CCD Observation of STF1169AB

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Abstract: Binary star system STF1169AB was observed on April 9th, 2017 using the 17-inch Corrected Dall-Kirkham, Optical Tube Assembly Astrograph Telescope at the Sierra Remote Observatory. Ten images were taken using a Charge-Coupled Device, allowing position angle and separation to be calculated to within 1.2% standard error. The position angle was recorded as 14.95 degrees and the separation as 20.73 arc seconds.

Introduction

Double star system STF1169AB (also classified as WDS-08165+7930 and ADS 6646) was observed on the night of April 9th, 2017 using the PlaneWave CDK-17 OTA Telescope at the Sierra Remote Observatory in California. STF1169AB was chosen for observation by Astronomy Research Seminar Team 5, of Cuesta College in San Luis Obispo, based on several criteria, including magnitude, separation, orbital period, and viewing angle from the Sierra Remote Observatory. The last observation of this system was made by A.A Kisselev, L.G. Romanenko, and O.A. Kalinichenko in 2009 (*Kisselev, 2009*). Cuesta College Research Team 5 had three goals. First, to verify STF1169AB's status as a binary system, second, to provide additional CCD data to the community, and third, to learn the process of writing a research paper. The team members are shown in Figure 1.

Figure 1. The authors from left to right: Thomas Gerow, Brandon Ramirez, Paul Whipp, Colette Newton, Robin Morales, David Anderson. Not pictured: Rachel Freed, David Rowe, and Russell Genet.

History

The first observation of the AB component of system STF1169AB was made by Friedrich Georg Wilhelm von Struve in 1832 at the Dorpat Observatory in Estonia, pictured in Figure 2. His visual micrometer measurements were published in his work *Stellarum Duplicium et Multiplicium Mensurae Micrometricae (Struve, 1837).* The AC component (STF1169AC) was not discovered until 1962, however, the data was not published until 2003. A.A Kisselev, L.G. Romanenko, and O.A. Kalinichenko (2009) published an analysis of this system and 11 other binaries. Through their analysis, they determined an unambiguous orbit for

Figure 2. Friedrich von Struve

STF1169AB. The published orbital period for this system is approximately 200 centuries.

Equipment and Methods

The observation was made at Sierra Remote Observatories in California. This location rarely experiences any adverse effects from climate and atmospheric change, providing reliable data collection (Sierra Remote Observatories, 2017). Team 5 collected ten CCD images of STF1169AB using a PlaneWave Instruments 17-inch Corrected Dall-Kirkham Astrograph (CDK-17). The optical design is illustrated in Figure 3, and the mechanical design in Figure 4. The telescope employs a large capacity IRF90 integrated rotator and focuser. The focuser supports up to 18 kg and has a range of 30,000 microns, while the rotator has a range of 360-degrees and a 90 mm aperture. The CDK-17 is also equipped with an A200 mount, which can support up to 125 kg payload, a high-tech high-resolution encoder which corrects leftover mechanical dissonances during adjustment. It is controlled by a Sidereal Technology Servo Controller (*"SitechServo", 2017*). The camera used was an Apogee F16M KAF-16803 (*Apogee Alta, 2017*) CCD with no filter wheel. The software used to control the telescope is an STI 1.4.2 mount interface, PWI 3.3.3 focuser and rotator interface, PWA 1.09 automation software, and MaxIm DL Pro 5 camera interface (*PlaneWave Instruments, 2017*).

The .FITS files were compressed and uploaded to a Google Drive, then downloaded and unzipped by team

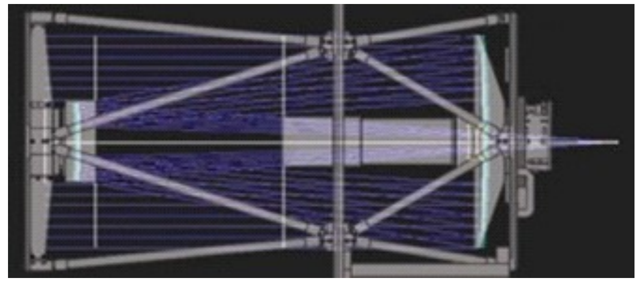

Figure 3. Optical Design

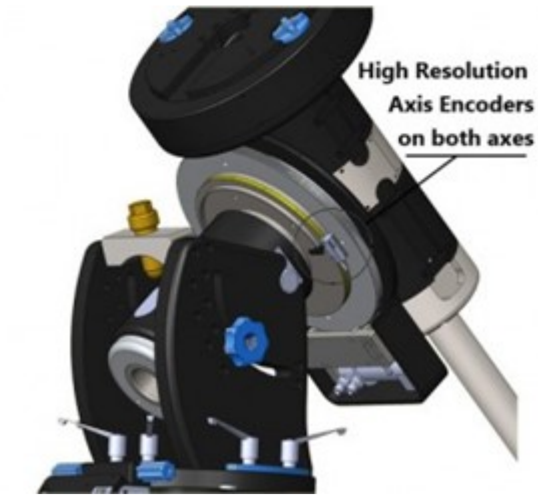

Figure 4. Mechanical Design

Calibration

Center (RA, Dec):	(124.132, 79.501)
Center (RA, hms):	$08^h\ 16^m\ 31.759^s$
Center (Dec, dms):	+79° 30' 04.698"
Size:	23.7 x 23.7 arcmin
Radius:	0.280 deg
Pixel scale:	0.635 arcsec/pixel
Orientation:	Up is -173 degrees E of N

Figure 5. Telescope Calibration Data

members to be analyzed. The team used www.astrometry.net to read the calibrations of the telescope camera, these calibrations can be seen in Figure 5 ("Astrometry.Net", 2017).

In order to measure the current orbital position of STF1169AB, team members used AstroImageJ, version db3.2.1. The program provides a tool that discerns accurate measurements of separation and position angle

("AstroImageJ", 2017). Three team members separately recorded results from AstroImageJ, with no discrepancies.

Results

The data obtained from the Sierra Remote Observatory included 10 separate FITS image files taken sequentially. Team 5 analyzed each image with AstroImageJ; the results can be seen in Table 1. The simple average of the data was taken to reduce it into a single data point to submit to the *Journal of Double Star Observations*. The standard error from the mean and standard deviation have also been determined, and included in the results.

Table 1. Final Data

	Position Angle	Separation
FITS 1	15.10	20.74
FITS 2	14.92	20.74
FITS 3	14.97	20.75
FITS 4	14.88	20.74
FITS 5	14.86	20.78
FITS 6	14.91	20.77
FITS 7	14.96	20.66
FITS 8	15.05	20.68
FITS 9	14.89	20.73
FITS 10	14.91	20.75
Average	14.945	20.734
Standard Dev.	0.07697	0.037178
Standard Error	0.02434	0.011757

Discussion

After analysis, the new observations do not add significant additional support to Kisselev's classification of STF1169AB as a binary system, rather than an optical double. The R^2 value of the quadratic fit of recorded position angles, shown in Figure 6, does have a higher value than the R^2 value of the linear fit, as shown in Figure 7. However, this difference is not significant, and when comparing these values, it cannot be determined if the observation increases confidence in Kisselev's orbit. Figure 8 shows the separation of all observations, representing a small slice of the system's orbit. A challenge presented by this system is its long orbital period, estimated at approximately 200 centuries. The system has been under observation for less than 1% of this time. Although our observations may not increase confidence in the orbit, the final observa-

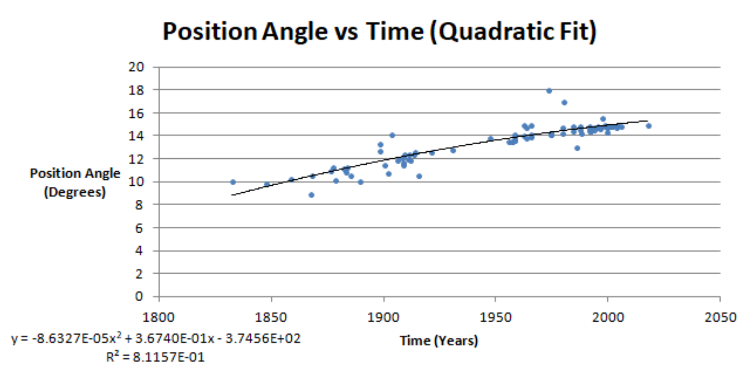

Figure 6. Quadratic fit to PA as a function of time.

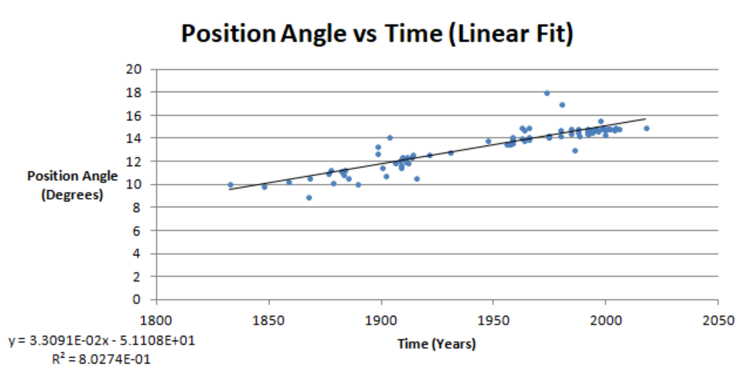

Figure 7. Linear fit to PA as a function of time.

CCD Observation of STF1169AB

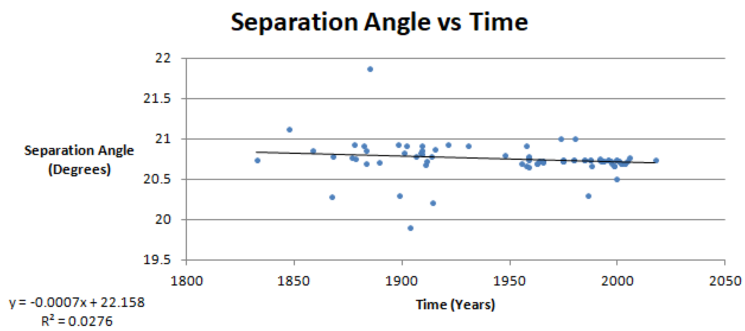

Figure 8. All observations of separation.

tion has a small standard error, especially when compared with previous eyepiece measurements. This will make an ideal stepping stone for future researchers observing this system.

Conclusion

Cuesta College Research Team 5 was able to achieve two of its three goals. Ten images were taken and analyzed, and the data has a low error from the mean, providing a precise CCD measurement. The student researchers of Team 5 also achieved their educational goal of learning the process of creating a research paper, thus preparing them for future research. However, the findings cannot suggest additional confidence of an orbital path for STF1169AB.

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