Double Star Measurements with a Three Inch Tasco Telescope

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Abstract: Observations were made of three double stars with known separations and position angles using a three inch 1960's Tasco telescope equipped with a Meade astrometric eyepiece. After these observations were completed, their mean values were compared with cataloged values. It was concluded that, under appropriate conditions, a modest aperture Tasco telescope can provide remarkably accurate and precise results.

Introduction and Experimental Design

We report below on a project conducted as part of the Fall 2007 Physics Research Seminar at Cuesta College near San Luis Obispo, California. We decided to determine how precisely and accurately observations could be made of visual double stars with a three inch Tasco telescope (Figure 1) and a low cost ($150) Meade astrometric eyepiece.

The observer (Grisham) was assigned three visual double stars to observe by Genet, the research seminar's leader. Grisham was not given any indication of the catalog position angles and separations of these three stars, nor did he have any access to such information at his remote observatory. After Grisham completed his observations, he, Johnson, and Genet calculated the means, standard deviations, and standard errors of the mean for Grisham's data. Only then did Genet reveal the catalog values (Haas 2006) for the three stars (Figure 2).

Observatory and Equipment

All observations were made at the Grisham Observatory in California Valley, seventy miles east of San Luis Obispo, California, at an elevation of 1,996 feet. The closest small town to this very dark site is thirty-eight miles away.

The 1960's three inch aperture vintage Tasco telescope features an air-spaced objective lens with crystal-sharp images, a German equatorial mount, and manual controls in both right ascension and declination. Play in the axes' journals was removed by shimming to close the tolerances. The eyepiece holder was modified from its original 0.965" to accommodate the 1.25" astrometric eyepiece. A Deluxe Reflex Sight Red-Dot Finder by Orion was added to facilitate "star hopping." Due to the added weight of the diagonal and larger eyepiece, the counter-balance bar was lengthened. A six inch diameter steel pier was imbedded three feet into 500 lbs. of concrete. The 12mm Meade astrometric eyepiece and a Meade 2x Barlow were used for all observations.

Procedures

The scale constant of the linear scale, in arc seconds per division, was independently determined for two different stars using the drift method (Argyle 2004). The eyepiece was rotated until the stars drifted from east to west exactly along the linear scale. The star drifts were then timed to one hundredth of a second. Ten drift times were recorded and averaged for each star.

To determine angular separation, the assigned double stars were aligned along the bottom of the 180° "fan" scale. They were then allowed to drift through the central calibrated linear scale. This process was repeated as many times as necessary to develop confidence that the resulting estimate of the separa-

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Figure 1: Grisham with his modified 1960's vintage three inch Tasco telescope on its optional tripod. Normally it is installed on a permanent steel pier imbedded in concrete. Its air-spaced objective provides remarkably sharp images.

tion was precise to within about one tenth of a division. Only then was the separation in divisions recorded. The average separation of multiple observations was multiplied by the scale constant to yield the final separation in arc seconds.

Position angles were determined using the drift method, taking the position angle directly from the protractor scale (Argyle 2004). First, the primary and secondary were aligned on the linear scale by rotating the astrometric eyepiece. Then, using the manual controls, the primary star was taken past the center of the linear scale and allowed to drift through the center. If the star drifted off to either side of the exact center, the process was repeated until the crosshairs in the center cleanly bisected the drifting star. If the star was so dim it was hidden behind the illuminated lines, it was required to disappear completely as it went through the center. Once the star properly passed through the exact center, it was allowed to drift to the 360° protractor. The position of the primary star as it crossed the protractor was then noted and recorded. This process was repeated ten times for each double star and the resulting position angles were averaged.

Observations

Two well known double stars in Ursa Major, Dubhe and Mizar, were used to calibrate the linear scale. The average drift times, standard deviations, and standard errors of the mean for the calibration stars are shown in Table 1, along with the calculated scale constant given in arc seconds per division.

The three double stars assigned by Genet for observation (with separations and position angles unknown to the observer, Grisham) were 100 Hercules, Kappa Hercules, and Nu Draco. Their cataloged coordinates and apparent magnitudes are shown in Table 2 (Haas 2006).

Star	RA	Dec	Mag 1	Mag 2
100 Her	18h 08m	+26° 06m	5.8	5.8
Kappa Her	16h 08m	+17° 03m	5.1	6.2
Nu Dra	17h 32m	+55° 11m	4.9	4.9

Table 2: Catalog coordinates and magnitudes of three assigned double stars

Grisham's measurements of the assigned double stars are shown in Table 3, along with their standard deviations and standard errors of the mean. Ten observations were made of position angles and separations and the results averaged.

Star	Epoch	Declination	Drift (sec)	Std. Dev.	Mean Error	Scale Const.
Dubhe	B2007.392	+61° 45m	72.62	0.13	0.04	10.34
Mizar	B2007.392	+54° 56m	60.00	0.19	0.06	10.37

Table 1: Scale constant determination

Star	Epoch	Obs. PA	St. Dev.	Mean Error	Obs. Sep.	St. Dev.	Mean Error
100 Her	B2007.460	183.3°	0.4°	0.1°	14.2″	0.9″	0.3″
Kappa Her	B2007.463	14.2°	0.3°	0.1°	27.1″	0.8″	0.3″
Nu Dra	B2007.466	311.1°	0.4°	0.1°	62.5″	0.7″	0.2″

Table 3: Observational results of the three assigned double stars

Results and Conclusions

Table 4 compares Grisham's observations with published values for the three stars (Haas 2006).

We concluded that there were no systematic or gross errors with respect to precision, and that the observed values were not significantly different from the cataloged values except for the observed position angle of Kappa Hercules. Kappa Hercules differed from the catalog by 1.2°, far greater than the calculated standard error of the mean (0.1°).

The reason for the variance in the position angle for Kappa Hercules may be that it is an optical double star which has increased its position angle because of proper motion from both components. Specifically, the proper motion in right ascension for the reference point star amounts to about -33 milliarcseconds (mas) per year, while that of the companion is approximately -27 mas per year. In declination, the proper motion of the primary star is approximately -7.9 mas per year, while that of the companion is -30.6 mas per year. It may be the combined effects of these proper motions that are causing the position angle to increase. As a consequence of these shifts, various catalogs are not in agreement concerning the position angle value, varying from 12 to 15 degrees. This double star warrants additional measurements by other researchers to obtain greater accuracy for its position angle.

We attribute the generally remarkable accuracy and precision of Grisham's observations to the high quality of his 1960's three inch Tasco telescope, not to mention its careful shimming, precise equatorial alignment, and stout pier. We also attribute this precision to the dark, clear skies of California Valley, and to the refined and painstaking observational procedures Grisham meticulously followed.

Figure 2: The moment of truth! With observations completed and mean values calculated, Genet (center) finally reveals the catalog values to Johnson (left) and Grisham (right). Both were very pleased with the remarkably close agreements!

To put Grisham's observational accuracy in context, Ronald Tanguay, who has had many years of experience working with reticle micrometers, states

Star	Obs. PA	Cat. PA	Diff.	Obs. Sep.	Cat. Sep.	Diff.
100 Her	183.3°	183°	0.3°	14.2″	14.2″	0.0″
Kappa Her	14.2°	13°	1.2°	27.1″	27.4″	-0.3″
Nu Dra	311.1°	311°	0.1°	62.5″	63.4″	-0.9″

Table 4: Comparison of observation values to catalog values

that, "Measurements within 5% of catalog values can be considered good and measurements within 1% or less can be looked upon as excellent work. With a well calibrated reticle micrometer, we may expect measurements to average about ± 1 degree in the position angle and ± 2% in separation from the data listed in the WDS Catalog. The reticle micrometer, if carefully calibrated, can be a reasonably accurate tool for use in measuring double stars." Note that Grisham's average difference from the catalog position angles is only 0.5° and his average difference in separations is 0.8%, both twice as accurate as what Tanguay says is "excellent work."

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Darrell R. Grisham is a retired United States Air Force C-141A Crew Chief and weather specialist. He has been observing from his home in California Valley for the past four years. Jolyon M. Johnson is starting his second year at Cuesta College. He has been studying astronomy for over a year. Russell M. Genet is a Professor of Astronomy and leads a research seminar at Cuesta College. He is also a Research Scholar in Residence at California Polytechnic State University and Director of the Orion Observatory, www.OrionObservatory.org. David L. Arnold has been conducting double star research in Flagstaff, Arizona for over 6 years. He has previously published 23 double star research reports in the Double Star Observer, as well as 12 reports in the Journal of Double Star Observations.