

Astrometric Measurements of WDS 14039-6219 (R 230)

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Abstract: Astrometric measurements of WDS 14039-6219 were made with iTelescope and Las Cumbres Observatory. The separation and position angle have no significant changes for pair AB, demonstrating behavior of common proper motion pair. Evidence suggests that the C component is optically placed. A possible D component is identified.

Introduction

The measurement and analysis of WDS 14039-6219 (R230) was performed to contribute data to the Washington Double Star Catalog (WDS) to assist in further determination as to this system's status: gravitationally bound binary star or a visual double star. R230 has three components and two different measured pairs: AB and BC. It was discovered by Henry C. Russell, an Australian Astronomer, in 1880.

The purpose of this project was to successfully collect new position angle (θ) and separation (ρ) measurements for the AB and BC pairs. Our images for the astrometry on this project were acquired through Las Cumbres Observatory (LCO). To date, there have not been any recorded measurements pertaining to the AC pair of our star. We provide the first set of measurements for this pair.

Materials and Methods

R230 was photographed in South Africa and Chile with a T32 wide deep field telescope from the iTelescope network, and in Australia with a 0.4-meter telescope from Las Cumbres Observatory (LCO). A total of 6 images (2 images from LCO and 4 from iTelescope) with the following filter and exposure times were acquired: clear filter at 6 second exposure time, red filter with 120 second exposure time, red filter with 4 second exposure time, hydrogen alpha filter with 180 second exposure time. Exposure times for LCO images were calculated with LCO Exposure Time Calculator (LCO Web).

Once the image request was fulfilled, calibration of

the images from LCO were accomplished through downloading and placement into a Google Drive account where they were filtered through a reduction and calibration process: OSS Pipeline (Fitzgerald 2018). This pipeline performs the following actions to each image: Removal of file compressions; File renaming to contain the object name, the filter, the exposure time, the UTC time and date, the air mass, MJD, and camera used; Removal of any known camera defects; Removal of cosmic ray; Removal of bad pixels through a Gaussian Kernel; and Insertion of World Coordinate System (WCS) into each image.

The iTelescope images were scheduled by BRIEF and reduced through the iTelescope calibration process. These images were analyzed in MaximDL to set the WCS using PinPoint Astrometry.

After reduction and calibration was complete, each image was measured for θ and ρ using the astrometry features of Mira Pro x64. Statistics of the measurements were found with the Mean, Standard Deviation, and the Standard Deviation of the Mean, on a Basic Stats Calculator provided by BRIEF.

Results

The θ and ρ measurements for the AB, AC, and BC components are outlined in Tables 1, 2, and 3 respectively.

When viewed in comparison to the historical data, the 2018 measurements have been added to the historical measurements for the AB pair, Table 4, and the BC

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Table 1. AB Pair Images and Theta and Rho Measurements

| WDS 14039-6219 R 230 AB Pair | | | | | |
|---------------------------------------|----------|----------------|---------------|-----------------|------------------|
| Image | Epoch | Filter | Exposure Time | Theta (Degrees) | Rho (Arcseconds) |
| Image 1: South Africa LCO | 2018.231 | Clear | 6 s | 154.28° | 36.42" |
| Image 2: Chile LCO | 2018.229 | Red | 4 s | 154.39° | 36.44" |
| Image 3: Australia iTelescope | 2018.324 | Red | 120 s | 155.35° | 37.98" |
| Image 4: Australia iTelescope | 2018.324 | Red | 120 s | 154.48° | 36.04" |
| Image 5: Australia iTelescope | 2018.324 | Red | 120 s | 154.96° | 37.32" |
| Image 6: Australia iTelescope | 2018.324 | Hydrogen Alpha | 180 s | 154.32° | 36.39" |
| Mean | | | | 154.6° | 36.8" |
| Standard Deviation | | | | 0.43° | 0.73" |
| Standard Deviation of the Mean | | | | 0.071° | 0.122" |

Table 2. AC Pair Images and Theta and Rho Measurements

| WDS 14039-6219 R 230 AC Pair | | | | | |
|---------------------------------------|----------|----------------|---------------|---------|--------|
| Image | Epoch | Filter | Exposure Time | Theta | Rho |
| Image 1: South Africa LCO | 2018.231 | Clear | 6 s | 155.25° | 78.99" |
| Image 2: Chile LCO | 2018.229 | Red | 4 s | 155.33° | 78.86" |
| Image 3: Australia iTelescope | 2018.324 | Red | 120 s | 154.77° | 76.61" |
| Image 4: Australia iTelescope | 2018.324 | Red | 120 s | 155.57° | 79.75" |
| Image 5: Australia iTelescope | 2018.324 | Red | 120 s | 155.26° | 78.87" |
| Image 6: Australia iTelescope | 2018.324 | Hydrogen Alpha | 180 s | 155.82° | 80.44" |
| Mean | | | | 155.3° | 78.9" |
| Standard Deviation | | | | 0.35° | 1.29" |
| Standard Deviation of the Mean | | | | 0.059° | 0.215" |

Table 3. BC Pair Images and Theta and Rho Measurements

| WDS 14039-6219 R 230 BC Pair | | | | | |
|---------------------------------------|----------|----------------|---------------|---------|--------|
| Image | Epoch | Filter | Exposure Time | Theta | Rho |
| Image 1: South Africa LCO | 2018.231 | Clear | 6 s | 156.08° | 42.58" |
| Image 2: Chile LCO | 2018.229 | Red | 4 s | 156.14° | 42.43" |
| Image 3: Australia iTelescope | 2018.324 | Red | 120 s | 155.02° | 40.58" |
| Image 4: Australia iTelescope | 2018.324 | Red | 120 s | 156.13° | 42.44" |
| Image 5: Australia iTelescope | 2018.324 | Red | 120 s | 156.24° | 42.46" |
| Image 6: Australia iTelescope | 2018.324 | Hydrogen Alpha | 180 s | 156.07° | 42.49" |
| Mean | | | | 155.9° | 42.2" |
| Standard Deviation | | | | 0.46° | 0.78" |
| Standard Deviation of the Mean | | | | 0.076° | 0.130" |

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Table 4. AB Pair Historical Data

| Epoch | Theta | Rho |
|----------|--------|---------|
| 1880.49 | 154.1° | 36.0" |
| 1892.35 | 154.4° | 35.373" |
| 1907.01 | 154.1° | 36.44" |
| 1918.9 | 153.2° | 35.644" |
| 1920.41 | 154.8° | 37.325" |
| 1942.29 | 155.4° | 36.540" |
| 1946.50 | 154.4° | 36.242" |
| 1971.24 | 154.3° | 36.408" |
| 1971.86 | 154.0° | 36.420" |
| 1983.80 | 154.2° | 36.763" |
| 1991.73 | 154.3° | 36.382" |
| 1991.73 | 154.3° | 36.382" |
| 1998.246 | 154.3° | 36.484" |
| 2000.0 | 154.2° | 36.42" |
| 2000.14 | 154.3° | 36.52" |
| 2018 | 154.6° | 36.8" |

Table 5. BC Pair Historical Data. A theta measurement for the 1880.32 epoch is not provided in the WDS.

| Epoch | Theta | Rho |
|----------|--------|---------|
| 1880.32 | - | 43" |
| 1907.01 | 154.0° | 42.97" |
| 1998.246 | 155.7° | 42.620" |
| 2000.0 | 155.8° | 42.58" |
| 2000.14 | 155.6° | 42.48" |
| 2018 | 155.9° | 42.2" |

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pair, Table 5. The 2018 measurements for the AC pair are the first to be reported and as such, do not have a historical record in the WDS and therefore is not provided for comparison.

Discussion

All historical measurements for R230 were acquired from the United States Naval Observatory, re-

viewed, and plotted using an Excel plotting tool, Figure 1, created by Richard Harshaw. The measurements pertaining to the AB component of R 230 were relatively similar to those of the historical data, Table 4. The Position Angle data provided by the USNO only varied in the tenths place. The same could be said about our measurements. Our measurements aligned with those from the historical data and showed no significant change between the years 1880.49 and our most recent data collection. The Separation Distance shows a similar trend. The only fluctuations between the numbers lie within the tenths place of the measurements, and was therefore, not considered a large enough change to suggest any linear or exponential movement. Our measurements in 2018 were consistent with the historical trend and it could suggest that the AB pair is a Common Proper Motion (CPM) pair.

The BC component of R 230 showed similar results. Although the Position Angle differs from the originating measurement in 1880.49, it is consistent with the remaining three observations since that epoch. The only difference between the measurements was found, again, in the tenths place of our measurements. Considering there is no pattern to these decimals, they are not definitive enough to suggest change in either the separation distance or position angle.

Similar to the AB pair, the historical measurements were plotted for the BC pair, Figure 2, using Harshaw's Excel tool. Further, using the tools within Excel, we were able to plot the graph of the linear path demonstrated by the BC component. The few historical data plots follow closely on this line indicating a possible optical double star or the C component is optically placed.

While analyzing our image, a smaller star was brought to our attention, Figure 3, to the right of the A

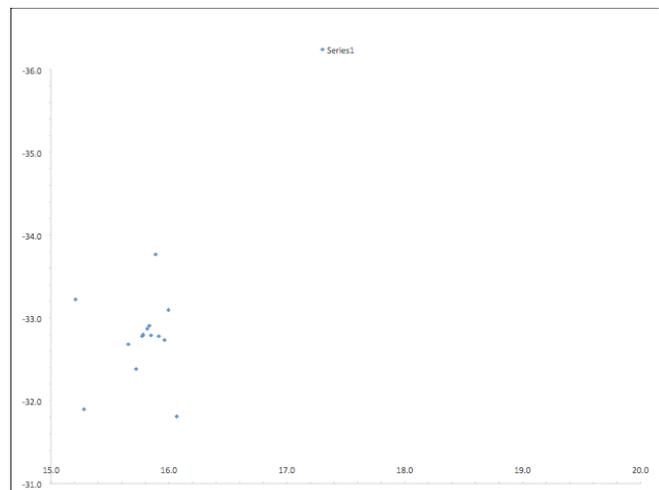


Figure 1. Graph of Historical Data of R230 AB

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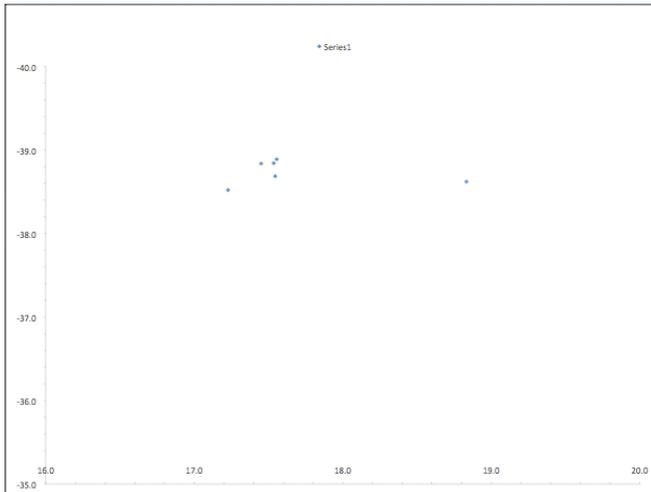


Figure 2. Graph of Historical Data of R 230 BC with data from 2018 measurements

component. This star could potentially be a D component to this system, yet requires more investigation and further discussion that is beyond the scope of this paper.

Conclusion

The analyzed measurements from the historical data acquired from the Washington Double Star Catalog showed no substantial changes to the theta and rho in the AB pair, suggesting a possibility that these stars may be a CPM system. The slight calculation changes in the tenths place of the measurements are most likely due to slight differences in measurements and is not a reliable difference to make predictions upon. For the BC pair, the C component shows a linear trend path where future observations will be beneficial to confirm our suggestion.

Acknowledgements

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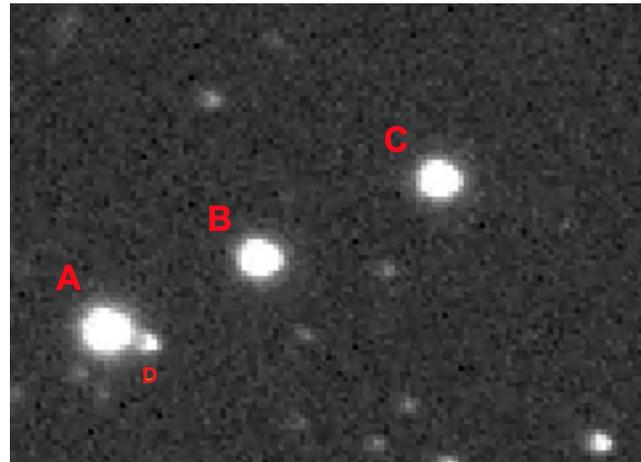


Figure 3. R 230 – All components including a possible D star.

Harshaw for his plotting tool.

References

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Francesca D'Amico is a sophomore at San Diego High School. She has been interested in astronomy since she was 12 and wants to study astrophysics when she goes to college. Cassidy Sullivan is also a sophomore at San Diego High School with similar desires to pursue theoretical astrophysics in college.