Analysis of an Unmeasured Component of WDS 12290+3735 KZA 36

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Abstract: Our recent observations of the system WDS 12290+3735 KZA 36 identified the presence of a previously unmeasured component. Historical images from the Palomar Observatory Sky Survey and the Two Micron all Sky Survey images show this component merged with the primary star. A new image acquired shows this component separated from the primary star. Analysis of Gaia proper motions also show similar directional movement of this component and the primary star, however the Gaia parallaxes indicate the distance between the two stars exceeds 31 parsecs.

Introduction

The multiple star system WDS 12290+3735 KZA 36 is listed in the Washington Double Star Catalog with 3 components, A, B and C. Author Nugent measured this system in April 2019 (Nugent and Iverson 2020) and he noticed a previously unreported component faintly visible several arc-seconds from the primary star A. We propose the identifier "D" for this previously unmeasured component. We decided not to publish the position angle and separation for the AD pair in our 2020 paper pending further analysis.

Methodology

Examining old astronomical plates can often be a very useful source of historical double star information. Archive images from the Palomar Observatory Sky Survey (POSS-II) and the Two Micron All Sky Survey (2MASS) are shown in Figure 1. Compared to the round images of the B and C components, the A component has an oval, non-spherical shape. This oval shape is most noticeable in the 2MASS image. Images of merged stars are frequently seen in both the POSS-II and 2MASS survey plates. In the case of KZA 36, saturation from the brighter primary star in Figure 1 makes it appear joined with the D component. The European Space Agency's (ESA) Global Astrometric Interferometer for Astrophysics (Gaia) satellite lists the magnitude of the proposed D component at +13.54 and the primary star A at +9.22. The KZA 36 system is shown as Figure 2 at the epoch 2020.49.

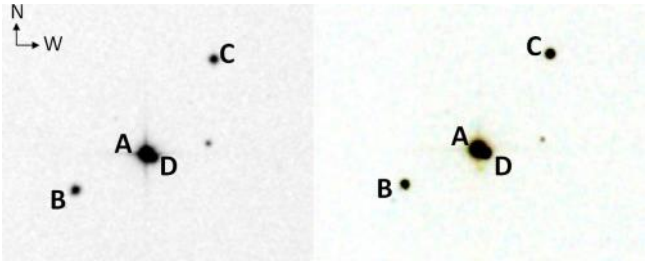

Figure 1. Left: POSS-II IR image, 15 April 1998. Right: 2MASS image, 2001.

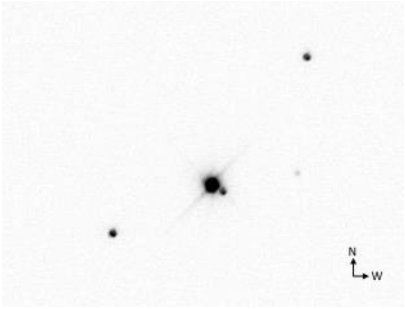

Figure 2. KZA 36, CCD image courtesy Dr. Allen Gilchrist. Image acquired 26 June 2020

Results and Discussion

New observations of the KZA 36 system were made using a 14-inch telescope with a plate scale of 0.2"/pixel. Our measurement of the AD pair for the epoch 2020.49 is PA = 237.7° and separation = 5.9" (see Table 1).

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	PA (°)	PA SEM	Sep (″)	Sep SEM	Date	Mag A	Mag D
WDS 12290+3735 AD	237.7	0.94	5.9	0.08	2020.49	9.22	13.54

Table 1: Position angle and separation for AD component.

If the A and D components of KZA 36 comprise a true binary system, the proper motions and distances of the stars should be similar. With the recent release of the Gaia satellite data archive, the most accurate proper motions and distances are now available. For KZA 36 A, B, C and our proposed D component we used the Aladin Sky Atlas program to overlay the Gaia proper motions on the POSS-II 1998 image. Figure 3 shows the A and D components have similar proper motions in both direction and magnitude. Gaia's proper motion error estimates for the A and D components are 4% and 9% respectively. Based on proper motion data alone it appears that the AD pair characterize a true binary system.

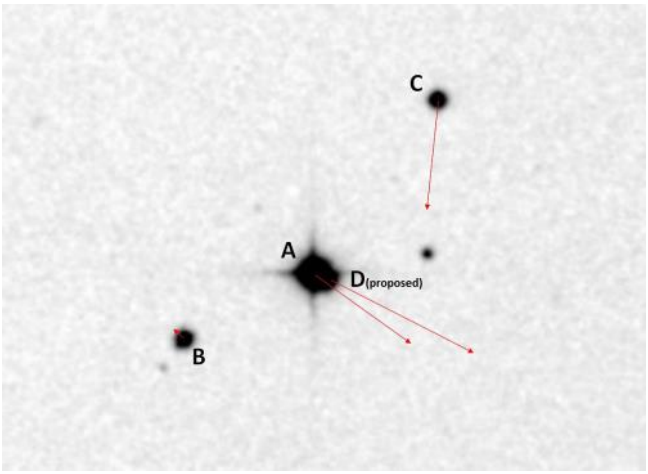

Figure 3. Gaia proper motions overlaid on the KZA 36 components. POSS-II image from 15 April 1998.

Using Gaia parallax data, we derived the distances between the components A and D. From Figure 4 we know their individual distances from Earth (sides a and b of the triangle). Using our measurement for the separation angle θ between the A and D components, we applied the law of cosines to solve for the distance between A and D (side c):

$$c = \sqrt{a^2 + b^2 - 2ab\cos\theta}$$

The AD distance is 43 ±12 parsecs. This large error is due to the D component's 12% parallax error. The Gaia parallaxes and resulting distances of the components are shown in Table 2. The obvious question is why the WDS measurements from 1928 – 2015 (10 published records) did not include the D component? Was the D component behind or in front of the A component until recently? Did the large magnitude difference (Δm = 4.4) discourage observers from measuring the D component or was it simply too faint to be visible?

We combined the Gaia proper motions of both the A

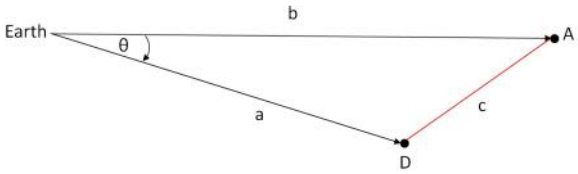

Figure 4. Law of cosines calculation for the distance between the AD components.

and D components to determine relative movement between the two stars. The net result shows that the D component is moving westward away from the A component by 0.011"/yr. This corresponds to 1.1 AU's per year at its distance. In 1928 when this system was first measured, the calculated AD separation was 4.9" and in 1956 when the first POSS images were exposed, the calculated AD separation was 5.2". The Gaia radial velocities of A and D are -3.8 and -3.5 km/sec respectively. This corresponds to their actual motion toward Earth of 0.8 AU's /yr. Both the A and D component's net motion away from each other and toward Earth is insignificant.

Thus, we conclude that the A and D components of KZA 36 form an optical alignment and not a physical binary pair. With the large distances between the AB (518 ± 22 pc) and AC (156 ± 4pc) components, both of these pairs also represent unrelated stars. Figure 5 shows a distance diagram for the KZA 36 system.

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RA	DEC	Component	Mag	Parallax (mas)	Parallax Error (mas)	Distance (parsecs)	Distance Error (parsecs)
$12^h\ 28^m\ 57.4^s$	+37° 35′ 41.0″	A	9.22	6.898	0.042	145	1
$12^h\ 28^m\ 01.8^s$	+37° 35′ 16.4″	B	12.68	1.507	0.048	663	21
$12^h\ 28^m\ 53.2^s$	+37° 36′ 47.9″	C	12.87	3.323	0.039	301	3
$12^h\ 28^m\ 57.0^s$	+37° 35′ 38.0″	D	13.54	9.778	1.150	102	12

Table 2: Gaia Position, magnitudes, parallaxes and distances of KZA 36 A,B,C components plus new D component.

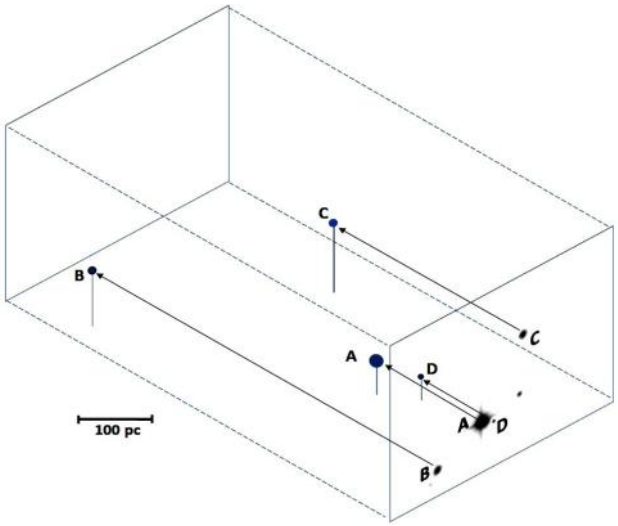

Figure 5. Projection of Gaia distances for the KZA 36 components. The proposed component D is just a chance optical alignment with A component. The unlabeled star below component C (Gaia mag = +15.5) is UCAC4 638-047996. Its Gaia distance is 1392 ± 83 pc.

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References

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