Analysis of WDS 17033+5935 STF 2128 Using GAIA DR3 Data and a Current Astrometric Measure. Confirmatory Evidence for Binary Star System

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Abstract

WDS 17033+5935 STF 2128 has an orbit in the Sixth Catalog of Orbits of Visual Binary Stars. The nature of STF 2128 was analysed using GAIA DR3 data and a current astrometric measure. STF 2128 was imaged using the Las Cumbres Observatory (LCO) Global Network of Telescopes. Calibrated images were obtained and analysed using the software AstroImageJ to determine separation, position angle and delta magnitude. Using GAIA DR3 data and apparent separation reported in this paper, minimum, mean and maximum physical distance separation was estimated. In addition, the angle between each of the components space velocity vectors in 3-dimensional space (Nugent metric), binding energy (E_{binding}), system escape velocity and relative 3-dimensional space velocity were calculated. Analysis shows that STF 2128 exhibits features of a binary star system.

1. Introduction

STF 2128 has an orbit in the Sixth Catalog of Orbits of Visual Binary Stars, Figure 1 (Izmailov 2019, Matson et al, 2026). The apparent orbit shows a short arc of data. The orbital period is estimated to be 2,294.5 years. Two recent studies of STF 2128 provide astrometric and orbital motion evidence of a binary star system (Blanco et al, 2018; Minarik et al, 2018)). The nature of STF 2128 was further analysed using GAIA DR3 data and a current astrometric measure.

STF 2128 AB was first measured in 1830.34 when the position angle was 57.5° and the separation was 11.57″ (Struve 1837). The last measure was in 2019.449 when the position angle was 42.462° and the separation was 12.1775″ (Izmailov 2020). The spectral types of the primary and secondary are K5 and M0 respectively (WDS Catalog notes).

Selected GAIA DR3 data for STF 2128 is shown in Table 1 (Prusti et. al. 2016; Vallenari et. al. 2023). The Renormalised Unit Weight Error (RUWE) for the primary is 1.016 and 1.010 for the secondary consistent with good single star models.

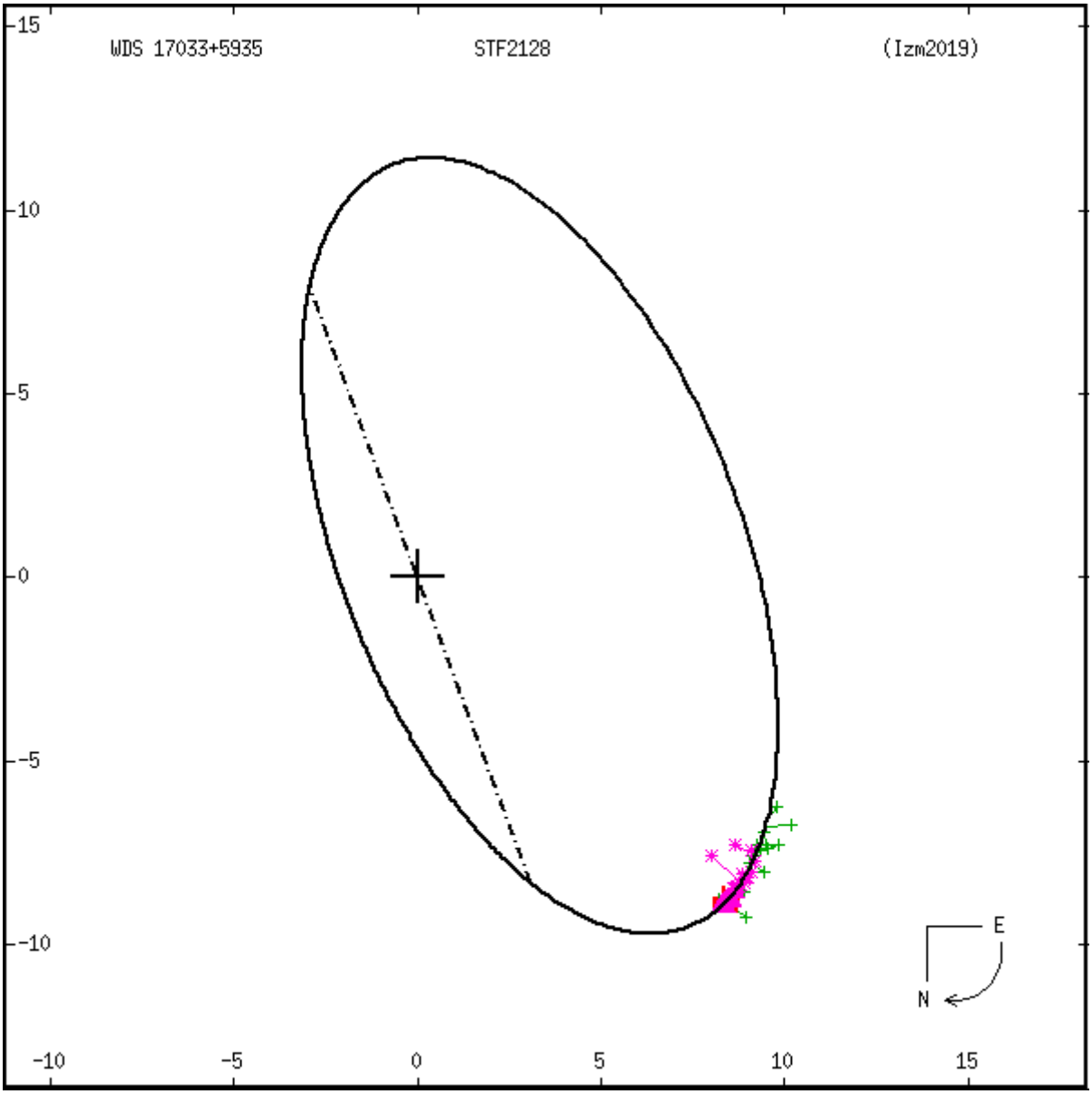

Figure 1: Apparent orbit of STF 2128 from the Sixth Catalog of Orbits of Visual Binary Stars (Izmailov 2019)

Table 1: Selected data on STF 2128 from GAIA DR3. Stellar luminosity value for the A component comes from GAIA DR3 FLAME and GAIA DR2 for the B component.

WDS Identifier 17033+5935 STF 2128	**Parallax ± 1σ mas**	**Total proper motion mas/yr**	**pmra ± 1σ mas/yr**	**pmdec ± 1σ mas/yr**	**Radial velocity ± 1σ km/sec**	**Luminosity SolLum**
A Component Gaia source id: 1437124683199761920	39.9765 ± 0.0150	428.602	-355.189 ± 0.020	239.877 ± 0.019	-71.84 ± 0.13	0.258
B Component Gaia source id: 1437124683199762304	39.9955 ± 0.0122	441.626	-364.087 ± 0.015	249.949 ± 0.017	-70.85 ± 0.152	0.101 (GAIA DR2)

The distance from the Sun to the primary and secondary of STF 2128 with 1σ parallax uncertainties are shown in Figure 2. The distances from the Sun to the primary and secondary show overlap.

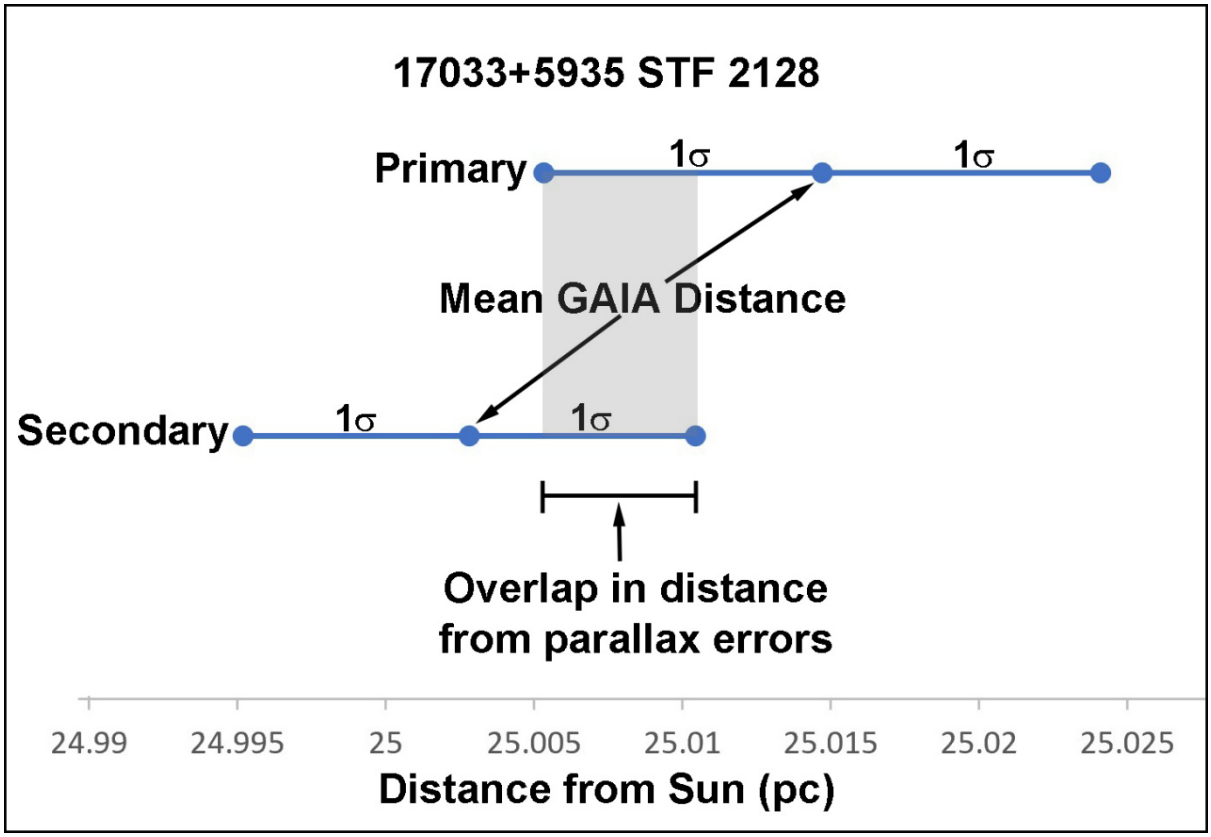

Figure 2: GAIA DR3 distances of the components of STF 2128 from the Sun including 1σ parallax errors

2. Methods

Using the Las Cumbres Observatory Global Network of Telescopes, STF 2128 was imaged on June 17, 2026 (Decimal Date: 2026.459; JD UTC: 2461208.514) at the LCOGT node at Tenerife with a Planewave Delta Rho 350 telescope and QHY600 CMOS camera system. The camera format was 9576 x 6388 pixels, 3.76 micron pixels size. Field of view 1.9 degrees x 1.2 degrees readout mode full-frame, 30'x30' in readout mode central30x30. Pixel size (1x1 binning, arcsec) ~0.74"/pixel, default binning 1 x 1, read noise (e-) ~ 3 to 3.5 e- and gain (e-/ADU) 0.7 e-/ADU.

Twenty images were taken. The images were recorded through a Bessel-V Filter and the exposure time for each image was 4.1 seconds. The air mass was 1.2. The calibrated images were individually inspected for quality and all were subsequently chosen for analysis. The images were analysed using AstroImageJ with apertures set at 7 pixels (object aperture), 10 pixels (inner radius of background annulus) and 12 pixels (outer radius of background annulus), Figure 3. and mean value, standard deviation and standard error of the mean determined for theta, rho and delta magnitude, Table 2.

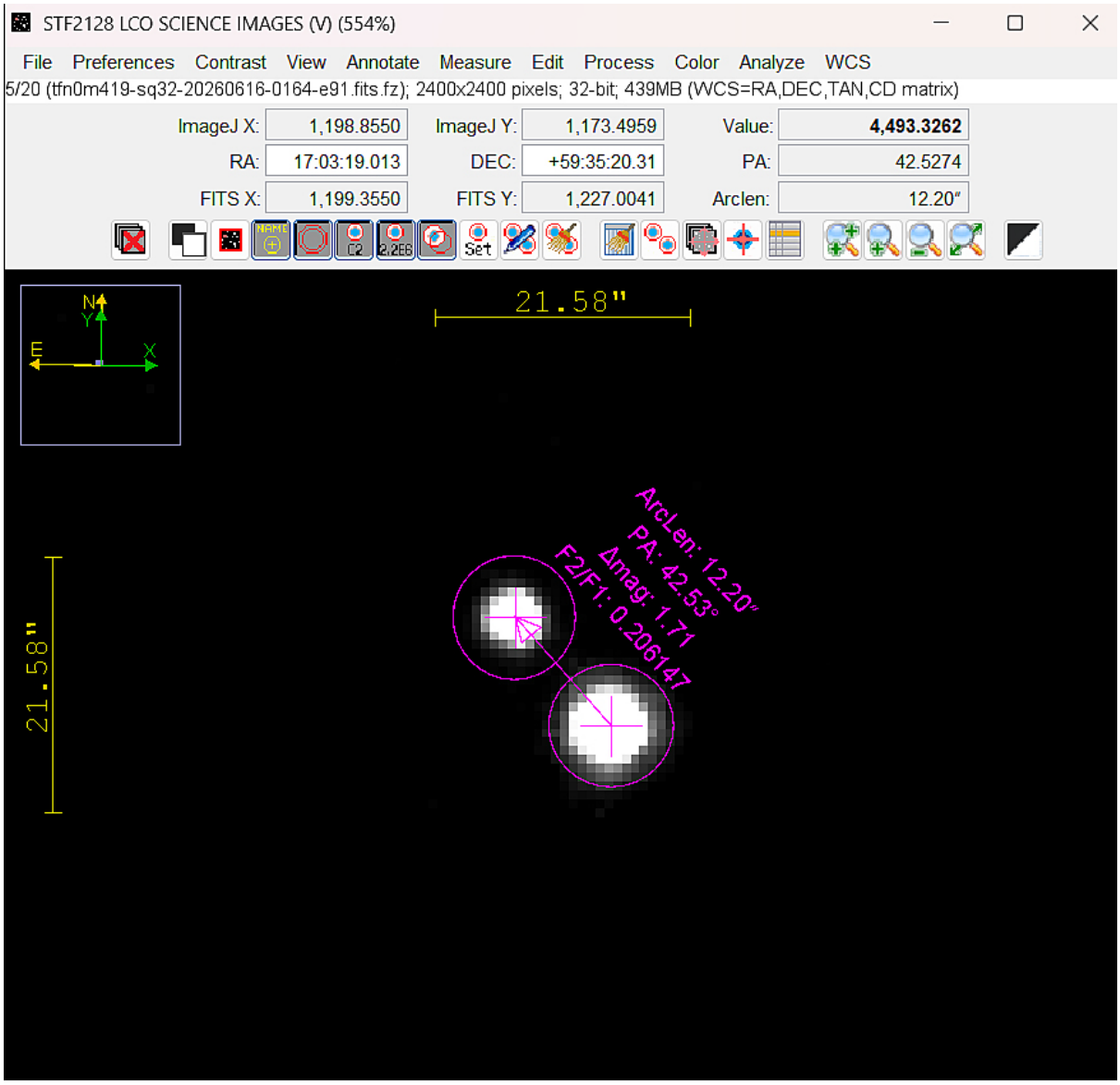

Figure 3: A representative image of STF 2128 analysed using AstroImageJ showing separation, position angle and delta magnitude

To calculate D, the mean physical separation distance of the components in pc, the cosine rule was used:

$$D = \sqrt{[D_A^2 + D_B^2 - 2D_A D_B \cos(\rho/3{,}600)]} \quad (1)$$

Where D is the mean separation distance of the two stars in pc; D_A is the mean distance from the Sun to the primary in pc, obtained from parallax measures; D_B is the mean distance from the Sun to the secondary in pc, and ρ is apparent separation in arcseconds (″) reported in this paper, Table 3.

The minimum and maximum distance separation with 1σ uncertainty was calculated using the data in Table 1, measure of apparent separation reported in this paper and Equation (1), Table 3.

The angle between each of the components space velocity vectors in 3-dimensions (Nugent metric) was calculated using the method of Nugent (Nugent, 2025), Table 3. Angles < 15° are designated as Common Space Motion pairs, values > 15° and < 30° are designated as Similar Space Motion pairs and values > 30° are designated as Different Space Motion pairs.

The space velocity of the A component and space velocity of the B component were calculated using the method of Nugent (Nugent, 2025). The relative 3-dimensional space velocity and system escape velocity were calculated using the method of Bonifacio (Bonifacio et al, 2020), Table 3.

Binding energy *($E_{binding}$)*, was calculated using the following formula (Letchford et al, 2022).

$$E_{binding} = \frac{1}{2}\left(\frac{m_A m_B}{m_A + m_B}\right) v^2 - \frac{G m_A m_B}{D} \quad (2)$$

Where, $E_{binding}$ is in $M_\odot(km\ s^{-1})^2$; m_A and m_B are the masses of the primary and secondary in solar masses ($M_\odot$); v is the galactic space speed difference between the two stars in km s^{-1}; D is their physical separation in parsec (pc); and G is the gravitational constant (4.30091×10^{-3} pc$(km\ s^{-1})^2/M_\odot$). The mass of the A and B components was not available with GAIA DR3 FLAME. Using the GAIA DR3 luminosity for the A component and the GAIA DR2 luminosity for the B component and Duric equations (Duric 2004, Letchford et al 2022), the mass of the A component was estimated to be 0.71 $M_\odot$ and 0.56 $M_\odot$ for the B component.

3. Data

The results of the analysis of the 20 images by AstroImageJ are given in Table 2.

Table 2: Theta, rho & delta magnitude determined for STF 2128 using AstroImageJ.

WDS 17033+5935 STF 2128				
Epoch	**Measurement**	**Theta (degrees)**	**Rho (arcseconds)**	**Delta Magnitude (Bessel-V filter)**
DD: 2026.459 JD: 2461208.514	Mean	42.5	12.20	1.71
	Standard Deviation	0.13	0.015	0.01
	Standard Error of the Mean	0.03	0.003	0.002
Ephemeris*				
2026.0		42.0	12.172	
2027.0		42.0	12.171	

* Sixth Catalog of Orbits of Visual Binary Stars (Matson et al, 2026)

The mean physical distance separation of the primary and secondary of STF 2128 is 0.012 pc which equates to 2,475 AU.

The binding energy of STF 2128 using the mean physical distance separation is +0.2 $M_\odot(km\ s^{-1})^2$ and -0.01 $M_\odot(km\ s^{-1})^2$ using the minimum separation distance.

Table 3. Primary space velocity, secondary space velocity, relative angle between the space velocity vectors (Nugent metric), relative space velocity, system escape velocity, mean physical distance separation, minimum distance separation and maximum distance separation for STF 2128 .

WDS Identifier	Primary space velocity (km/s)	Secondary space velocity (km/s)	Angle between the space velocity vectors (degrees)	Relative space velocity (km/s)	System escape velocity (km/s)	Mean Separation (AU)	Minimum Separation (AU)	Maximum Separation (AU)
17033+5935 STF 2128	88.0	88.1	1.2	1.9	2.7	2,475	1,101	5,968

4. Discussion

The mean physical distance separation of the primary and secondary of STF 2128 is 2,475 AU. The minimum separation distance is 1,101 AU and the maximum separation distance is 5,968 AU. The approximate upper bound for physical 3D separation of a binary systems is 2,500 AU (Nugent, 2026). The angle between the components space velocity vectors in 3-dimensional space is 1.2 degrees indicating the pair show common space motion. The system escape velocity is greater than the relative space velocity. Also, the binding energy of the system is close to zero. These features are indicative of a binary system.

5. Conclusion

Analysis using GAIA DR3 data and a current astrometric measure shows that WDS 17033+5935 STF 2128 exhibits features of a binary star system.

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