# High School Observations of the Visual Double Star 3 Pegasi

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**Abstract:** Using a Meade 10” LX200 telescope and a Celestron Micro Guide eyepiece, students from Arroyo Grande High School learned proper techniques for visually measuring the separation and position angle of a visual double star (3 Pegasi). The project was part of a physics research seminar at Cuesta College in San Luis Obispo, California.

## Introduction

This project was part of the Fall 2007 Physics Research Seminar at Cuesta College near San Luis Obispo, California. The observers, all students at Arroyo Grande High School, met with their instructor, Genet, and Johnson on October 6, 2007 (B2007.763) at Marble’s home, located in Arroyo Grande, California to conduct the observations. White brought his Meade 10” LX200 telescope, which was used with a Celestron Micro Guide eyepiece for all observations.

The authors had a wide variety of astronomical experience. Most had never made astronomical observations before, while a few were seasoned observers. The high school students learned one procedure for measuring the separation and the position angle of a visual double star using a reticle eyepiece.

## Procedures

The drift method was used to calculate the scale constant in arc seconds per division for the linear scale of the Celestron Micro Guide eyepiece (Teague 2004). A bright star was aligned at one end of the linear scale and the telescope was moved with the fine controls east and west in right ascension. If the star deviated from the linear scale, the eyepiece was rotated until there were no deviations. The right ascension motor was then turned off and the time taken for the star to drift from one end of the linear scale to the other was recorded. The mean value of repeated observations was used in the following equation to calculate the scale constant for the Celestron Micro Guide eyepiece:

$$z = \frac{15.0411 t \cos(d)}{D}$$

where

$z$ is the scale constant in arc seconds per division

15.0411 is the number of arc seconds per second of the Earth’s rotation

$t$ is the average drift time in seconds

$d$ is the declination of the star

$D$ is the number of divisions on the linear scale (60)

The angular separation, i.e. the distance between the primary and secondary stars in arc seconds, was found by using the linear scale to count the number of divisions between the two stars and estimating the separation to the nearest tenth of a division. The mean value of several observations was then multiplied by the scale constant to obtain the angular separation.

To measure the position angle, i.e. the position of the secondary with respect to the primary in relation to the north celestial pole, the authors first aligned the primary with the center of the linear scale. The eyepiece was then rotated until the linear scale bisected the secondary. The right ascension motor was turned off to let the primary and secondary drift out to the protractor at the edge of the field of view. When the primary reached the protractor, the motor was turned back on to hold its position. The angle on the protractor, indicated by the position of the primary star, was noted and recorded. The mean position angle from several such observations was calculated. The position angle correction for the Celestron Micro Guide eyepiece, given on page 153 of *Observing and Measuring Visual Double Stars* (Teague 2004), was applied to give the correct measured position angle.

## Visual Observations

To eliminate timing errors, the observers chose Delta Cephei with a high declination of +58° 17.31m to determine the scale constant of the linear scale. Twelve trials resulted in an average drift time of 58.36 seconds with a standard deviation of 0.57 and a standard error of the mean of 0.17. This yielded a scale constant of 7.69” per division with a standard deviation of 0.08 and a standard error of the mean of 0.02.

Professor Tom Frey, a visual double star observer in San Luis Obispo, Califonria, suggested that the observers measure the bright visual double star 3 Pegasi (WDS STFA 56) which is located at right ascension 21h 37.7m and declination +06° 37m with a primary magnitude of 6.2 and a secondary magnitude of 7.3 (Mason 2007). After ten trials, the authors determined the average separation to be 39.8” with a standard deviation of 2.2” and a standard error of the mean of 0.7”. Eight trials gave a position angle of 349.0° with a standard deviation of 0.5° and a standard error of the mean of 0.2°.

## Analysis and Conclusions

Our measurement of the separation of 3 Pegasi was 39.8”, while the Washington Double Star (WDS) Catalog value is 39.1”. This difference of 0.7” was well within our error expectations. The standard deviation for the observed separation was 2.2”, which is higher than expected. This could be due to the inexperience of some of the observers. The measured position angle was 349.0° while the double star catalog in *Double Stars for Small Telescopes* (Haas 2006) also gives a position angle of 349°. However, the WDS Catalog gives a position angle is 348°, a 1° difference from the authors’ position angle.

Ronald Tanguay, an experienced double star observer, says in *The Double Star Observer’s Handbook* that “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” (Tanguay 2003). The observed average difference from the WDS Catalog position angle was 1° and the average difference in separation was 1.8%. Both parameters fit within what Tanguay says are “excellent work.”

Upon further investigation into the proper motions of 3 Pegasi, double star observer Dave Arnold kindly suggested to us that

> *Analysis of the proper motion vectors for both stars indicates that this is a common proper motion pair, with motions in right ascension and declination that are almost identical, so this provides verification that this pair's parameters really are relatively fixed. This pair is not listed in the visual binary section of Sky Catalog 2000.0 because no orbit has been determined. However, it doesn't appear that this pair has shifted significantly since it was discovered in the [position angle/separation] parameters.*

The common proper motion of the primary and secondary components suggests this may be a binary star. If 3 Pegasi is a binary star, further analysis over several hundred years may provide both the orbital period and the masses of both stars.

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*Stephanie M. Marble, Christianne M. Gonzalez, Corey M. Cameron, James B. Johandes, Brett R. Chapman, and Sarah F. Fishbein are students at Arroyo Grande High School and were enrolled in the physics research seminar at Cuesta College. Jolyon M. Johnson is starting his second year as a student at Cuesta College and is also enrolled in the physics research seminar. Robin White, the observatory assistant at Cuesta College, is a highly experienced observer. 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.*