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Orbits of Ten Visual Binary Stars

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Abstract We present the orbits of ten visual binary stars: WDS 01015+6922, WDS 01424–0645, WDS 01461+6349, WDS 04374–0951, WDS 04478+5318, WDS 05255–0033, WDS 05491+6248, WDS 06404+4058, WDS 07479–1212, and WDS 18384+0850. We have also determined their masses, dynamical parallaxes and ephemerides.

Key words: binaries: visual

1 INTRODUCTION

The study of binaries has a number of goals: to measure accurate stellar masses, to test evolutionary models and star formation theories. To determine the masses of a binary, one requires among other things the inclination which is the best determined from a visual orbit. Although the WDS Catalog (Mason et al. 2001) contains more than 100,000 systems, less than 2000 have orbits included in the Sixth Catalog of Orbits of Visual Binary Stars (Hartkopf & Mason 2003).

This work presents orbits of ten visual binary stars. The orbits of the stars WDS 01015+6922, WDS 01461+6349, WDS 05491+6248, WDS 06404+4058 and WDS 07479–1212 were calculated for the first time and the orbits of the stars WDS 01424–0645, WDS 04374–0951, WDS 04478+5318, WDS 05255–0033, WDS 18384+0850 were revised. All ten orbits have previously been announced in the IAU Commission 26 (2006, Inf. Circ. 158).

2 METHOD, RESULTS AND DISCUSSION

The problem of computing orbital elements of a binary from a set of observed positions is especially difficult in the case when observations cover a short arc. Whether a set of observations is sufficient to determine the orbit depends on the amount, consistency and distribution of the data. In cases with periods of several centuries or more, the observations define a limited arc, and the orbits calculated in these cases are preliminary. The most obvious examples in this work are the stars WDS 06404+4058 and WDS 01015+6922. Hence, the orbits of these two double stars are preliminary.

The orbits were determined using the Kovalski-Olević (Olević & Cvetković 2004) method. This method yields a solution even in cases when the observations cover only a short arc or when there are gaps. All the observations were assigned the appropriate weights according to the weighting rule of Hartkopf et al. (1989, 2001). The dynamical parallaxes and individual masses were calculated for stars on the main sequence using the Angelov (1993) method. Trigonometric parallaxes published in the Hipparcos and Tycho Catalogues (ESA, 1997) were used when calculating the total masses of the systems.

In Table 1 we present the identifications of the stars in several widely used catalogs and, in the last two columns, their spectral types taken from the WDS catalog (Mason et al. 2001) and Hipparcos trigonometric parallaxes. Table 2 presents the numerical values of the orbital elements (epoch J2000) and their estimated formal errors. The orbits are illustrated in Figures 1–10. The solid curves represent the newly determined orbital elements, while the dashed curves represent previously published orbital elements. The solid lines mark the lines of node. All measured positions are connected to their predicted positions on the new orbit by "O-C" lines. The interferometric measurements are represented by filled circles and all other measurements

(visual, photographic), by plus signs. The direction of motion is indicated in the lower right corner of each plot and a "+" sign marks the position of the primary star. Table 3 gives predicted ephemerides for these systems for the period 2007–2010.

Table 1 Stellar Data

Name	WDS	ADS	BDS	HIP	HD	Sp.	$\pi_{\rm HIP}$[mas]
A 2901	01015+6922	836	—	4789	5839	B9	2.80 ± 1.06
A 1	01424−0645	1345	888	7968	10508	F2	7.74 ± 3.57
STF 148	01461+6349	1380	903	—	10663	G2V	—
RST 3401	04374−0951	—	—	21536	29392	F8	10.54 ± 1.61
HU 612	04478+5318	3434	2335	22279	30136	F2	8.14 ± 1.02
A 848	05255−0033	4020	13059	25365	35548	B9pHgSi	4.42 ± 0.80
STF 3115	05491+6248	4376	2926	27472	38284	A4V	7.91 ± 0.92
STF 945	06404+4058	5296	3515	31928	47412	F2	8.30 ± 1.62
STF 1146	07479−1212	6381	4269	38048	63336	dF5	33.06 ± 0.84
HU 198	18384+0850	11524	8687	91389	172171	K1III	-25.80 ± 18.05

Table 2 Orbital Elements (J2000)

Name WDS	P[yr]	T	$a['']$	e	$i[\circ]$	$\Omega[\circ]$	$\omega[\circ]$
A 2901	1517.34	1950.56	0.990	0.621	69.3	48.4	330.2
01015+6922	±60.15	±61.32	±0.080	±0.033	±0.9	±0.7	±0.9
A 1	357.02	2205.28	0.641	0.299	50.8	76.1	1.9
01424–0645	±6.67	±2.50	±0.060	±0.008	±0.6	±0.7	±1.9
STF 148	625.27	2013.18	1.081	0.689	67.6	147.9	121.6
01461+6349	±20.06	±17.99	±0.158	±0.048	±1.2	±0.9	±3.6
RST 3401	159.41	1966.85	0.354	0.473	143.3	96.2	46.2
04374–0951	±2.43	±2.70	±0.043	±0.033	±2.4	±3.3	±4.8
HU 612	309.87	1903.76	0.502	0.424	40.3	3.8	200.9
04478+5318	±4.07	±5.05	±0.068	±0.043	±2.9	±3.3	±5.7
A 848	534.41	2425.78	0.400	0.315	66.3	19.8	17.2
05255–0033	±12.49	±2.11	±0.055	±0.019	±0.8	±0.8	±1.8
STF 3115	976.83	2131.60	1.350	0.338	131.8	48.8	159.4
05491+6248	±11.61	±9.62	±0.012	±0.055	±0.5	±0.4	±2.1
STF 945	2679.33	4486.86	2.307	0.534	72.1	67.4	186.7
06404+4058	±38.68	±2.17	±0.056	±0.013	±0.4	±0.3	±1.5
STF 1146	570.44	2054.74	2.409	0.610	113.9	12.5	149.9
07479–1212	±13.65	±10.68	±0.084	±0.017	±0.4	±0.4	±1.7
HU 198	877.14	2020.98	0.822	0.446	103.7	130.1	14.1
18384+0850	±24.53	±23.27	±0.090	±0.026	±1.2	±0.3	±2.6

Table 3 Ephemerides

WDS Designation α, δ (2000)	Discoverer Designation	2007 θ ρ $[\circ]$ $['']$	2008 θ ρ $[\circ]$ $['']$	2009 θ ρ $[\circ]$ $['']$	2010 θ ρ $[\circ]$ $['']$
01015+6922.....	A 2901	61.0 0.408	61.4 0.407	61.8 0.407	62.2 0.406
01424–0645.....	A 1	250.1 0.819	250.5 0.821	250.8 0.822	251.2 0.823
01461+6349.....	STF 148	252.3 0.137	261.9 0.142	270.6 0.151	278.2 0.162
04374–0951.....	RST 3401	272.5 0.425	271.4 0.429	270.4 0.434	269.3 0.438
04478+5318.....	HU 612	358.1 0.655	358.6 0.657	359.1 0.660	359.6 0.662
05255–0033.....	A 848	175.0 0.298	175.5 0.302	176.0 0.305	176.4 0.309
05491+6248.....	STF 3115	337.9 0.786	337.3 0.783	336.6 0.779	335.9 0.775
06404+4058.....	STF 945	329.8 0.471	330.6 0.472	331.5 0.472	332.3 0.472
07479–1212.....	STF 1146	346.6 1.202	345.8 1.170	344.9 1.138	344.0 1.106
18384+0850.....	HU 198	130.7 0.461	130.4 0.460	130.1 0.460	129.8 0.459

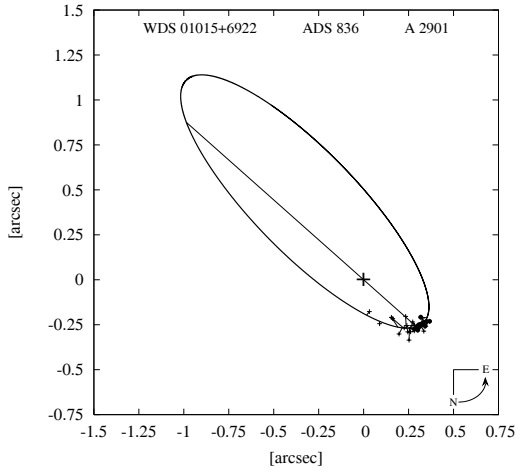

Fig. 1 Orbit of A 2901.

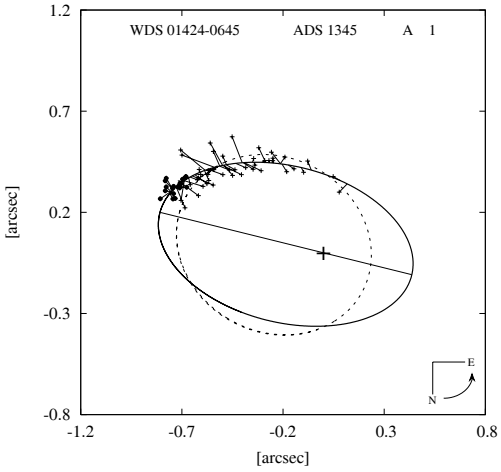

Fig. 2 Orbit of A 1.

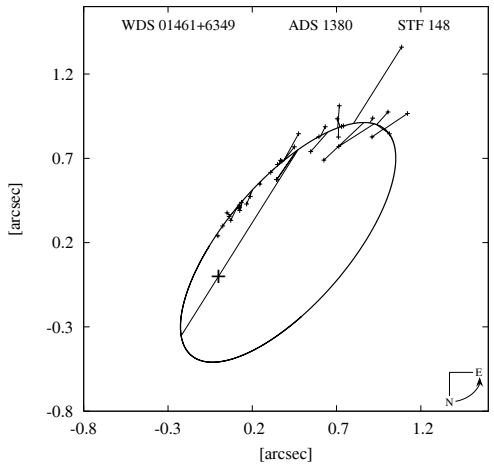

Fig. 3 Orbit of STF 148.

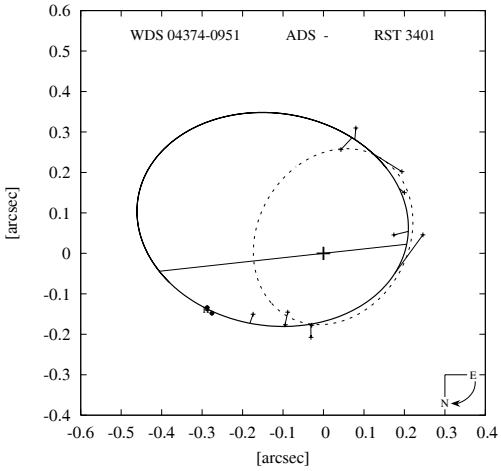

Fig. 4 Orbit of RST 3401.

WDS 01015+6922. This is a binary system discovered by R. Aitken in 1917 at the Lick Observatory, and up to the present day 49 observations have been made. The observations cover a short arc (47 °) and because of that this orbit should be classified as preliminary. The total mass of system calculated from our orbital elements and Hipparcos parallax is 19.2 $M_{\odot}$.

WDS01424–0645. This binary star was discovered by R. Aitken in 1899.78. Prior to this work, the orbit has been calculated by Erceg (1981, Inf. Circ. 85). Our solution and the Hipparcos parallax yield a total mass of 4.46 $M_{\odot}$, which is not a reliable value due to the large error in the Hipparcos parallax.

WDS 01461+6349. It was discovered by F. G. W. Struve in 1832.62, and up to the present day 36 observations have been made. According to our orbital elements and dynamical parallax ($\pi_{\rm dyn} = 0''.01123$), the total mass of the system is 2.3 $M_{\odot}$, and individual masses are 1.2 $M_{\odot}$ (primary) and 1.1 $M_{\odot}$ (secondary) that are in a good agreement with the expected value for this spectral type.

WDS 04374–0951. Since 1938.14 when it was discovered by R. A. Rossiter, 14 observations of this binary star have been made. Prior to our calculation, an orbit was published by Heintz (1979), but the predicted positions showed significant deviations from the most recent observations. The total mass of system is 1.5 $M_{\odot}$.

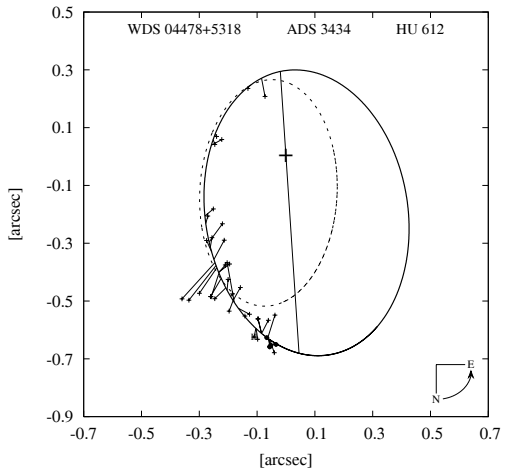

Fig. 5 Orbit of HU 612.

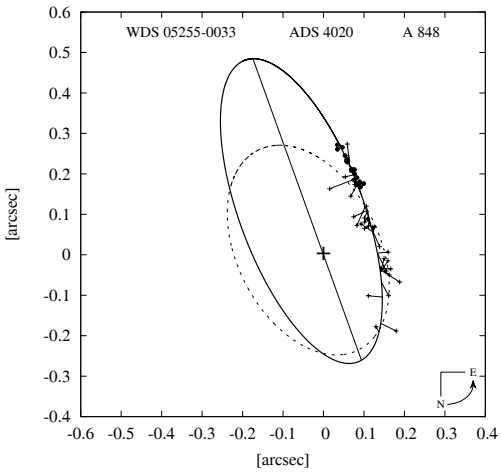

Fig. 6 Orbit of A 848.

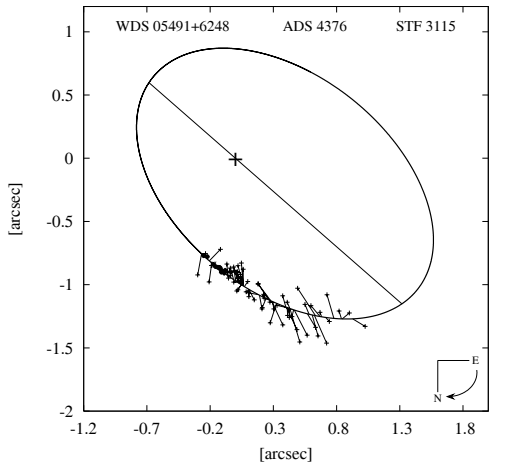

Fig. 7 Orbit of STF 3115.

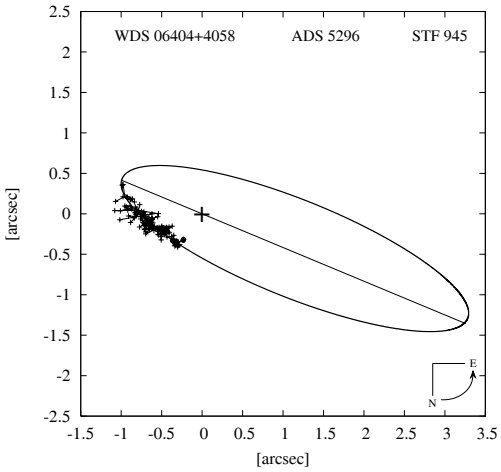

Fig. 8 Orbit of STF 945.

WDS 04478+5318. Since 1902.69 when it was discovered by W. J. Hussey, 38 observations of this binary star have been made. Prior to this work, orbits were calculated by Heintz (1979) and Starikova (1978) both with too short orbital period. The total mass of system is 2.4 $M_{\odot}$.

WDS 05255–0033. This binary star was discovered by R. Aitken in 1904.88, and up to the present day 49 observations have been made. Prior to this work, an orbit was calculated by Baize (1981), but it exhibits significant deviations from the position angles obtained from the most recent observations. The total mass of system, calculated from our orbital elements and Hipparcos parallax, is 2.6 $M_{\odot}$.

WDS 05491+6248. Since 1831.63 when it was discovered by F. G. W. Struve, 77 observations of this binary have been made. According to its spectral type (A4V) this star belongs to the main sequence, therefore, we are able to calculate the dynamical parallax and individual masses. The value of calculated dynamical parallax ($\pi_{\rm dyn} = 0\farcs00874$) is in a good agreement with a Hipparcos trigonometric parallax ($\pi_{\rm HIP} = 0\farcs00791 \pm 0\farcs00092$). The individual masses are 2.2 $M_{\odot}$(primary) and 1.7 $M_{\odot}$(secondary) which are reasonable values for the spectral type.

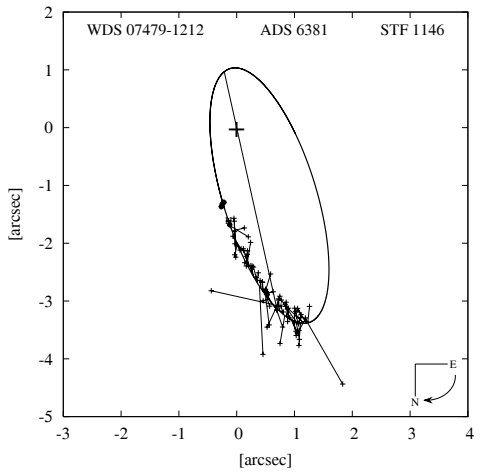

Fig. 9 Orbit of STF 1146.

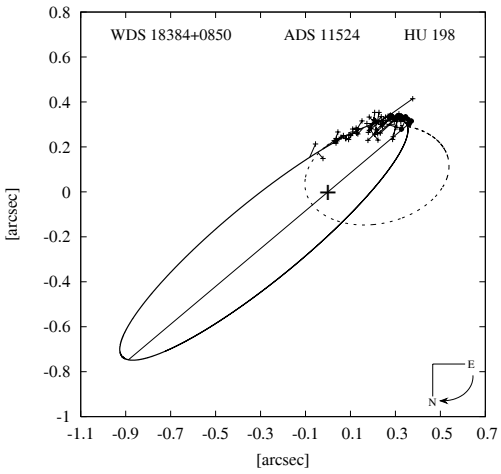

Fig. 10 Orbit of HU 198.

WDS 06404+4058. This binary star was discovered by F. G. W. Struve (1830.77), and up to the present day 119 observations have been made. That almost 180 years of observing covered only a short arc (75 °) indicates a long orbiting period. Our orbital elements are the first ones calculated of this binary.

WDS 07479–1212. Since 1831.83 when it was discovered by F. G. W. Struve, 87 observations of this binary have been made. The total mass of system calculated from our orbital elements and Hipparcos parallax is 1.2 $M_{\odot}$.

WDS 18384+0850. Since 1900.47 when it was discovered by W. J. Hussey, 73 observations of this binary star have been made. This star (also known as X Oph) is a Mira-type variable star with a composite spectrum, K1III+M6IIIe (Baize & Petit 1989) and variability period of 333.85 days (Templeton, Mattei & Willson 2005). The study of binary Mira-type variable stars is of particular interest for understanding stellar evolutions. Prior to this work an orbit was calculated by Baize (1980), but it exhibits deviations from the most recent observations. These deviations are not very large but are systematic. Our elements give a somewhat better fit. Although the trigonometric parallax from Hipparcos is not useful due to large error, we calculated the total mass of system using our orbital elements and parallax from Bright Star Catalogue (Hoffleit & Warren 1995). With a $\pi = 0''.011$ parallax value the total mass of system is 0.54 $M_{\odot}$.

3 CONCLUSIONS

In the cases where an old orbital solution exists, our solutions offer an improvement on the orbital elements. The derived parameters (masses and dynamical parallaxes) will be useful for some future work. In our opinion it will be especially interesting to keep under study the evolution of the binary star WDS 18384+0850 and the attention of observers should be drawn to a system containing a Mira-type variable star.

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