Investigation of BPM 751 has uncovered a potential third star in the system (BPM 751C)

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Abstract: The purpose of this study was to determine the orbital pattern of the star system BPM 751. The stars BPM 751A and BPM 751C were measured, with the objective of determining whether the two stars are an unrecorded binary star system using current data from the Las Cumbres Observatory (LCOGT) in 2020 and historical data from the Digital Access to a Sky Century (DASCH) project at Harvard University (DASCH, 2020). A significant technique used in this research was the use of scanned plate data dating from 1911 to 1950, adding 27 newly discovered data points to the research project. The measurements taken in 2020 showed an average separation of 30.45″. The average PA was 295.32°. These results showed a change in PA and separation that suggest a possible orbit, which strongly suggests that BPM 751AC are a possible binary system. The parallax data, which showed the two stars were a similar distance from earth supported this statement. However, there are large differences in the proper motion data. This means that the two stars could also be an optical double as opposed to a binary pair. The data points toward BPM751AC being a binary system.

Introduction

BPM 751 system (Figure 1), at right ascension 18h 15m 49.56s and declination 15° 16' 05.0″, was originally discovered in the Bordeaux Proper Motion Project in 1995 (Ducourant, et al., 2006). A potentially related star in the system was discovered, labelled BPM 751C. Astrometric Observations were made using LCOGT and additional historical photographic plate records from 1911 from Harvard University (DASCH, 2020). These plates were digitally scanned and converted into FITS files, the PA and Separation were measured to gather historical data about the system. Results were plotted on a graph to analyse and therefore determine whether the pair had undergone any changes in regard to its position angle and separation over the period of study (1911-2020) that indicated an orbital pattern. As the chosen pair has not been formally recorded within the Washington Double Star (WDS) catalogue, it has been assigned the name BPM 751C. BPM 751B in the same system was the original target of study, however BPM 751B could not be recorded reliably on images taken by the LCOGT due to the delta magnitude of 2.8 between it and BPM 751A. It was then noted that the star, referred to as BPM 751C, had changed its position angle and separation in regard to BPM 751A over the study period, and was therefore chosen as the system to research as a possible binary.

This study was undertaken as part of an InStAR Astronomy Research Seminar. This seminar provides students with practical experience in astronomical research and gives them an understanding of the nature of scientific research.

Figure 1 shows the system being studied (BPM751) with the two targets in yellow.

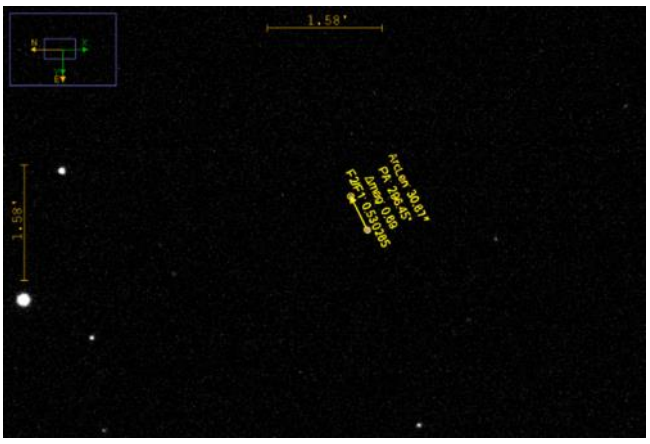

Figure 1. BPM751 system with BPM751A&C highlighted taken with a 0.4m telescope located in Teide Observatory, Tenerife, Spain operated by the LCOGT.

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Equipment and Procedures

Equipment:

BPM751 was imaged using a SBIG STL-6303 CCD camera with a 0.4m telescope located in Teide Observatory, Tenerife, Spain, and a Meade 16-inch (40cm) RCS tube and 3-element optics, mounted in LCOGT equatorial C-ring mounting of the LCOGT network.

Photographic plate data was retrieved from Harvard University of the BPM 751 system through the Digital Access to a Sky Century @ Harvard (DASCH). This program used a collection of digitised astronomical plates, gathered over the span of 100 years and dating back as far as 1911. Telescope used: Metcalf Refractor 0.4m Telescope (DASCH, 2020)

Procedures:

Observation requests were submitted to the LCOGT for images of the star system, specifically the identified binary pair BPM 751AB. These photographs were taken on the 1st, 2nd, and 3rd of October, and on the Besselian Date 2020.75. The data was automatically reduced by the LCOGT and provided with plate solving, and then imported as FITS files into AstroImageJ. The aim was to observe the position angle and separation of BPM 751AB. However, it was found that they could not be accurately measured due to the high magnitude difference between BPM 751 A and B. After some analysis of the data, a second possible binary pair BPM 751AC was found, and measurements of the position angle and separation of those two stars was completed using AstroImageJ. Additionally, historical plate data was requested from the DASCH program. These plates were converted into FITS files and measured with AstroImageJ. These two sets of results allowed observations to be made about the possible binary system BPM 751AC.

Results

Thirty nine data sets and measurements were gathered from the chosen system. These included the historical data from the years 1911, 1912, 1913, 1914, 1916, 1950 and 2020.

Table 1 summarizes the results of PA and Sep over the past 109 years. These years were selected because they show the most significant changes in the data over the 109-year research period.

Year	Theta	Rho	New Theta	Made By	Type
1911.55	289.22	26.73	289.22186	EC_2020	P
1911.63	289.41	27.03	289.41186	EC_2020	P
1911.63	289.41	27.03	289.41186	EC_2020	P
1912.38	290.1	26.62	290.10186	EC_2020	P
1912.38	290.64	26.62	290.64186	EC_2020	P
1912.44	289.27	26.72	289.27186	EC_2020	P
1912.44	289.27	26.72	289.27186	EC_2020	P
1912.51	290.24	26.2	290.24186	EC_2020	P
1912.51	290.24	26.2	290.24186	EC_2020	P
1913.35	290.9	26.31	290.90186	EC_2020	P
1913.41	290.46	26.51	290.46186	EC_2020	P
1913.58	290.73	26.6	290.73186	EC_2020	P
1913.60	289.4	26.24	289.40186	EC_2020	P
1914.33	289.74	26.87	289.74186	EC_2020	P
1914.38	290.56	26.98	290.56186	EC_2020	P
1914.41	291	26.59	291.00186	EC_2020	P
1914.46	289.11	27.91	289.11186	EC_2020	P
1914.48	290.77	27.07	290.77186	EC_2020	P
1914.48	291.28	26.26	291.28186	EC_2020	P
1914.53	290.73	26.8	290.73186	EC_2020	P
1914.72	291.71	27.09	291.71186	EC_2020	P
1916.42	290.25	26.43	290.25186	EC_2020	P
1950.39	291.7	27.49	291.70186	EC_2020	P
1950.46	292.05	27.04	292.05186	EC_2020	P
1950.47	291.48	27.82	291.48186	EC_2020	P
1950.56	290.64	27.91	290.64186	EC_2020	P
1950.56	293.2	27.42	293.20186	EC_2020	P
2020.86	296.45	30.27	296.45186	EC_2020	C
2020.86	296.45	30.83	296.45186	EC_2020	C
2020.86	296.62	30.17	296.62186	EC_2020	C
2020.86	294.95	30.67	294.95186	EC_2020	C
2020.86	294.97	30.67	294.97186	EC_2020	C
2020.86	295.18	30.67	295.18186	EC_2020	C
2020.86	295.19	30.02	295.19186	EC_2020	C
2020.86	294.06	29.9	294.06186	EC_2020	C
2020.86	295.04	31.37	295.04186	EC_2020	C
2020.86	294.95	30.63	294.95186	EC_2020	C
2020.86	294.79	30.01	294.79186	EC_2020	C
2020.86	295.13	30.2	295.13186	EC_2020	C
2020.86	295.315	30.4508333	295.31686	EC_2020	C

Table 2: A complete set of all data gathered from the LCOGT and Harvard plate data used in Figure 2.

Year of Observation	Position Angle (°)	Standard Deviation (°)	Separation(″)	Standard Deviation(″)
Average 1911.61	289.34	0.11	26.93	0.17
Average 1950.49	292.20	0.93	27.53	0.35
Average 2020.86	295.32	0.75	30.45	0.42

Table 1: The mean and standard deviation for the PA and separation for 1911, 1950 and 2020. These years were chosen because they show the large changes in the recorded data across 109 years.

Table 2 shows the Rho (separation) and Theta (PA) values that were recorded from the plates from 1911 to 1950, as well as the present day values that were recorded in 2020.

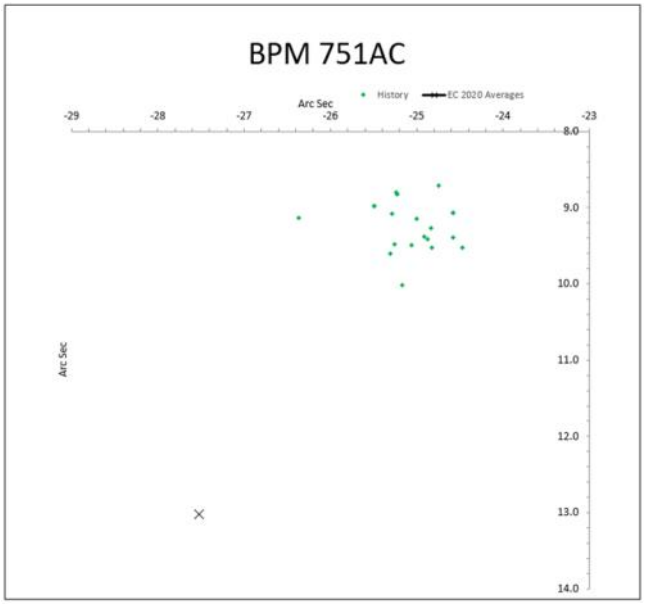

Figure 2. A graph of the PA versus separation for an average of the 12 current data points (Black X) and historical recorded data (green diamonds).

values should therefore not be taken as definitive statements and do not make any conclusions about the nature of the pair. The proper motion data showed a significant difference in the movement of the two stars. BPM 751A had a proper motion in right ascension (PMRA) of 18.45 mas, while BPM 751C had a PMRA of -2.16 mas. BPM751A had a proper motion in declination (PMDEC) of -35.12 mas, and BPM751C had a PMDEC of -0.19 mas. This significant difference in the predicted motion of the two stars possibly indicates that they may not be binary. However, the star's motion in general, particularly from the recorded PA and separation results may suggest a possible association between the two stars shown in Figure 2. To confirm this, more data should be collected over a longer period.

During the research period, observations of BPM 751B were attempted, however the results that were recorded were highly uncertain due to the star's high magnitude difference with respect to A. The star was too dim to be recorded with certainty and in the future, a larger telescope should be used with longer exposures or speckle interferometry Measurements of BPM751A,C indicated a changing magnitude difference between the two stars over the 109-year period of study. A cross reference with the American Association of Variable Star Observers (AAVSO) chart database (Figure 3) confirms that the star in this study has been identified as BPM751A, and is listed as a variable star with no designation in the AAVSO catalogue.

Figure 3 is a finder chart for BPM 751A,C; showing BPM 751A's classification as a variable star with no designation.

	Proper Motion RA (mas/yr)	Proper Motion RA Error (mas/yr)	Proper Motion Dec (mas/yr)	Proper Motion Dec Error (mas/yr)	Parallax (mas)	Parallax Error (mas)
BPM 751 A	18.452	0.07	-35.12	0.81	1.56	0.04
BPM 751 C	-2.16	0.07	-0.16	0.08	1.18	0.04

Table 3: Shows the current parallax and proper motion data for the pair of stars.

Discussion

The PA of BPM 751AC changed by 5.68° and the separation increased by 3.71″ over the course of 109 years. The data first recorded in 1911 recorded a PA of 289.22° and a separation of 26.7″. In 1950, the PA of the two stars had changed by 1.83° to 291.05° and the separation changed by 1.12″ to 27.82″. Currently, in 2020.86, the PA is at 294.90° and the separation at 30.41″ representing a change of 5.68° and 3.71″ from 1911 respectively. The parallax of BPM 751A was 1.56mas, while the parallax of BPM 751C was measured at 1.18mas. As the parallax is under 5mas, these

Conclusion

The results of this survey are predominantly inconclusive. The PA of the two stars changed by 5.68° and the separation increased by 3.71″ over the course of 109 years. These results indicate the probable discovery of a previously unobserved binary star system. However, the proper motion data indicates that there are large differences in the movement patterns of the two stars, decreasing the possibility of BPM751A,C being a binary pair. In the future, it would be useful to conduct similar observations and measurements of the star system to further determine whether there is a viable orbital

pattern, and therefore, classify it as a binary star system.

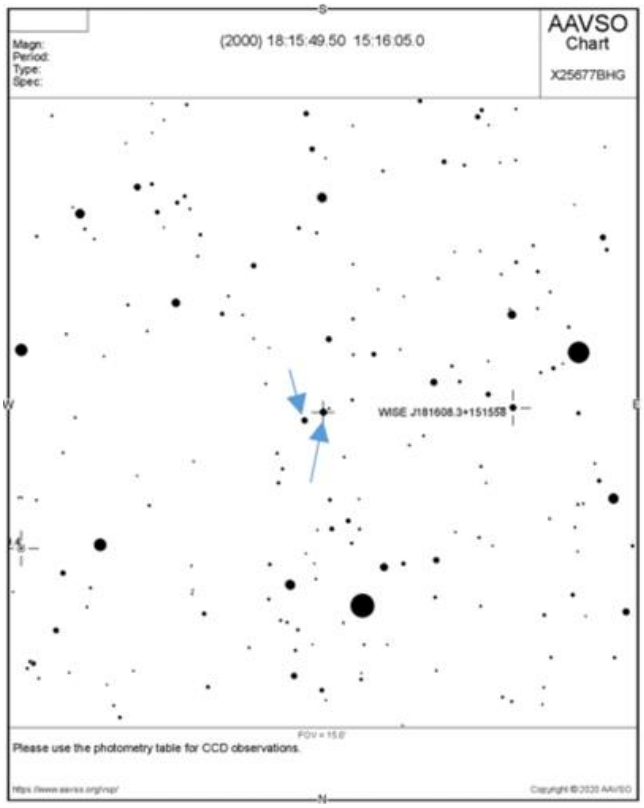

Figure 3. A finder chart for BPM751A,C. (courtesy AAVSO). The pair of blue arrows point toward the two stars BPM751AC.

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