Astrometric Measurements of WDS 04136-2532

Vivek Vijayakumar[1] and Curran Poulsen[2], Alex Falatoun[3] Pat Boyce[4], and Grady Boyce[4]

1. San Marcos High School, San Marcos, CA
2. Justin Siena High School, Napa, CA
3. Mesa Community College, San Diego, CA
4. Boyce Research Initiatives and Education Foundation (BRIEF), San Diego, CA

Abstract: Astrometric measurements were obtained for WDS 04136-2532 (SEE 34) using the iTelescope network. A mean position angle of 63.3° ± 0.6° and a separation distance of 15.5" ± 0.1" were measured showing an increase of 0.5º and decrease of 0.7" respectively from the last observation in epoch 2003.95. Historical data, combined with our recent measurements, did not indicate signs of orbital motion, but instead supports a linear trend.

Introduction

The research conducted in this paper is part of a program through Boyce Research Initiatives and Education Foundation (BRIEF) that allows high school students, college students, and other amateur astronomers, the opportunity to conduct scientific research and learn real world applications of the scientific process. The focus of study is astrometric measurements, position angle (Theta) and separation (Rho) of double star systems listed in the Washington Double Star (WDS) Catalog where candidates were selected, imaged, and analyzed to help add to the understanding of whether the star's association is merely an optical double or a gravitationally bound star system. Determining the latter in conjunction with other measurements could provide significant insight to the stars, such as their mass, which in turn opens opportunities to find radius, density and more.

For this research, the double stars available for conducting research were reviewed in the WDS Catalog based on their visibility during the Fall semester (August - February), and filtered by a minimum separation of 6 arcseconds with a magnitude difference no greater than 6. Additionally, the double star system selected has less than 10 observations making it favorable to study because our research provides additional observations, which may assist with further analysis of this system at some future date.

The star system ultimately chosen was WDS 04136 -2532 (henceforth referred to as SEE 34), for having met the aforementioned criteria for examination, and our team's desire to prevent a large data gap, since the last measurement was over a decade ago. The observation history for SEE 34 is outlined in Table 1.

Table 1. Historical Measurements of SEE 34

WDS 04136-2532 (SEE 34)		
Epoch	Position Angle θ (°)	Separation ρ (")
1897.76	55.1	19.78
1899.26	53.5	19.00
1906.72	55.8	19.10
1945.01	60.0	18.12
1979.941	61.0	16.90
1998.91	62.0	16.22
1999.713	62.7	16.167
2003.93	62.76	16.179

Astrometric Measurements of WDS 04136-2532

Figure 1. *iTelescope Network's T32 telescope in Siding Spring, Australia*

Figure 2. iTelescope Network's T30 Telescope in Siding Spring Australia

Equipment, Observations, and Data Analysis Procedures

Equipment

iTelescope Network's T32, Figure 1, is located the Siding Spring Observatory in New South Wales, Australia. The attached charged coupled device (CCD) has an anti-blooming gate full well and uses a 17" Planewave CDK optical tube assembly (OTA) on a Planewave Ascension 200HR mount. This telescope was selected due to its geographical location and its high resolution at 0.63"/pixel.

Due to the magnitude difference in the pair, and the fact that the primary emits more light at longer wavelengths, iTelescope Network's T30, Figure 2, was selected for its UV filter to assist in separating the stars on the CCD chip. Located in the Siding Spring Observatory, T30 has a CCD with a 100,000e- Non-anti blooming gate, a 20" Planewave OTA, and a Planewave Ascension 200HR mount with a resolution of 0.81"/pixel.

Observations

The date of observation was chosen to align as closely as possible to a new moon phase in order to have the lowest luminosity from the moon as determined by the Staralt visibility tool (Sorensen, 2002)[1].

Six images were taken at epoch 2017.87 with T32.

Three of these images were with a Hydrogen-alpha filter at 60 seconds exposure, and three images were with a blue filter at 60 seconds exposure. The images with the Hydrogen-alpha filter had over saturated pixels, while the blue filters produced one image where both the primary and secondary stars could be identified. Due to the long gap between observations, the one useable image was omitted from the results in order to report on only one epoch. In order to add to our collected data, on epoch 2017.95, fifteen more images were taken with T30 using a combination of UV and blue filters, though three were discarded due to excessive atmospheric distortion. Figure 3 shows one of our images of the star system.

Analysis Procedures

All images were preprocessed (flat-fielded and dark subtracted) by the iTelescope network. The pixels that contained our double star systems were checked for counts to make sure that none of the images were oversaturated. After assessing the quality of the images, they were uploaded to astrometry.net in order to assign World Coordinate System (WCS) positions.

The image analysis software SAOImage DS9 (referred to henceforth as DS9) was used to consistently measure the position angle (θ) and separation distance (ρ) for each image. First, a 7" circle was created using the Regions feature and placed over the A star, followed by a circle of the same radius around the B star.

DS9's auto-centroiding feature was used to find the

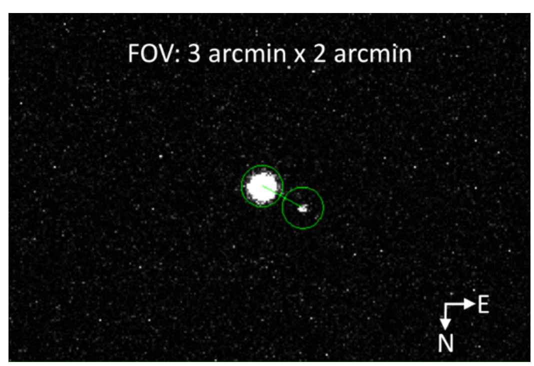

Figure 3. *One of our images of the star system, with the A component at the top left, and the B component at the bottom right*

Astrometric Measurements of WDS 04136-2532

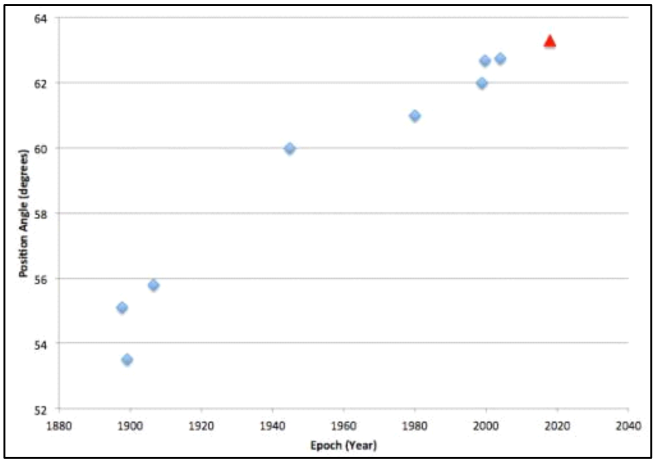

Figure 4. Position angle in degrees and epoch in years for SEE 34, including historical data and new measurement (red triangle).

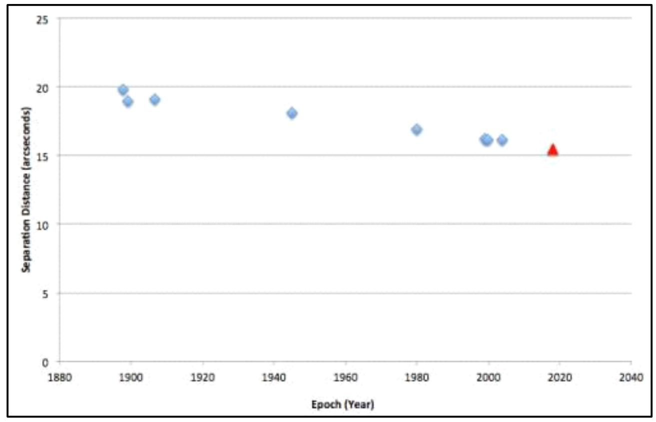

Figure 5. Graph of separation distance in arcseconds and epoch in years for SEE 34, including historical data and new measurement (red triangle).

center of each star, which effectively calculates the weighted mean position of all the counts per pixel enclosed in the circle. The coordinates for the centroid of each star were recorded and then placed as endpoints of a line segment. The length of the line segment provided the separation distance in arcseconds and its orientation relative to some reference provided the position angle.

Results

Astrometric measurements are reported in Table 2. For the epoch 2017.95 we measured a mean position angle of 63.34° ± 0.59° and separation distance of 15.49" ± 0.10". The uncertainty values are the calculated standard deviation of the mean.

Additionally, graphs of position angle vs. epoch, Figure 4, and separation distance vs. epoch, Figure 5, include our measurements in an historical context.

Discussion

We have found that our new measurement, if we omit the data point from 1899, supports a linear progression. The measurement from 1899 is an apparent outlier with respect to the other measurements, and doesn't seem to have any supporting documentation. With the position angle being 63.34° ± 0.59°, there hasn't been any change in position angle with respect to the last measurement in 2003 within the standard error of mean. With the separation distance being 15.49" ± 0.10", there has been a clear change in separation since the last measurement in 2003. When plotted in a proper motion plot (Figure 6), it is evident there is a linear progression, and the 1899 data point seems to be an outlier. This is not indicative of a physical binary, but more of an optical pair.

Conclusion

We measured the position angle and separation distance of WDS 04136-2532 (SEE 34), using observations from iTelescope Network's T30 and T32 tele- scopes. The position angle showed no significant changes since the last measurement in 2003. The separation distance has decreased by approximately one arcsecond. We conclude that SEE 34 is a linear case (if we reduce the statistical weight of the 1899 measurement).

Table 2. Position angle, separation distance and uncertainties for SEE 34[2].

WDS 04136-2532 SEE 34					
Epoch	Number of Images	Mean *Position Angle* θ (°)	$\sigma\theta$ (°)	Mean *Separation* ρ (")	$\sigma\rho$ (")
2017.95	12	63.3	0.6	15.5	0.1
2003.93	Last Measurement (Sinachopoulos, et al)	62.8	-	16.2	-

Astrometric Measurements of WDS 04136-2532

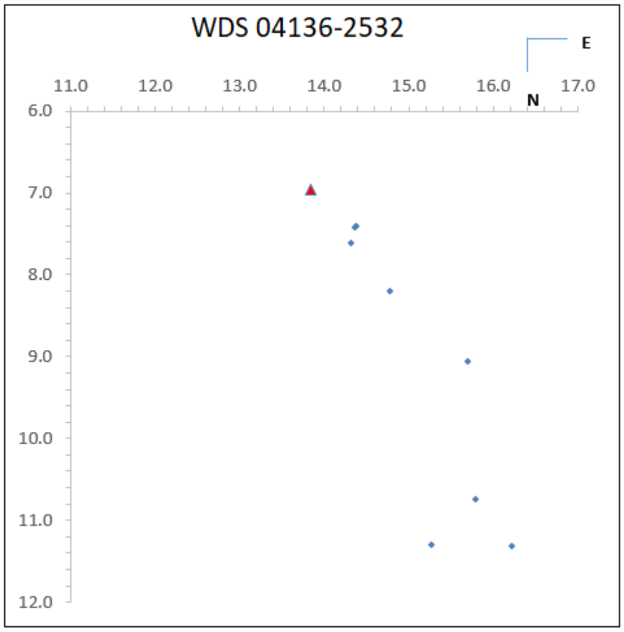

Figure 6. Relative proper motion plot of SEE 34, expressed as ΔRA vs. ΔDEC relative to the primary, placed at the origin. The blue diamonds represent previous measurements, and the red tri- angle represents measurements taken on epoch 2017.95.

Acknowledgements

The authors would like to thank the Boyce Research Initiatives and Education Foundation (B.R.I.E.F). Without their organization and guidance, none of this would have been possible. Additionally, we want to thank the United States Naval Observatory (USNO) for supplying thee historical data of our binary star system, which we used throughout the research process. We would also like to thank astronomy.net for providing the World Coordinate System (WCS) coordinates, and Matthew Salehi for additional contributions.

References

1. "Credits." *ING Banner*, 8 Aug. 2014, www.ing.iac.es/PR/credits.html.

2. Sinachopoulos, D., et al. "CCD Astrometry and Components Instrumental Magnitude Difference of 432 Hipparcos Wide Visual Double Stars." *Astronomy & Astrophysics (A&A)*, EDP Sciences, 16 July 2007, www.aanda.org/articles/aa/abs/2007/36/aa6290-06/aa6290-06.html.