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Orbital elements of six visual binary stars

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Revised orbital elements of the visual binary stars STT 515, BU 4 AB, STF 183 AB, A 207, STT 43 and A 2413 are given. Dynamical parallaxes and total masses of the systems have been calculated.

Key words: visual binaries: orbits – stellar masses – dynamical parallaxes

1. Introduction

The present work is a continuation of the revision of some orbits of visual binary stars (Aristidi et al. 1999, Scardia et al. 2000 a), which are no longer valid, using the speckle observations obtained by the PISCO speckle camera developed by Observatoire Midi-Pyrénées and used on the Cassegrain focus of the 2-meter *Télescope Bernard Lyot* (TBL) of the Pic du Midi Observatory (Aristidi et al. 1997, Aristidi et al. 1999, Scardia et al. 2000 b). The procedures used for the revision of the orbital elements, the calculation of the sum of the masses of the system, and respective uncertainty, and the graphic representation of the results are the same as in the previous work (Scardia et al. 2000a). The values of the stellar masses as a function of the spectral type, used as reference, have been taken from Straizys and Kuriliene (1981). In the tables containing the ephemerides column 1 contains the date in years, column 2 the separation ρ in arcsec and column 3 the position angle θ in degrees. In the tables of the O-C, restricted for reasons of space to the observations following 1978, column 1 contains the date in years, column 2 the observed separation ρ in arcsec, column 3 the $\Delta\rho(O - C)$, column 4 the observed position angle θ (reduced to 2000) in degrees, column 5 the $\Delta\theta(O - C)$, column 6 the number of nights and column 7 the name of the observer. The figures show the apparent orbit obtained by us and the observations used for the calculation of the orbital elements. The orientation of the orbit is in conformity with the convention accepted by the observers of visual binary stars.

2. WDS 01095 +4715 – STT 515 – ADS 940

The binary star has been well observed. The observations are quite numerous, but very scattered before 1940 when, because of the narrow separation and the strong brightness of the principal star, the couple was difficult to observe. The previous orbit of Baize (1958), although still acceptable in position angle, shows systematic residuals in separation. Thus we have recalculated the orbital elements obtaining:

node	=	142.3	(2000)
omega	=	249.0	
i	=	148.0	A = -0.09028
e	=	0.258	B = -0.38062
T	=	1886.926	F = -0.41605
P	=	391.0	G = 0.14864
n	=	0.92072	
a	=	0.450	

This orbit is preliminary. The real period is probably long ($P > 400$ years), but for the moment it is, like the other orbital elements, still uncertain (Fig. 1). The parallax measured by the satellite Hipparcos is $0''.00443 \pm 0''.00080$. The sum of the masses of the system, corresponding to such a measurement, is $6.9 M_{\odot}$, slightly in excess for a binary of a spectral type B7Ve, while the semi-major axis is 101.6 A.U.. The dynamical parallax is $0''.0033$, in reasonable agreement with the measured one; but this calculated parallax is not acceptable because it leads to an exaggerated sum ($16.8 M_{\odot}$) of the masses of the system.

Ephemerides

1	2	3	1	2	3
2001.0	0.497	125.6	2006.0	0.501	122.5
2002.0	0.498	124.9	2007.0	0.501	121.9
2003.0	0.498	124.3	2008.0	0.502	121.3
2004.0	0.499	123.7	2009.0	0.503	120.7
2005.0	0.500	123.1	2010.0	0.503	120.1

O-C

1	2	3	4	5	6	7
1978.615	0.469	0.001	140.2	-0.0	1	MCA
1978.770	0.490	0.022	140.6	0.5	3	HEI
1978.810	0.560	0.092	139.5	-0.6	1	POP
1979.732	0.490	0.020	141.6	2.1	1	TOK
1979.770	0.474	0.004	139.7	0.3	1	MCA
1979.874	0.460	-0.010	141.0	1.7	3	WOR
1980.718	0.480	0.008	137.8	-0.9	1	MCA
1980.882	0.479	0.007	139.0	0.4	1	MCA
1980.893	0.461	-0.011	137.7	-0.9	1	MCA
1980.898	0.483	0.011	137.8	-0.8	1	MCA
1980.916	0.529	0.057	136.0	-2.6	2	TOK
1981.701	0.476	0.003	138.1	0.1	1	MCA
1982.603	0.465	-0.010	134.1	-3.3	1	TOK
1982.670	0.460	-0.015	138.7	1.3	2	LEF
1983.069	0.481	0.006	136.7	-0.4	1	MCA
1983.716	0.479	0.003	136.6	-0.1	1	MCA
1983.933	0.638	0.161	144.5	8.0	1	BNU
1984.060	0.478	0.001	136.7	0.3	1	MCA
1984.770	0.530	0.052	135.0	-0.9	3	HEI
1984.997	0.482	0.004	135.5	-0.3	1	MCA
1985.480	0.460	-0.019	137.8	2.3	2	WOR
1985.753	0.492	0.013	135.9	0.6	2	TOK
1985.838	0.508	0.029	135.0	-0.2	1	BNU
1985.848	0.483	0.004	134.4	-0.8	1	MCA
1986.883	0.500	0.019	134.3	-0.2	4	WOR
1986.892	0.486	0.005	133.5	-1.0	1	MCA
1987.754	0.487	0.005	133.4	-0.6	1	MCA

O-C

1	2	3	4	5	6	7
1988.655	0.490	0.007	132.7	-0.7	1	MCA
1988.814	0.490	0.007	134.6	1.3	3	WOR
1988.909	0.488	0.005	132.6	-0.6	1	FU
1990.772	0.477	-0.009	131.0	-1.0	1	BAG
1990.835	0.480	-0.006	132.4	0.4	1	WSI
1990.915	0.480	-0.006	131.7	-0.2	1	WSI
1990.942	0.470	-0.016	130.0	-1.9	1	WSI
1991.029	0.487	0.001	132.0	0.2	1	BAG
1991.250	0.491	0.005	131.3	-0.4	1	HIP
1991.904	0.492	0.005	131.1	-0.2	1	MCA
1992.678	0.474	-0.014	132.0	1.2	1	BAG
1992.766	0.500	0.012	131.8	1.1	1	WSI
1992.766	0.490	0.002	133.6	2.9	1	WSI
1993.760	0.514	0.025	130.0	-0.1	1	BAG
1993.762	0.507	0.018	131.0	0.9	1	BAG
1993.894	0.470	-0.020	131.2	1.2	1	WSI
1993.920	0.490	0.000	130.2	0.2	1	HRT
1994.920	0.460	-0.031	130.3	0.9	1	WSI
1994.986	0.470	-0.021	128.7	-0.6	1	WSI
1994.986	0.460	-0.031	128.7	-0.6	1	WSI
1995.760	0.492	0.000	129.0	0.2	1	HRT
1995.929	0.492	0.000	128.6	-0.1	1	HRT
1996.052	0.490	-0.002	128.2	-0.5	1	GII
1996.927	0.470	-0.023	129.1	1.0	1	WSI
1996.927	0.460	-0.033	130.4	2.3	1	WSI
1998.666	0.505	0.010	127.1	0.1	1	PIC
2000.017	0.500	0.004	125.0	-1.2	1	WSI

3. WDS 01213 +1132 – BU 4 AB – ADS 1097

The previous orbit of Muller (1954) has a period which is too short and no longer represents the observations either in position angle or in separation. At the small separations BU 4 AB is a difficult couple to observe because of the great difference in magnitude between the components. Our observation (1998.679 PIC) is the first speckle observation of this binary. The orbit is very eccentric and there are no observations near the perihelion between 1920 and 1945 when the components were at a distance of less than $0''.15$ (Fig. 2). Thus we have recalculated the orbital elements of BU 4 AB obtaining:

node	=	147.0	(2000)
omega	=	242.4	
i	=	133.1	A = 0.02362
e	=	0.868	B = -0.30558
T	=	1943.069	F = -0.36809
P	=	242.7	G = 0.08730
n	=	1.48331	
a	=	0.402	

Our geometrical elements do not differ much from those found in 1954 by Muller, but our orbit, of degree 3, is however more eccentric and the period is longer. The Hipparcos parallax is $0''.00616 \pm 0''.00141$, to which corresponds a sum of the masses of the system of $4.7 M_{\odot}$, in excess for a binary of spectral type F1III (but C.D.S. report F0), while the semi-major axis is 65.3 A.U..

Ephemerides

1	2	3	1	2	3
2001.0	0.514	110.8	2006.0	0.528	109.3
2002.0	0.517	110.5	2007.0	0.530	109.0
2003.0	0.520	110.2	2008.0	0.533	108.7
2004.0	0.522	109.9	2009.0	0.535	108.4
2005.0	0.525	109.6	2010.0	0.537	108.1

O-C

1	2	3	4	5	6	7
1978.600	0.360	-0.061	114.7	-4.3	3	WOR
1978.850	0.470	0.047	118.1	-0.8	3	HEI
1981.832	0.470	0.032	116.2	-1.4	3	WOR
1984.860	0.530	0.077	118.1	1.8	3	HEI
1985.810	0.390	-0.067	111.4	-4.5	3	LBU
1986.818	0.470	0.008	110.9	-4.7	5	SCA
1986.870	0.490	0.028	115.5	-0.0	3	LIN

O-C

1	2	3	4	5	6	7
1987.800	0.450	-0.016	115.0	-0.2	3	HEI
1990.841	0.470	-0.008	112.1	-2.0	2	PRI
1991.250	0.511	0.031	114.0	0.1	1	HIP
1991.970	0.480	-0.003	114.5	0.8	2	HEI
1994.900	0.560	0.066	110.6	-2.1	2	HEI
1997.679	0.490	-0.013	113.1	1.3	1	LIN
1998.679	0.544	0.038	111.7	0.2	1	PIC

4. WDS 01551 +2847 – STF 183 AB – ADS 1522

The binary star has been well observed. The orbits of Couteau (1973) and Starikova (1982) do not represent recent observations. The observations made before 1950 appear very scattered both in separation and position angle perhaps because of the considerable difference in magnitude between the components. Some perplexity is caused by the most recent observation available (1999.736 WSI) using speckle interferometry, because it leaves a strangely large residual in position angle.

node	=	174.0	+/-	1.2	(2000)
omega	=	304.9	"	5.5	
i	=	116.6	"	1.3	A = -0.29155
e	=	0.473	"	0.032	B = -0.14660
T	=	1969.505	"	1.3	F = -0.37866
P	=	276.1	"	26.4	G = 0.16344
n	=	1.30388	"	0.12	
a	=	0.480	"	0.024	

Our orbit, of degree 3, has a shorter period and less eccentricity. The orbital elements are quite well defined, only the period is still rather uncertain (Fig. 3). The Hipparcos parallax is $0''.00727 \pm 0''.00189$. The sum of the masses of the system, corresponding to such a measurement, is $3.8 M_{\odot}$, with an uncertainty of 82%, in excess for a binary of spectral type F2, while the semi-major axis is 66.0 A.U.. The dynamical parallax is $0''.0074$, agreeing well with the observed one.

Ephemerides

1	2	3	1	2	3
2001.0	0.319	153.8	2006.0	0.312	147.9
2002.0	0.318	152.7	2007.0	0.311	146.7
2003.0	0.317	151.5	2008.0	0.309	145.5
2004.0	0.315	150.3	2009.0	0.307	144.2
2005.0	0.314	149.1	2010.0	0.305	143.0

O-C							O-C						
1	2	3	4	5	6	7	1	2	3	4	5	6	5
1978.840	0.240	-0.020	188.2	5.8	3	HEI	1986.889	0.303	-0.001	170.3	-0.2	1	MCA
1980.583	0.270	-0.002	180.2	0.7	3	WOR	1986.903	0.280	-0.024	169.5	-1.0	3	WOR
1980.860	0.240	-0.034	180.8	1.7	3	HEI	1987.757	0.306	-0.001	169.0	-0.4	1	MCA
1980.890	0.320	0.046	178.9	-0.1	3	MRL	1987.980	0.340	0.032	165.7	-3.4	2	GII
1980.904	0.257	-0.017	178.4	-0.6	1	TOK	1988.658	0.310	0.000	168.1	-0.2	1	MCA
1982.681	0.291	0.006	177.5	1.2	1	FU	1988.804	0.370	0.060	168.0	-0.1	1	ISO
1982.710	0.230	-0.055	180.0	3.7	3	HEI	1988.840	0.310	-0.000	168.6	0.6	3	HEI
1982.859	0.279	-0.007	174.1	-1.9	3	TOK	1988.964	0.280	-0.031	164.5	-3.4	3	COU
1982.860	0.310	0.024	177.5	1.5	3	COU	1989.712	0.315	0.002	166.8	-0.2	1	MCA
1983.014	0.288	0.001	177.2	1.4	1	FU	1990.755	0.314	-0.001	165.9	0.2	1	MCA
1983.066	0.275	-0.012	176.5	0.8	1	MCA	1990.832	0.330	0.015	165.9	0.3	2	PRI
1983.713	0.287	-0.004	175.2	0.4	1	MCA	1991.250	0.310	-0.006	165.0	-0.1	1	HIP
1983.842	0.370	0.079	172.4	-2.1	1	ZUL	1991.894	0.320	0.003	164.5	0.1	1	MCA
1984.705	0.292	-0.003	173.4	0.0	1	MCA	1992.693	0.190	-0.121	161.0	-2.4	1	MIU
1984.900	0.280	-0.016	174.8	1.7	2	HEI	1995.760	0.322	0.002	160.2	0.3	1	HRT
1985.745	0.313	0.013	171.9	-0.7	1	TOK	1995.916	0.324	0.004	159.4	-0.3	1	HRT
1985.770	0.340	0.040	171.2	-0.7	1	COU	1997.685	0.340	0.002	160.8	3.1	2	LIN
1985.810	0.270	-0.030	171.1	-0.8	2	LBU	1998.679	0.329	0.009	156.6	0.1	1	PIC
1985.838	0.299	-0.001	171.6	-0.2	1	MCA	1999.736	0.360	0.040	149.7	-5.6	1	WSI
1986.800	0.270	-0.034	170.8	0.2	3	HEI							

5. WDS 02182 +3920 - A 207 - ADS 1762

The orbit of Heintz (1975) no longer represents observations and the most recent one of Scardia (1982), although still acceptable, is based on visual observations which stopped in 1976. Our observation (1998.679 PIC), carried out at Pic du Midi with the B. Lyot telescope, is the first speckle observation of this binary. The measurement taken in 1991.25 by the satellite Hipparcos appears to be in disagreement with the observations made from the ground in the same years.

node	=	156.8	+/-	7.7	(2000)
omega	=	56.6	"	19.7	
i	=	43.8	"	12.5	A = -0.23044
e	=	0.327	"	0.17	B = -0.10446
T	=	1933.752	"	5.2	F = 0.18935
P	=	193.3	"	68.2	G = -0.21516
n	=	1.86239	"	0.66	
a	=	0.310	"	0.048	

Our orbit is preliminary because all the orbital elements are still rather uncertain (Fig. 4). The measurement of the parallax taken by the satellite Hipparcos is $0''.01200 \pm 0''.00311$; it seems to be overestimated and leads to a sum of the masses of the system of $0.46 M_{\odot}$, which is frankly unacceptable for a system of spectral type F5. In 1981 Scardia, on the basis of a spectrum taken at Merate with the telescope Ruths, having a diameter of 137 cm, and a spectrograph Boller and Chivens mod. 31523 (dispersion 114 Å/mm), classified this star as being of spectral type F9 (Scardia, 1982). The dynamical parallax is $0''.0065$; the corresponding sum of the masses of the system is $2.87 M_{\odot}$.

Ephemerides

1	2	3	1	2	3
2001.0	0.367	356.1	2006.0	0.367	0.7
2002.0	0.367	357.0	2007.0	0.366	1.6
2003.0	0.367	357.9	2008.0	0.366	2.5
2004.0	0.367	358.8	2009.0	0.365	3.4
2005.0	0.367	359.8	2010.0	0.365	4.3

O-C							O-C						
1	2	3	4	5	6	7	1	2	3	4	5	6	7
1976.860	0.320	-0.005	326.2	-6.1	3	HEI	1988.850	0.280	-0.076	349.8	5.0	3	HEI
1981.790	0.310	-0.030	341.1	3.3	3	HEI	1991.250	0.474	0.114	342.0	-5.1	1	HIP
1981.826	0.350	0.010	329.2	-8.6	1	COU	1996.000	0.350	-0.015	356.3	4.8	2	HEI
1983.950	0.360	0.014	335.9	-4.1	3	SCA	1998.679	0.317	-0.049	354.8	0.8	1	PIC
1984.880	0.370	0.022	341.0	0.0	2	HEI							

6. WDS 02407 +2637 – STT 43 – ADS 2034

Heintz's orbit (1962) has not represented observations in separation for a long time. For that reason we recalculated a new set of orbital elements having a substantially shorter period. Although this star lends itself well to observation with speckle interferometry (the magnitudes of the components are 7.55 and 8.77) up to now there have been only three observations made with this technique and they have been concentrated within the last 5 years. The observations are quite numerous, but very scattered in separation.

node	=	39.0	(2000)	
omega	=	203.8		
i	=	124.2	A = -0.75647	
e	=	0.324	B = -0.35398	
T	=	1804.422	F = -0.00889	
P	=	289.2	G = 0.57912	
n	=	1.24481		
a	=	0.886		

Our orbit must be considered as being preliminary (degree 4) because the arc of the observed orbit is only 90° and is placed completely around the aphelion (Fig. 5). The parallax measured by Hipparcos is $0''.01385 \pm 0''.00125$. The corresponding total mass of the system is $3.1 M_\odot$, overestimated for a star of spectral type F7V, while the semi-major axis is 64.0 A.U. long. The dynamical parallax is $0''.0149$ agreeing well with the measured one.

Ephemerides

1	2	3	1	2	3
2001.0	0.739	353.7	2006.0	0.693	348.6
2002.0	0.729	352.7	2007.0	0.684	347.5
2003.0	0.720	351.7	2008.0	0.675	346.4
2004.0	0.711	350.7	2009.0	0.667	345.2
2005.0	0.702	349.7	2010.0	0.658	344.1

0-C

1	2	3	4	5	6	7
1979.750	0.950	0.027	8.9	-0.9	3	ZUL
1980.900	0.750	-0.164	9.1	0.0	1	ZUL
1980.900	0.880	-0.034	10.6	1.5	1	POP
1981.900	1.020	0.114	4.7	-3.8	3	HEI
1982.796	1.070	0.171	9.0	1.1	4	LEF
1984.000	1.090	0.201	8.1	1.0	3	LBU
1986.245	0.860	-0.010	4.7	-0.9	2	ZUL
1986.760	1.000	0.135	6.3	1.0	3	LIN
1986.875	0.930	0.066	5.3	0.1	2	ZUL

0-C

1	2	3	4	5	6	5
1990.074	0.830	-0.007	3.6	0.8	4	WOR
1990.940	0.950	0.121	2.4	0.2	2	HEI
1991.250	0.863	0.037	3.9	2.0	1	HIP
1995.770	0.790	0.004	355.2	-3.1	1	WSI
1995.970	0.880	0.096	358.3	0.1	2	ALZ
1996.960	1.070	0.295	355.6	-1.7	2	ALZ
1998.679	0.754	-0.006	354.9	-0.9	1	PIC
1999.689	0.680	-0.070	357.8	2.9	1	WSI
1999.709	0.736	-0.014	354.9	0.0	1	CAI

7. WDS 02572 +0153 – A 2413 – ADS 2236

The previous orbits of Scardia (1980) and Heintz (1991) by now leave systematic residuals on the observations both in position angle and in separation. We therefore recalculated the orbital elements obtaining:

node	=	4.6	+/-	0.7	(2000)
omega	=	274.5	"	3.4	
i	=	69.7	"	1.1	A = 0.06516
e	=	0.4593	"	0.014	B = -0.20815
T	=	1929.241	"	0.44	F = 0.60979
P	=	115.8	"	4.5	G = 0.06586
n	=	3.10880	"	0.12	
a	=	0.615	"	0.036	

This orbit, of degree 3, is by now well defined and will certainly change very little in the future. Only the period is still slightly uncertain. The parallax measured by Hipparcos is $0''.02012 \pm 0''.00150$. The sum of the

masses of the system, corresponding to such a value, is $2.1 M_{\odot}$, with an uncertainty of 29%, agreeing very well with the values foreseen for a system of spectral type G0. The semi-major axis is 30.6 A.U.. Compared to the orbit calculated by Scardia in 1980, the total mass of the system, whose uncertainty was then of 55%, is now much better defined. The dynamical parallax is $0''.0193$, well in agreement with the measured parallax (Fig. 6).

Ephemerides

1	2	3	1	2	3
2001.0	0.434	145.5	2006.0	0.486	154.1
2002.0	0.444	147.3	2007.0	0.496	155.6
2003.0	0.455	149.1	2008.0	0.505	157.0
2004.0	0.465	150.8	2009.0	0.514	158.4
2005.0	0.476	152.5	2010.0	0.523	159.8

O-C							O-C						
1	2	3	4	5	6	7	1	2	3	4	5	6	5
1979.625	0.280	-0.037	81.0	1.4	3	WOR	1989.090	0.290	-0.038	113.5	-0.6	1	LBU
1979.840	0.320	0.004	80.8	0.5	3	HEI	1989.100	0.340	0.012	114.6	0.4	4	WOR
1982.939	0.280	-0.030	84.5	-7.4	5	MSS	1990.916	0.341	0.002	121.2	1.1	1	HRT
1983.960	0.340	0.029	94.5	-1.2	3	HEI	1990.920	0.310	-0.029	128.5	8.4	3	HEI
1984.079	0.300	-0.011	92.5	-3.6	1	SCA	1991.250	0.343	0.001	122.0	0.9	1	HIP
1985.050	0.330	0.018	95.5	-4.3	3	SCA	1991.713	0.344	-0.001	122.9	0.3	1	HRT
1985.940	0.330	0.016	103.7	0.6	3	LBU	1995.768	0.382	0.002	134.2	0.4	1	HRT
1986.069	0.310	-0.005	104.5	1.0	3	WOR	1995.921	0.381	-0.001	133.3	-0.9	1	HRT
1986.824	0.330	0.013	100.0	-6.3	4	SCA	1996.020	0.390	0.007	131.0	-3.4	2	ALZ
1987.859	0.350	0.029	106.1	-3.8	5	SCA	1998.679	0.418	0.008	140.5	-0.1	1	PIC
1989.043	0.340	0.013	112.6	-1.4	4	SCA							

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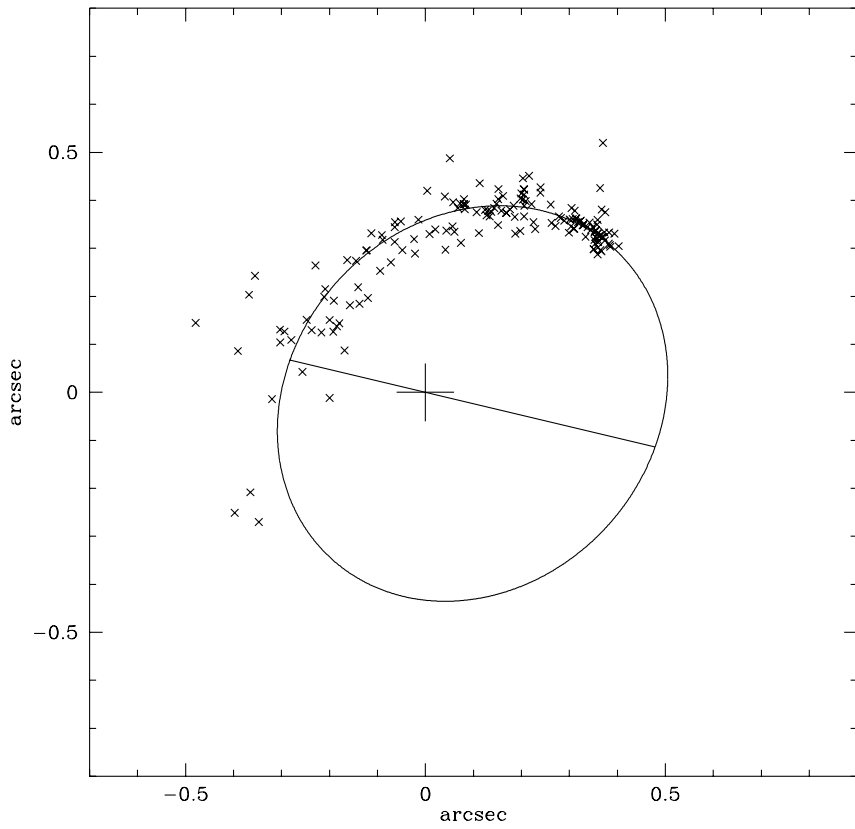


Fig. 1: STT 515 – ADS 940

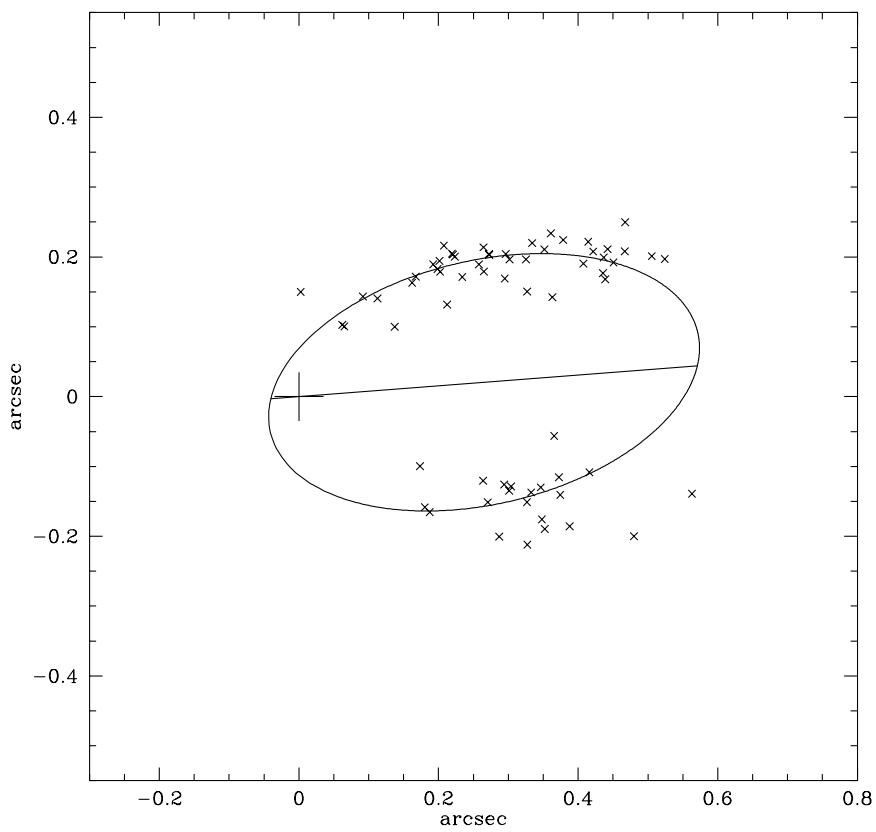


Fig. 2: BU 4 AB – ADS 1097

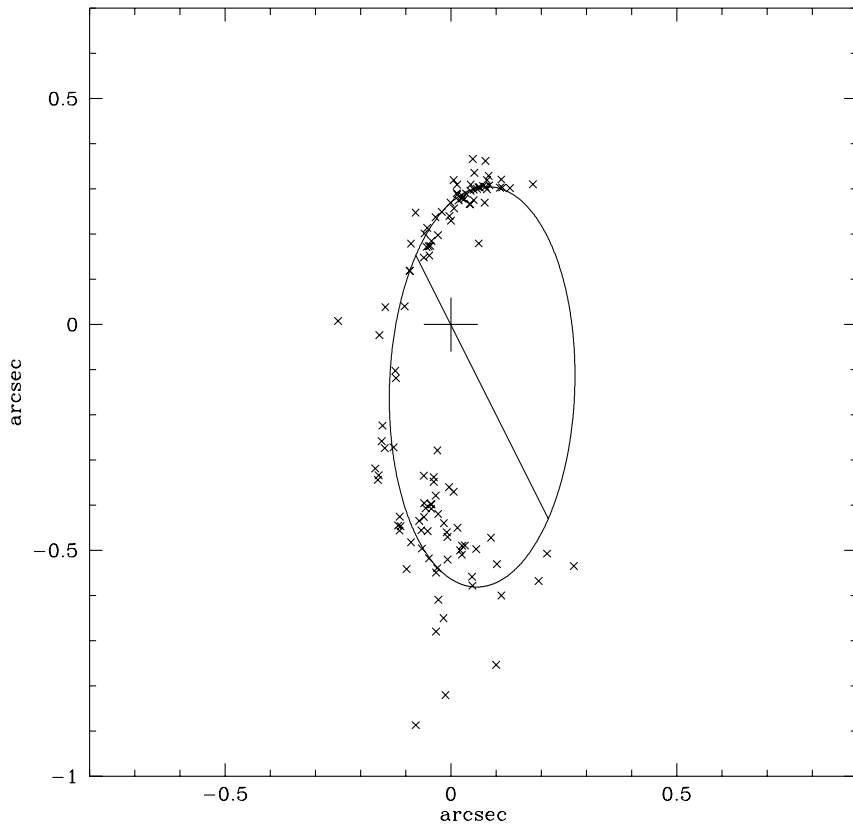


Fig. 3: STF 183 AB – ADS 1522

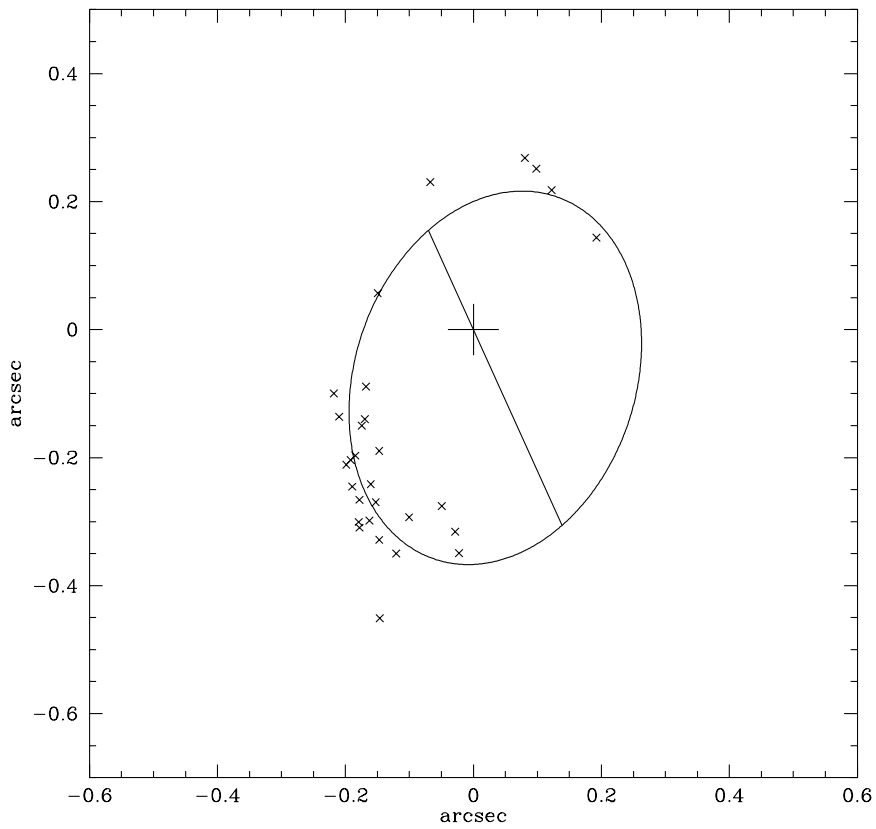


Fig. 4: A 207 – ADS 1762

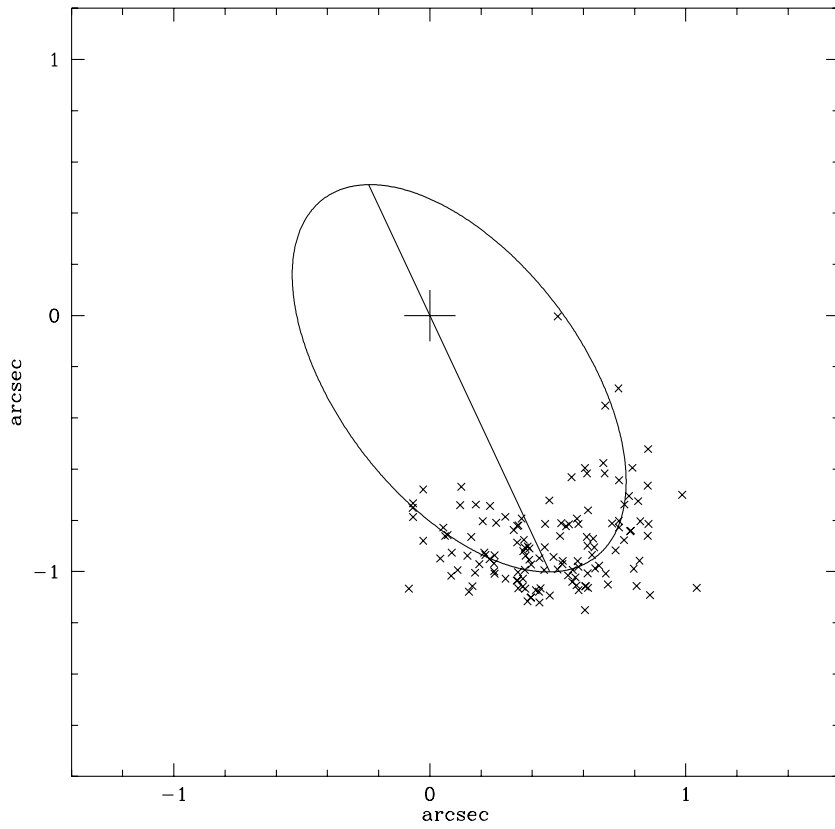


Fig. 5: STT 43 – ADS 2034

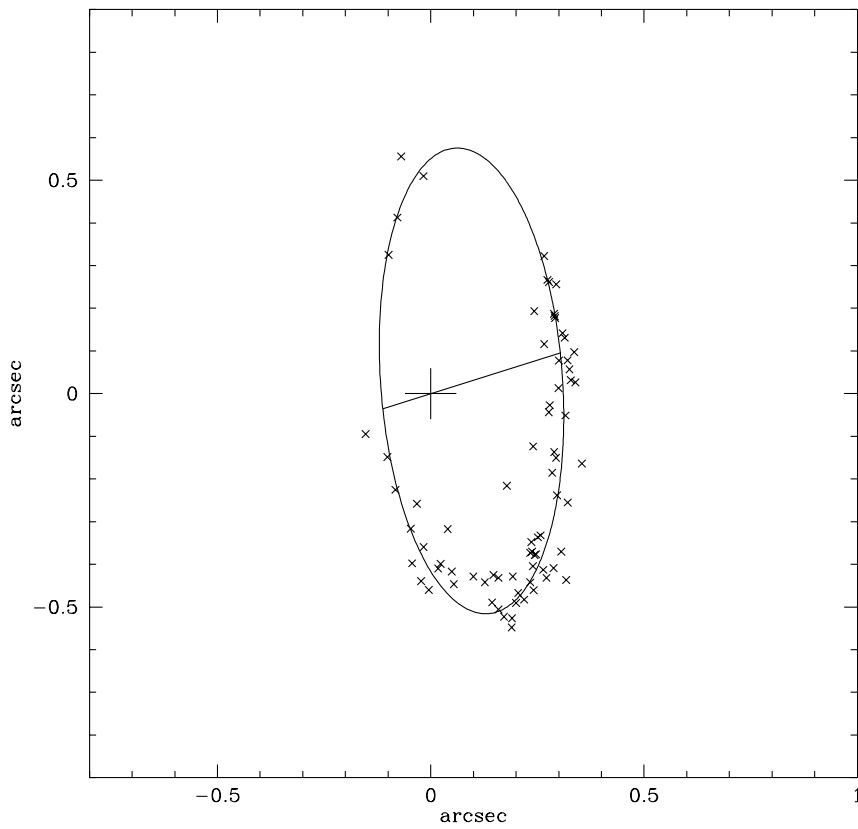


Fig. 6: A 2413 - ADS 2236