CCD Measurement of STT 547AB

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Abstract: The AB component of the multi-star system STT 547 was observed during the summer of 2016. The position angle was 190° and the separation was 5.99″. These values are consistent with historical data. A typographical error was found in the position angle for epoch 2011.8016 in the historical data maintained in the Washington Double Star database. The corrected value was used in our data analysis. Two orbits have been proposed for STT 547AB and our measurements do not provide enough additional data to prefer one orbit or the other. Additional measurements over the next few years should allow the confirmation of one of the orbits.

Introduction

Multi-star system WDS 00057+4549 STT 547AB was imaged with CCD cameras to measure its position angles and separation. This system was chosen for study from the Washington Double Star catalog (WDS) and the Sixth Orbital Catalog using a set of criteria: separation of 4 arc seconds or more, visual magnitude of 12 or brighter, and with a difference in visual magnitude of less than 3.

STT 547AB is a multi-star system in the constellation Andromeda at a distance of 11.75 parsecs. It was discovered and first measured by Otto Vasil'evich Struve using a micrometer and a refracting telescope in 1876 (Struve 1878). The most recent observation was by Gianpiero Locatelli of the Maritime Alps Observatory (Locatelli 2016).

STT 547's A component is spectral class K6e with magnitude 8.98 and its B component is spectral class M0.5 with magnitude 9.15 (Tamazian, Docobo, Melikian, Karapetian 2006). There are currently 399 observations of STT 547AB recorded in the WDS. *The Sixth Catalog of Orbits of Visual Binary Stars* contains two orbital solutions: the first solution has a period of 1550.637 years (Popovic & Pavlovic 1996); the second solution, calculated using the technique of apparent-motion parameters (AMP) has a period of 509.65y±96.99 years (Kiyaeva, Kisselev, Polyakov, Rafal'Skii 2001). Both solutions are graded 4 or "preliminary."

Equipment

The iTelescope network of remotely operated telescopes was used to acquire CCD images of STT 547AB. The first iTelescope system used was T18, which is a 12" Corrected Dall-Kirkham (CDK) with a focal ratio of f/7.9 and equipped with an SBIG STXL-6303E camera and Astrodon Series E LRG, Astrodon 10nm Ha, SII, OIII, and Photometric V filters (Figure 1). T18's field of view is 37.41 x 24.94 arcminutes with 0.73″ per pixel resolution.

The second iTelescope system used was T7, a 17" CDK with a focal ratio of f/6.8, equipped with an SBIG STL11000M monochrome camera and Luminance, R, V, B, Ha, OIII, SII, and I filters (Figure 2). The field of view of T7 is 28x42 arcminutes with 0.63″ per pixel resolution. Both T18 and T7 are located in Nerpio,

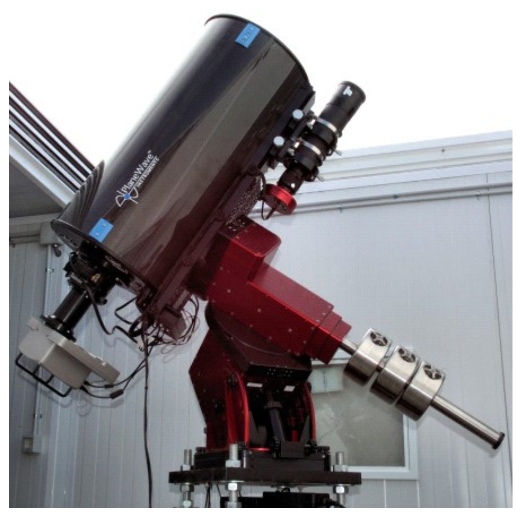

Figure 1*. T18 12" PlaneWave f/7.9 CDK Astrograph with SBIG STXL-6303E CCD in Nerpio, Spain*

CCD Measurement of STT 547AB

***Figure 2**. T7 17" PlaneWave f/6.8 CDK Astrograph with SBIG STL11000M CCD in Nerpio, Spain*

Spain. Besides having suitable capabilities, these telescope systems in Spain were used because of the good weather available at the time of the observations.

Methods and Procedures

iTelescope.net's web-based launchpad application was used to schedule operation times for T18 and T7. Exposure times of 180 seconds were chosen for all images. H-alpha, red, and luminance filters were used.

The acquired images were calibrated for rotation and pixel scale. Pinpoint Astrometry, a plug-in for MaxIm DL imaging software, was used to obtain a plate solution for most of the images by locating a number of stars in the image and comparing their positions against the *Fourth U.S. Naval Observatory CCD Astrograph Catalogue* (UCAC4). Matching the images to a star catalog was necessary to determine the RA and Dec of each star in the image. The calibration information was added to the FITS header of the image which was then saved for further processing in other software tools. Two images could not be plate solved by Pinpoint Astrometry, so the website Astrometry.net was used for calibration. Images were uploaded to www.astrometry.net, which then calibrated the images using their own algorithm and the USNO-B and Tycho2 catalogs. Astrometry.net then provided a calibrated version of the image for download. Plate solving was performed on every image individually to obtain highest accuracy.

Each calibrated image was then opened with Mira Pro x64, a software product from Mirametrics, Inc. This software enables many different analytic measurements of the stars in the image including visual magnitude, absolute position in RA and Dec, separation in arc seconds, and relative position angles. Using the point and click Distance & Angle function of Mira Pro x64, the position angle and separation between the stars were measured.

To begin a measurement, the brightest star of the pair—the 'A' component—is clicked. In the case of STT547AB, both stars have nearly identical visual magnitudes and it was not obvious which star was the primary star. Historical data on this pair, along with information from the SIMBAD astronomical database, were used to determine the 'A' component and verify the angle measurements in order to be consistent with previous measurements of this star system.

When the first star was selected, Mira Pro calculated the centroid of the star and synchronized the start of the measurement from that point. Releasing the mouse button on the second star allowed the software to locate that star's centroid position and provided the desired measurement from these centroid positions. For highest accuracy, the software was set to calculate the centroid of each star selected in the measurement process.

The centroid calculation uses the brightness data for many pixels in the star image to calculate a weighted measurement of the star's exact position. This makes it possible for the centroid calculation to pinpoint a star's location within a fraction of a pixel. The parameters of this calculation can be adjusted if necessary to account for the size of the stars in the image. If the stars in the image are close together, the radius of the centroid calculation may need to be reduced to prevent including both stars in one centroid calculation. In some cases, where the star might be overexposed resulting in blooming, the software is unable to calculate a centroid. It is then possible to disable centroid measurement and use other methods of pinpointing a star's center. For example, if there are diffraction spikes in the image, these can be used to locate the center of the star.

After completion of the position angle and separation measurements, the data were placed into an Excel spreadsheet to calculate the mean, standard deviation, and standard error of the mean for each parameter measured. Once these were calculated, each measurement was compared to STT 547AB's data available in the Washington Double Star (WDS) catalog. This comparison allowed confirmation that the measurements were being made appropriately and that the new data was in agreement with previously published data.

CCD Measurement of STT 547AB

Results

A total of eight images were acquired on two nights of observing: six on July 8, 2016 by T18 (two images each with H-alpha, red, and luminance filters) and two on July 11, 2016 by T7 (one each with H-alpha and luminance filters). All exposure times were 180 seconds. A sample image is provided with the stars labeled and image direction indicated (Figure 3).

The mean, standard deviation, and the standard error of the mean for the separation distance (ρ) in arc seconds and the position angle (θ) in degrees were calculated (Table 1). The date is the mean of the two observation dates.

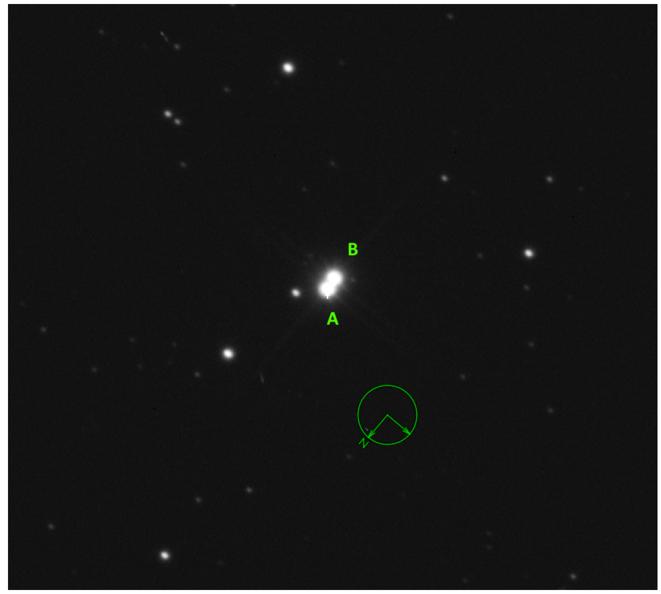

Figure 3. *Sample Image of STT 547AB with stars labeled.*

Discussion

Star system STT 547 contains as many as 12 or more components ranging in separations from 5.9″ to more than 300″. The AB pair in this system, which was first reported in 1876, was chosen for research partly because of the intrigue of it having two competing orbital solutions.

Historical data from the US Naval Observatory was requested and received. These data were then imported into a spreadsheet for the purpose of plotting and comparing with our newly measured data point. As the data graph was reviewed, we noticed a data point which appeared to be out of place with respect to the other historical data points. The measurement for Epoch 2011.8016 was reported to have an angle of 196.61 degrees while the data point previous to this one listed an angle of 186 degrees. The measurement following this one showed an angle measurement of 186.65. Referencing the original paper by Pavlovic, et. al, showed that the correct angle reading for 2011.8016 should have been 186.61 degrees. There appears to have been a typographical error when entering this data point into the WDS historical database. In the plots shown in this paper, the correct angle value has been inserted to correct this error.

Since STT 547 has two proposed orbital solutions, the new data have been plotted along with the historical data on a graph with both proposed orbital solutions (Figure 4 and 5). The new measured data point is shown in red with the label 2016.5. In order to graph these data, the orbit diagrams from the *Sixth Catalog of Orbits of Visual Binary Stars* were copied and brought into an image editing software tool. The images were scaled to the same size and overlaid with transparency so that the orbit diagrams could be superimposed. This combined image was then pasted on top of the graph of the historical data points which was created in an Excel spreadsheet. The scaling of the graphed data points and the overlaid image of the orbits were adjusted to match and the image was then copied as a combined graphic for insertion into this paper.

Conclusion

The new observation data agreed well with the historical data, suggesting no gross inaccuracies or systematic error, while the calculated standard deviation indicates that the new measurements were reasonably precise. The new observation data, unfortunately, does not contribute enough additional information to choose between either of the two proposed orbits. It is believed, however, that additional data collected within the next 10-20 years may be sufficient to select one or-

Table 1. Measured Data Results for STT547AB

WDS No.	ID	Date	Nights	Observations		θ	ρ
00057+4549	STT 547AB	2016.52	2	8	**Mean**	190.00	5.99
					Std Dev	2.059	0.367
					Std Error	0.728	0.130

CCD Measurement of STT 547AB

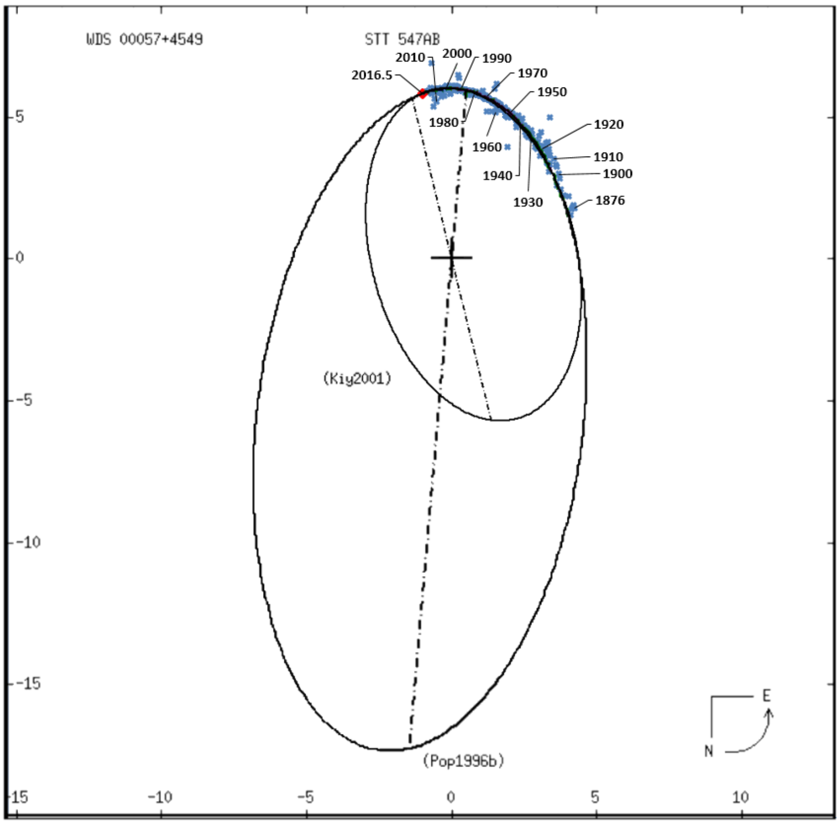

Figure 4. *Graphical representation of historical data points for STT 547AB pair.*

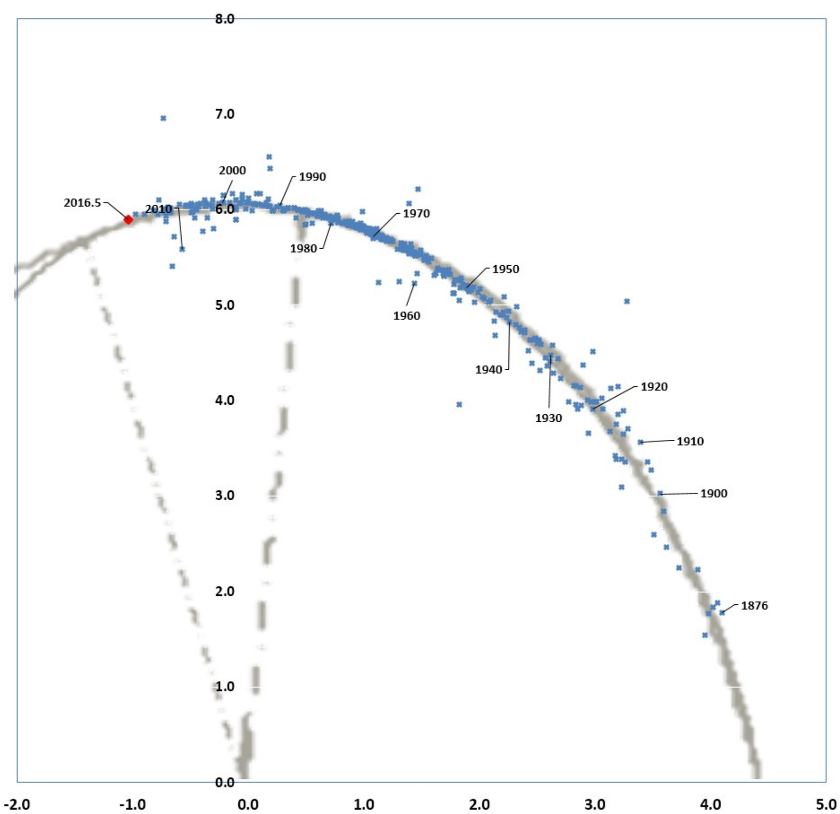

Figure 5. *Graphical representation of historical data points for STT 547AB pair. Enlarged for clarity.*

CCD Measurement of STT 547AB

bital solution over the other. Continued observations of this binary pair are warranted.

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Allen Priest and Kent Smith (Figure 5) are both members of the San Diego Astronomy Association (SDAA), and are involved in astrophotography and community outreach. Priest is an experienced electrical engineer and is teaching double star astronomy through Cuesta College at The Cambridge School in San Diego, CA. Smith is an assistant teacher for a course on double star astronomy at Mt. Everest Academy in San Diego, CA.

Figure 5. Kent Smith (L) and Allen Priest