Astrometric Measurement of Double-Star System 03074+1753 HJL 1020

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Abstract: The separation and position angle between the A and B stars in the system HJL 1020 were observed using the iTelescope network. The angle and distance between the components were then measured and reported. For telescope T3, we measured Rho (ρ) of 105.75" ± 0.92" Standard Error of the Mean (SEM) and Theta (θ) of 359.19° ± 0.4° (SEM). For telescope T18, we measured ρ of 105.28" ± 0.36" (SEM) and θ of 359.13° ± 0.21° (SEM). Combined with the historical measurements, our measurements suggest the distance between the A and B stars decreasing from 1896 to 2016. The plot of the data suggests an optical double due to a lack of Keplerian motion after 120 years.

Introduction

The purpose of this paper was to select, observe, and measure a double star system from the Washington Double Star Catalog (WDS). The current separation and position angle between the two stars in the system HJL 1020 were measured and a new data point was added to the historical plot.

Selection of a binary star system from the Washington Double Star Catalog (Mason et al, 2015) followed specific criteria: a magnitude difference of 3 or more with the lowest magnitude being 11 or higher, a separation distance greater than 5.5 arc-seconds, a positive Declination and a Right Ascension of 01 to 08 hours. HJL 1020 matched these criteria.

HJL 1020 is in the constellation of Aries and its primary star is also known as 53Arietis. 53Arietis was once catalogued as a beta type Cepheid variable, but its variability was ruled out from an examination of seven years of photographic plates, a collection of new spectroscopic plates, and spectroscopic plates from 1956 (Sterken 1988). The B star is thought to be a part of a spectroscopic binary pair. This spectroscopic pair is thought to be orbiting the A star (Halbwachs, 2012).

The difference in magnitude between the primary and secondary star is 4.3, with the primary magnitude being 6.1 in the V band and the secondary magnitude being 10.42 in the V band as well, according to the SIMBAD Astronomical Database, which provides basic data, cross-identifications, bibliography and measurements for astronomical objects outside the solar system.

The first separation measurement of 109.3" was in 1896 and the last separation measurement of 104.2" was in 2014. There were 10 observations over 118 years. After receiving the historical data from the WDS catalog, the separation between the A star and B star over the 118 years was plotted and the data shows the distance between these stars decreasing.

The European Space Agency's Hipparcos Space Astrometry Mission gathered precision position data for 100,000 stars. We accessed the Hipparcos parallax data for HJL 1020 through the VizieR catalogue database (VizieR). According to the data for HJL 1020, the primary star has a parallax of 3.92 mill-arc-sec with an error of 0.79 milli-arc-sec giving a midpoint distance of 831.6 light years (Table 1). This table shows the distance in parsecs and light years.

3074+1753	Parallax		Parallax	Distance	Distance
Inputs	millisec of arc	Error	sec of arc	Parsecs	Light years
Star A	3.92	0.79	0.00392	255.1	831.6
Star B	not recorded	N/A	N/A	N/A	N/A

Table 1. Distance to star based on Hipparcos data

Materials and Methods

For centroid measurements with sub-pixel accuracy, telescopes with better than 1 to 2 arc-sec/pixel resolutions were sought. The telescope T18 (Figure 1) in Spain with a resolution of 0.73 arc-secs/pixel and the telescope T3 (Figure 2) in New Mexico with a resolution of 1.02 arc-secs/pixel were chosen. A Red filter with exposure lengths of 60 and 120 seconds and a Luminance filter for 60 and 90 seconds were chosen for the T18 telescope. T3 is a One-Shot Color system and exposures of 60, 90 and 120 seconds were used for a total of 10 measurements.

MaximDL was used to insert World Coordinate system (WCS) positions into the FITS headers by comparison to approximately 150 stars in the Fourth U.S. Naval Observatory CCD Astrograph Catalogue (UCAC4); and Mirametrics Mira Pro x64 software was used for measuring the stars Theta (angle) and Rho (distance). Microsoft Excel was used to calculate statistics and plot results along with the historical data.

Optical Design: Corrected Dall-Kirkham Astrograph
Aperture: 318mm
Focal Length: 2541mm
F/Ratio: f/7.9
Mount: Paramount PME
Instrument Package
CCD: SBIG STXL-6303E
Non Anti-Blooming Gate (NABG)
Resolution: 0.73 arc-secs/pixel
Array: 3072 by 2048 (6.3 Mega pixels)
FOV: 37.41 x 24.94 arc-mins
Observatory: Nerpio, Spain

Figure 1. T18 in Spain

Optical Design: Apochromatic Refractor
Aperture: 150mm
Focal Length: 1095mm
F/Ratio: f/7.3
Mount: Paramount GTS
Instrument Package
CCD: SBIG ST-4000XCM One Shot Color CCD
Resolution: 1.45 arc-secs/pixel
Array: 2048 by 2048 (8.3 Mega pixels)
FOV: 49.6 x 49.6 arc-mins
Observatory: Mayhill, New Mexico

Figure 2. T3 in New Mexico

Data

Figure 3 shows an example of an image of the XY pair that was used for measuring the Theta and Rho in HJL 1020. The historical data along with the newly measured data are shown in Table 2. This data was plotted in Figure 4 to get a better idea of the motion of the stars in relation to each other.

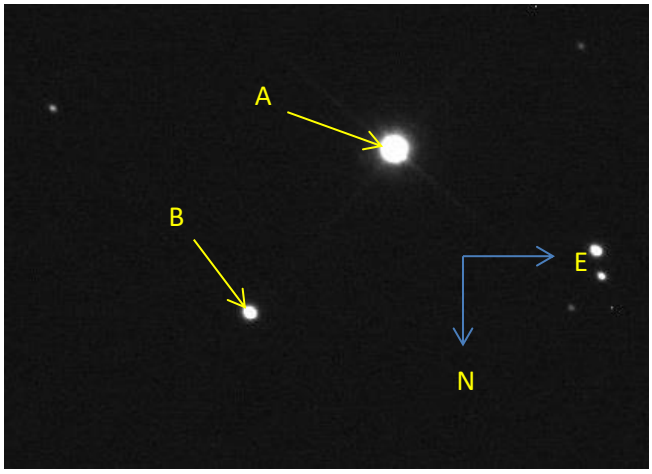

Figure 3. Example image of HJL 1020 cropped to show the target pair from the T18 telescope

Epoch	Position Angle	Separation
1896.94	357.5	109.29
1897.91	357.4	109.2
1929.33	357.7	108.31
1950	357	107
1959.42	357.6	107.11
1991.8	358.6	105.92
1999.75	358.9	105.57
2000.894	358.8	105.01
2010.558	359	105.29
2014.008	358.8	104.2
2016.813	359.15	105.42

Table 2. Historical data with new data from 2016

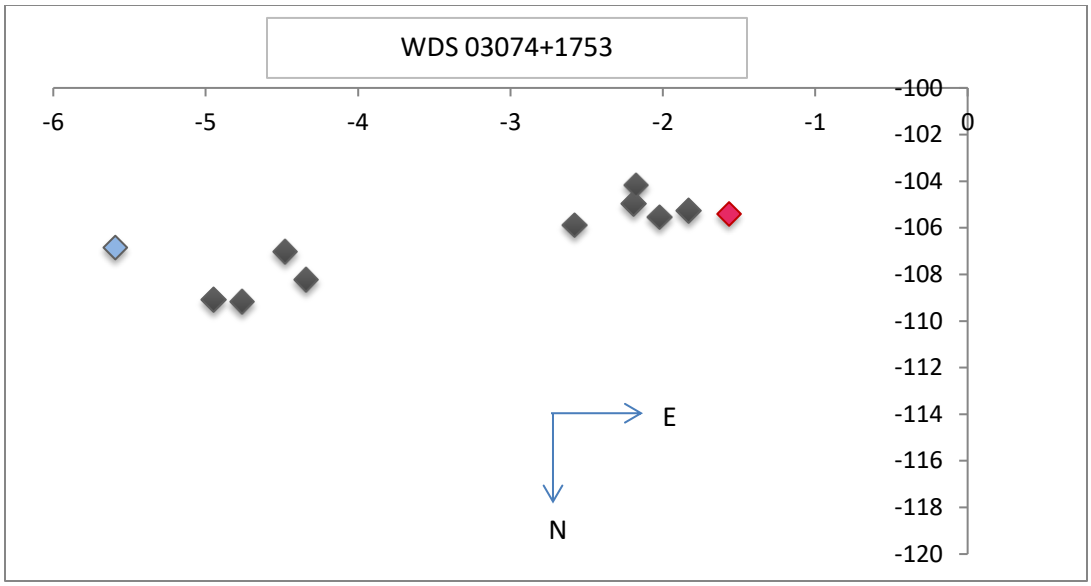

Figure 4. XY plot of AB pair historical position with new position data shown with a pink diamond. First data point (1896) shown with a light blue diamond.

Table 3 reports the newly calculated position angles and separations along with the uncertainties in each for the sets of images of each telescope. We measured a mean position angle of 359.19° ± 0.133° and a mean angular separation of 105.75" ± 0.307" for T3. We measured a mean position angle of 359.13° ± 0.03° and a mean angular separation of 105.28" ± 0.05" for T18. The most recent historical data is reported as a comparison.

WDS 03074+1753			
Telescope: (number of images used in each filter)		**θ (degrees)**	**ρ (arcseconds)**
T03: (3 Color)	Mean	359.19	105.75
	Standard deviation	0.4	0.92
	Std. error of mean	0.133	0.307
T18: (4 R), (3 luminance)	Mean	359.13	105.28
	Standard deviation	0.21	0.36
10 images total	Std. error of mean	0.03	0.05
2014.01 measurement (Last one previous to this investigation)		358.8	104.2

Table 3. Summary of final data with standard deviations and standard error of the mean.

Discussion

The observed data shows a continuation of the historical trend which appears to suggest rectilinear motion of the B star relative to the A star. A determination cannot yet be made as to whether this is due to an orbit that is an elongated ellipse whose orbital motion is not yet apparent or to the fact that the two stars are unrelated and are changing their relative positions by reason of the difference in their proper motions.

Conclusion

We obtained astronomic measurements of position angle and separation in 2016.8 of the double star system HJL 1020 using the T3 and T18 telescopes of the iTelescope network. Our astrometric data shows the distance between the component stars is decreasing. The absence of obvious Keplerian motion after 120 years suggests an optical double. The question of whether or not this is a common proper motion pair or physical binary with a very long period and highly elliptical orbit could be answered if the distance to the secondary star was obtained.

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