

Results of Measurements for Struve and Baillaud Stars

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Abstract: In this paper I report the measurements of the pairs whose parameters (Rho and Theta) have not been updated for a long time. I made use of digitized plates from several photographic surveys downloaded from Internet and the astrometric software FV

Introduction

Looking up neglected double stars in the Washington Double Star Catalog (Mason, Wycoff & Marcoff, 2006 ;hereafter WDS), I chose those systems, observed by F.G.W. Struve (Σ STF) and one by R. Baillaud, whose parameters have not been updated for a long time (at least 50 years).

For this work, I used the NASA free software FV (http://heasarc.gsfc.nasa.gov/docs/software/fvtools/fv/fv_download.html) and the digitized plates from Digitized Sky Survey (hereafter DSS; http://stdatu.stsci.edu/cgi-bin/dss_plate_finder), SuperCosmos Sky Survey (hereafter SCSS; <http://www.wfau.roe.ac.uk/sss/>) and Two Micron All Sky Survey (hereafter 2MASS; <http://irsa.ipac.caltech.edu/>).

For the measures, the software FV has a tool named Ruler with which I made, manually, the measurements of every plate. To decrease the mean error in the measures, I took 10 measurements by plate. After, they were processed in a statistical software, obtaining average value and standard deviation. The results of these measurements are given in Table 1.

Additionally, from historical measures of WDS and my measures, I fitted in, using linear adjustment, the annual relative proper motion (both RA and DEC) in those system that have enough measures allowing such adjustment.

Results

STF 565AD(WDS 04381+4207)

See Figure 1. According to historical data of WDS, this pair was observed the first time in 1896 (Rho: 69.96", Theta: 51.7°, Epoch: 1896.13) (Urban et al. 1998). The last measure was performed in 1910 by Farman (1907) (Rho: 71.62", Theta: 52.1°, Epoch: 1906.02). In 14 years, before our measurements, Rho changed 1.66" and Theta 0.4°

This system is composed by two stars with magnitudes (The Tycho Reference Catalog, Hog et al. 1998) of 7.53 and 11.3. The value of magnitudes in infrared bands (2MASS Cutri et al. 2003, hereafter 2MASS) are J:5.11; H: 4.69; K:4.47 (component A) and J:10.76; H: 10.69; K:10.61 (component D).

The annual proper motion for the primary component is $\mu(\alpha) = 55.2 \pm 1.6 \text{ mas*yr}^{-1}$ and $\mu(\delta) = -58.3 \pm 1.3 \text{ mas*yr}^{-1}$ (TYCHO-2, Hog et al. 2000, hereafter TYCHO -2); and for the other, $\mu(\alpha) = -9 \pm 1.1 \text{ mas*yr}^{-1}$ and $\mu(\delta) = 0.8 \pm 0.7 \text{ mas*yr}^{-1}$ (UCAC2, Zacharias et al. 2004, hereafter UCAC2).

Their different proper motion shows its optical nature. Still, I calculated the relative proper motion for this system (from historical data of WDS and our

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Table 1: Results of the measurements.

Discoverer	RA+DEC	Mag 1	Mag 2	PA (deg)	Sep (as)	Epoch	Notes
STF 565AD	04381+4207	7.55	11.3	48.5	70.63	1994.030	3
				45.8	69.54	1998.854	2
STF 629	05328+8324	9.08	11.04	20.5	18.46	1955.074	1
				23.8	20.53	1983.846	1
				27.5	21.10	1998.056	1
STF1104AC	07294-1500	6.02	11.59	185.9	21.50	1999.061	2
STF 1257	08466+6527	7.73	11.20	133.8	26.56	1954.894	1
				141.0	27.19	1984.167	1
				142.6	27.41	1998.016	1
				142.3	27.61	1999.193	1
				143.1	27.80	2000.154	1
				143.0	27.65	2000.206	2
STF 1845	14237+6159	8.35	11.30	312.5	39.13	1953.202	1
				312.8	39.15	1955.203	1
				311.9	42.12	1984.099	1
				311.6	41.41	1984.165	1
				311.9	42.50	1990.076	1
				311.5	42.95	1991.207	1
				312.0	42.77	1992.321	1
				311.5	43.30	1995.253	1
				311.8	43.26	1995.308	1
				311.7	43.03	1996.146	1
				311.1	43.59	1996.438	1
				311.5	42.89	1997.217	1
				311.7	42.71	1997.268	1
				311.3	42.77	1997.296	1
				310.9	42.87	1997.531	1
311.3	42.86	1999.270	2				
STF 1876AC	14464-0723	7.90	12.70	296.2	56.91	1953.451	1
				293.4	51.55	1983.347	1
				293.1	50.84	1986.484	1
				293.0	50.62	1989.324	1
				292.6	48.81	1996.297	1
				292.2	48.39	1999.301	1

Table continues on next page.

Results of Measurements for Struve and Baillaud Stars

Table 1, continued: Results of the measurements.

Name	RA+DEC	Mag 1	Mag 2	PA (deg)	Sep (as)	Epoch	Notes
STF 2042	16258+0542	8.57	11.43	117.0	16.25	1950.294	1
				122.1	12.78	1983.452	1
				122.5	12.78	1990.385	1
				122.8	11.74	1993.391	1
				125.9	11.29	1997.293	1
				125.6	10.81	1999.305	2, 4
BAL 2913	18066+0452	12.52	12.76	14.99	12.82	1950.518	1
				15.04	12.76	1982.478	1
				15.42	12.58	1983.674	1
				13.68	12.87	1988.362	1
				14.80	12.69	1991.456	1
				15.61	12.42	1993.566	1
				14.24	12.40	1999.548	2
STF 2952AC	22542+2801	7.74	10.41	244.7	171.00	1954.656	1
				244.5	168.14	1982.880	1
				244.4	167.75	1986.839	1
				244.4	167.31	1989.531	1
				244.5	167.81	1990.806	1
				244.3	167.20	1991.754	1
				244.5	166.58	1992.652	1
				244.4	167.65	1994.678	1
				244.5	167.29	1995.650	1
				244.5	167.58	1995.716	1
				244.4	167.15	1997.873	2

Table Notes

1. DSS
2. 2MASS
3. SCSS
4. Revised by Francisco Rica (coordinator of LIADA's Double Star Section, in a private communication)

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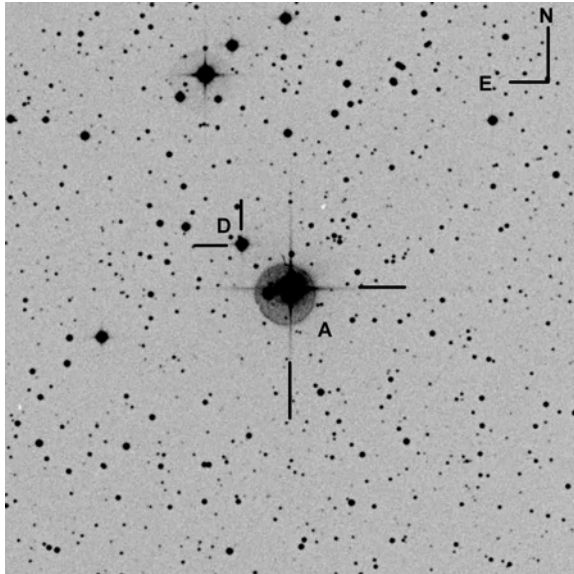


Figure 1: SCSS Image for STF565AD, January 11th, 1994

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measures) to confirm or not its optical nature: $\Delta\mu(\alpha) = -57.3 \pm 9.5 \text{ mas*yr}^{-1}$ and $\Delta\mu(\delta) = 55.36 \pm 5.6 \text{ mas*yr}^{-1}$.

STF 629 (WDS 05328+8324)

See Figure 2. This pair was first measured in 1832 by F. G. Wilhelm Struve (Rho:13.16"; Theta: 342.1°; Epoch: 1832.77) (Struve 1837). The last measure dates in 1999 (Cutri et al., 2003). In between the last measure was done in 1911 by K. Schiller (Rho:16.30"; Theta: 7.5°; Epoch: 1911.31)(Schiller 1913)

The system is composed of two stars of magnitudes 9.08 and 11.04 (The Hipparcos and Tycho Catalogues ESA 1997, hereafter HIPPARCOS/TYCHO). Additionally, their IR bands value are the next (2MASS, Cutri et al. 2003):

For A: J:7.77 ; H: 7.46; K: 7.40

For B: J:10.61 ; H: 10.45; K: 10.37

The annual proper motions (HIPPARCOS) for the primary and secondary component are, respectively, $\mu(\alpha) = -58.76 \pm 0.84 \text{ mas*yr}^{-1}$ and $\mu(\delta): -43.06 \pm 0.93 \text{ mas*yr}^{-1}$; and $\mu(\alpha): -28.8 \pm 39.2 \text{ mas*yr}^{-1}$ and $\mu(\delta): -12.2 \pm 38.2 \text{ mas*yr}^{-1}$.

Their very different proper motion indicates its optical nature. In addition, the high relative proper motion, $\Delta\mu(\alpha): 82.6 \pm 1.6 \text{ mas*yr}^{-1}$ and $\Delta\mu(\delta): 40.1 \pm 2.8 \text{ mas*yr}^{-1}$, confirms that nature.

STF 1257 (WDS 08466+6527)

See Figure 3. This pair was first measured in 1893 (Rho: 26.49"; Theta: 120.8°; Epoch: 1893.21)(Urban et

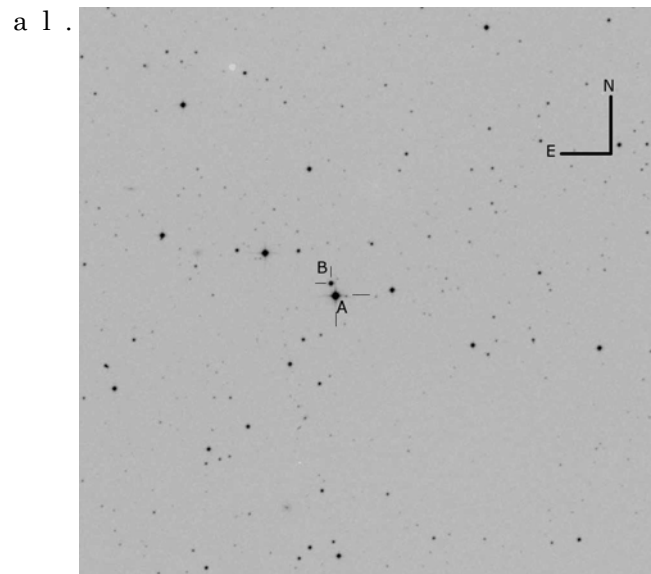


Figure 2: DSS Image for STF 629, January 21st, 1998

1998). The last measure dates from 1905 (Rho: 26.05"; Theta: 124.3°; Epoch: 1905.33) by S.W. Burnham (Burnham 1906).

According to TYCHO/HIPPARCOS catalog, the magnitudes for primary and secondary components are, respectively, 7.84 and 11.20. Their IR magnitudes in J, H, K bands are (2MASS):

For A: J:5.87 ;H:5.31 ;K:5.19

For B: J:10.76 ;H:10.40 ;K:10.34

With respect to their proper motion, the only available value is for primary component, $\mu(\alpha): 30.62 \pm$

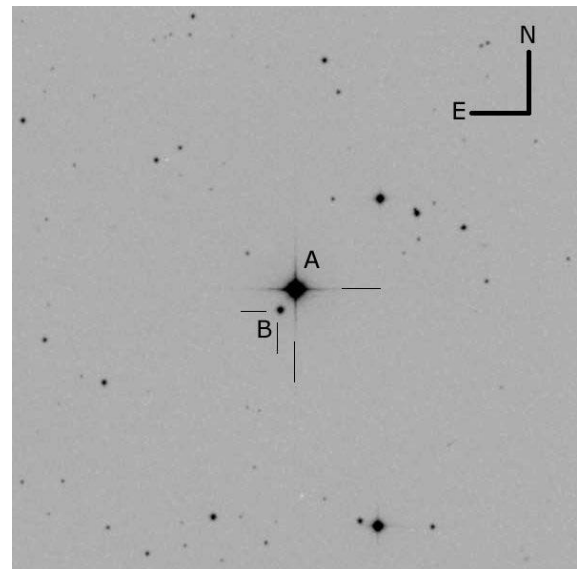


Figure 3: DSS Image for STF 1257, February 26th, 2000

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0.62 mas*yr⁻¹ and $\mu(\delta)$: 25.01 ± 0.6 mas*yr⁻¹ (HIPPARCOS). Thus, to get more information about its nature, we calculated the annual relative proper motion from the historical data of WDS and our measures, obtaining: $\Delta\mu(\alpha)$: -54.63 ± 1.72 mas*yr⁻¹ and $\Delta\mu(\delta)$: -80.37 ± 1.48 mas*yr⁻¹. This high value indicates that it is an optical pair.

STF 1845 (WDS 14237+6156)

See Figure 4. This pair was measured the first time in 1906 by S.W. Burnham (Rho:34.38"; Theta: 313.8°; Epoch: 1906.15) (Burnham 1906) and the last measurement, was in 1908 (Rho:34.66"; Theta: 315.1°; Epoch: 1908.42)(Urban et al. 1998)

The magnitudes for the primary and secondary components are, respectively, 8.35 and 11.30. In IR (2MASS), their magnitudes in the different bands are:

For A: J:7.31 ;H:7.12 ;K:7.08

For B: J:10.87; H:10.50 ;K:10.45

The proper motion, from Hipparcos is only available for the primary component: $\mu(\alpha)$: 28.58 ± 0.54 mas*yr⁻¹ and $\mu(\delta)$: -6.47 ± 0.69 mas*yr⁻¹. Using the historical data requested to WDS database and our own measurements, I calculated the relative proper motion for this system, obtaining: $\Delta\mu(\alpha)$: -82.62 ± 2.1 mas*yr⁻¹ and $\Delta\mu(\delta)$: 47.0 ± 2.1 mas*yr⁻¹. The high value indicates its optical nature

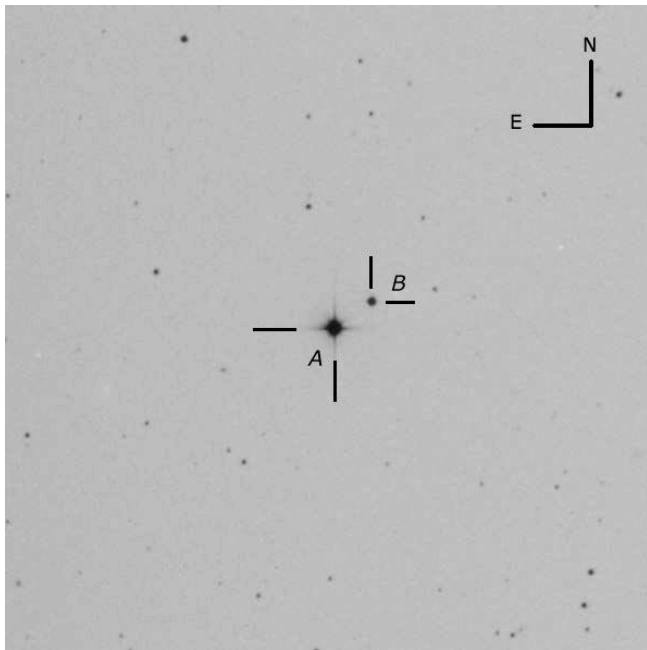


Figure 4: DSS Image for STF 1845 February 13th, 1997

STF 1876AC (WDS 14464-0723)

See Figure 5. According to historical data of WDS,

this system has been measured 5 times. The first time was in 1891 (Rho: 70.66"; Theta: 302.2°; Epoch: 1891.39)(Hough 1906). The last measurement is dated in 1999 (Rho: 48.27"; Theta: 292.0; Epoch: 1999.21) (2MASS).

This pair is composed of two stars of magnitudes 7.89 (TYCHO) and 12.70 (NOMAD Catalog, Zacharias et al. 2005, hereafter NOMAD). The magnitudes in infrared bands (2MASS) are J: 6.71; H: 6.47; K: 6.39 (component A) and J:11.47; H: 11.13; K:11.01 (component C).

The proper motion for both components comes from different catalogs. For primary, $\mu(\alpha)$: -10.0 ± 2.4 mas*yr⁻¹ and $\mu(\delta)$: -107 ± 2.6 mas*yr⁻¹ (PPMS, Bastian & Roeser 1993; hereafter PPMS), and for D $\mu(\alpha)$: -2 ± 1 mas*yr⁻¹ and $\mu(\delta)$: -38 ± 4 mas*yr⁻¹ (USNO B-10, Monet et al. 2003, hereafter USNO B-10)). However, I calculated, using our own measures and the historical data of WDS, the annual relative proper motion for this system, $\Delta\mu(\alpha) = 136.65 \pm 3.95$ mas and $\Delta\mu(\delta)$: -174.04 ± 6.06 mas. The large difference in the individual proper motions (and the annual relative proper motion) indicates its optical nature.

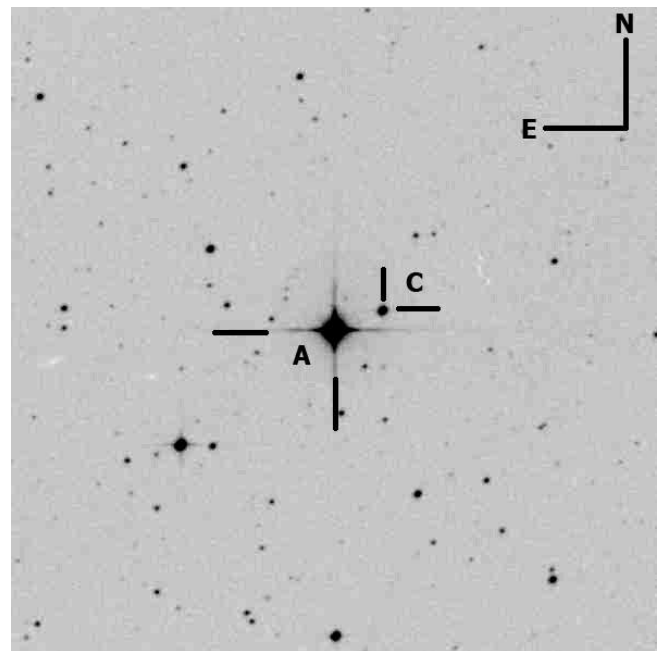


Figure 5: DSS Image for STF 1876AC, Avril 20th, 1999

STF 2042 (WDS 16258+0542)

See Figure 6. This pair has been measured three times, the first being in 1901 (Rho: 20.35"; Theta: 108.9°; Epoch: 1901.39) (Burnham 1903). Recently, one more measurement appeared in the historical data of the WDS: in 2007 (Rho: 10.19"; Theta: 128.5°;

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Epoch: 2007.440; Mason, Hartkopf & Wycoff 2008).

This system is composed of two stars of magnitudes 8.57 and 11.43 (TYCHO-2). Their magnitudes in infrared bands are: J: 7.64; H: 7.50; K: 7.39 (Primary component) and J: 9.37; H: 8.71; K: 8.56. (2 MASS)

The proper motions of both stars were obtained from the HIPPARCOS catalog. The A component shows a motion: $\mu(\alpha)$: $37.7 \pm 9.3 \text{ mas*yr}^{-1}$ and $\mu(\delta)$: $-41.9 \pm 9.1 \text{ mas*yr}^{-1}$; and the B component, $\mu(\alpha)$: $-2.5 \pm 2.8 \text{ mas*yr}^{-1}$ and $\mu(\delta)$: $-3.4 \pm 2.7 \text{ mas*yr}^{-1}$. The large difference in their motion indicates the optical nature for this pair. (The calculated annual relative motion proper is: $\Delta\mu(\alpha) = -104.59 \pm 3.67 \text{ mas}$ and $\Delta\mu(\delta)$: $2 \pm 3.97 \text{ mas}$)

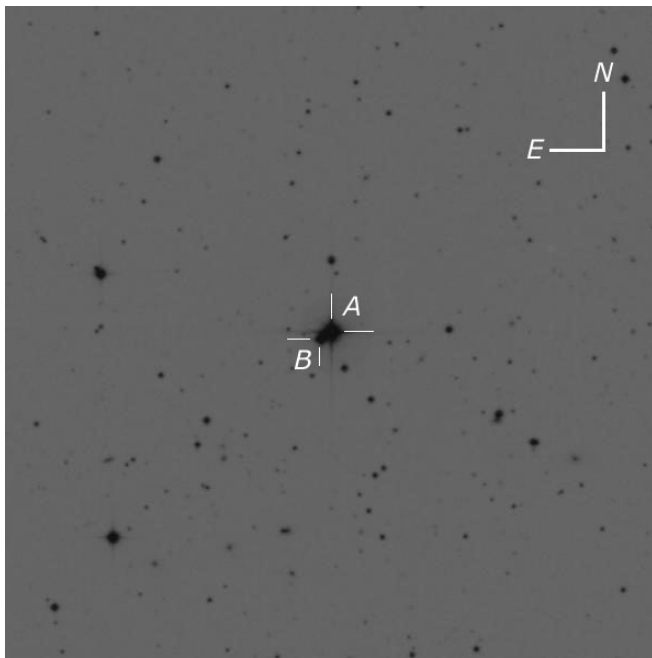


Figure 6. Digitized Sky Survey Image for STF 2042, May 23rd, 1993

BAL 2913 (WDS 18066+0452)

See Figure 7. This double star was observed by R. Baillaud in 1910 (Rho: $12.2''$, Theta: 15.6° ; Epoch: 1910.45)(1943). In 2007, a last measure appears in the historical data from WDS (Rho: $12.54''$; Theta: $14.2''$; Epoch: 2007.470; Mason, Hartkopf & Wycoff 2008). In 97 years, before our measurements, Rho had changed $0.34''$ while Theta 1.4° .

This system is composed of two stars with similar magnitudes (A: 12.52; B: 12.76, WDS). In the J, H, K bands are not very different. So, A (J: 11.63; H: 11.43; K: 11.35) and B (J: 11.97; H: 11.83; K: 11.75).

According to UCAC2, the annual proper motion for

the primary component is $\mu(\alpha) = 0.3 \pm 2 \text{ mas*yr}^{-1}$ and $\mu(\delta) = -8 \pm 1.9 \text{ mas*yr}^{-1}$; for the secondary, $\mu(\alpha) = 0.2 \pm 2 \text{ mas*yr}^{-1}$ and $\mu(\delta) = -4.2 \pm 1.9 \text{ mas*yr}^{-1}$. Additionally the calculated relative proper motion for this system is: $\Delta\mu(\alpha) = -2.16 \pm 1.55 \text{ mas*yr}^{-1}$ and $\Delta\mu(\delta) = 3.62 \pm 3.13 \text{ mas*yr}^{-1}$. Could it be a physical pair?

The difference between their visual brightness is only 0.24 magnitudes, while their J-H and H-K colors are very similar; for the primary, J-H = 0.20; H-K = 0.08; and the secondary, J-H = 0.14; H-K = 0.08. This may mean both components are very similar.

The parallax value for the primary component (HIPPARCOS) is 13.1 mas (76.3 parsecs). The parallax of the secondary is not available.

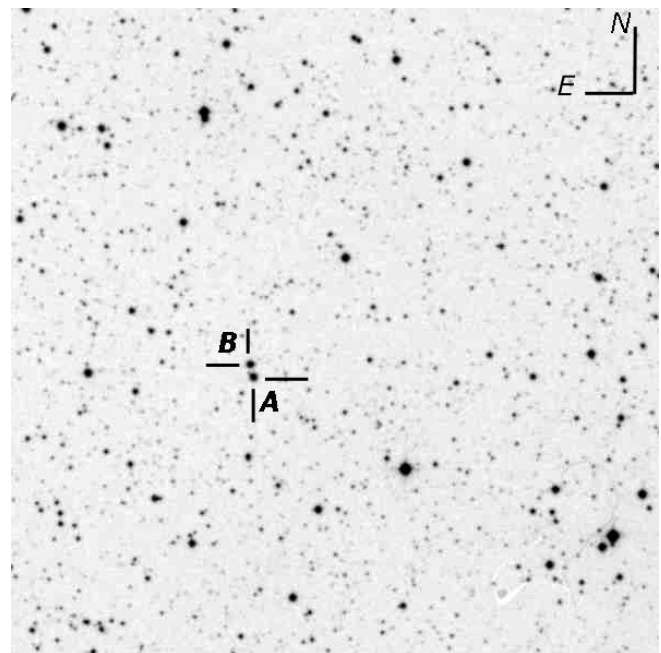


Figure 7: DSS Image for BAL 2913, July 26th, 1993

STF2952 AC (WDS 22542+2801)

See Figure 8. According to the historical data of WDS, this system has been measured in 5 times. The first time in 1925 (Rho: $200''$; Theta: 230° ; Epoch: 1925.94)(Opik 1927). The last measurement is dated 2007 (Rho: $165.90''$; Theta: 244.4° ; Epoch: 2007.608) (Arnold 2008).

This pair is composed of two stars of magnitudes 7.74 and 10.43 (TYCHO-2). In the infrared bands, their magnitudes in J, H and K bands are 6.73; 6.54 and 6.49 (Component A); and 9.12, 8.81 and 8.74 (Component C)

The proper motions, from TYCHO-2, for both components are: $\mu(\alpha) = 65.3 \pm 1.0 \text{ mas*yr}^{-1}$ and $\mu(\delta) =$

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— $37.6 \pm 1.1 \text{ mas*yr}^{-1}$ (A); $\mu(\alpha) = 35.5 \pm 1.5 \text{ mas*yr}^{-1}$ and $\mu(\delta): -13.7 \pm 1.4 \text{ mas*yr}^{-1}$. For the C component, the relative proper motion is $\Delta\mu(\alpha) = 53.72 \pm 12.94 \text{ mas*yr}^{-1}$ and $\Delta\mu(\delta): 519.07 \pm 129.45 \text{ mas*yr}^{-1}$.

This large difference in the proper motion of both stars indicates its optical nature.

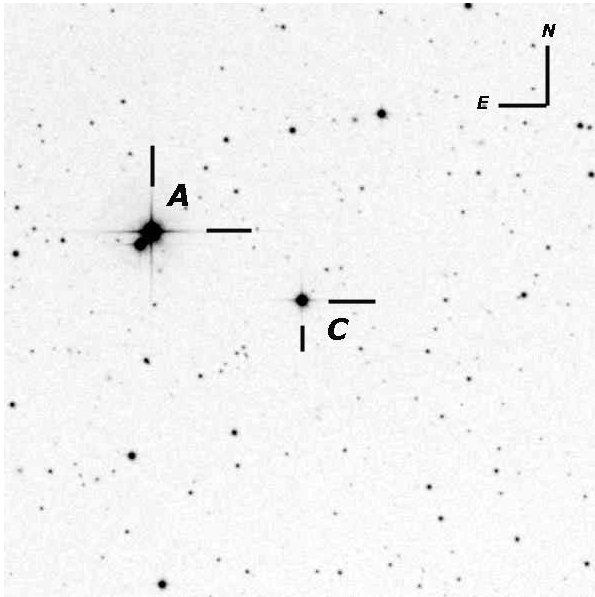


Figure 8: Digitized Sky Survey Image for STF 2952C, August 26th, 1995

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This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory.

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Software

FV: http://heasarc.gsfc.nasa.gov/docs/software/ftools/fv/fv_download.html

Digitized Sky Survey: <http://stdatu.stsci.edu/>

SuperCosmos Sky Survey: http://www-wfau.roe.ac.uk/sss/pixel_intro.html

Two Micron All Sky Survey: <http://irsa.ipac.caltech.edu/>

Mr Ángel Manuel López has been a member of Agrupación Astronómica Madrid (www.aam.org.es) for seven years, where he is the coordinator of the double star section and a member of the solar section.

