 + (\delta_2 - \delta_1)^2}$$

$$\phi = tan^{-1}[\frac{\Delta\alpha * cos\delta_1}{\delta_2 - \delta_1}]$$

where δ_1 and δ_2 are primary and secondary stars' DECs, and $\Delta\alpha$ is the difference in RA measured in radians.

- Repeated measurements 6 times and averaged
- Compared experimental values to the known values published in the Washington Double Star (WDS) Catalog.

Results

We achieved our goal to analyze well researched double star images accurately, and therefore we can confidently proceed to analyze "neglected double stars".
According to Tanguay, 2006, "for pairs in the 1.0-arcsecond separation range, measurements of separation should not differ more than about ±10 percent and position angle not more than about ±5.0° from the published values. For wider pairs that span around 100 arcseconds, your separation measurements should not vary more than about ±1 percent and position-angle measurements not more than about ±0.5° from the *WDS* values."

Several examples of our data are listed below:

	Separation distance, arcseconds				Position Angle, degrees			
	Obs.	Lit.	Diff.	% Diff	Obs.	Lit.	Diff.	% Diff
Alberio	35.84	34.7	1.14	3.285	54.14	54	.14	0.3
Mizar	710.37	706.8	3.57	0.5	71.13	70	1.13	1.6

Based on Tanguay's criteria, our observations were reasonably accurate in their separation and position angle measurements. Our data on the other images mentioned were equally accurate.

Conclusion

Double stars analysis is relatively straight forward and can be performed with equipment available to most high schools.

Educational outcomes include: instrument setup, orientation, instruction, observations, analysis, presentation of data, and writing up findings for publication. Accurate recording of data is a useful and important life skill for all students to learn. Another important life skill is learning to work together to accomplish a specific goal. This project allows novice and experienced observers to work hand-in-hand to accomplish a specific goal, such as the publishing of a research paper in the Journal of Double Star Observations.

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This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.