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Search for radial velocity variation in visual binary and multiple stars

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Abstract. Radial velocity measurements are given for 143 stars, predominantly for the components of visual binaries. A critical examination of the present and older observations extending over several decades indicates that the majority of the observed stars have a variable radial velocity. The cause of the radial velocity changes is the binary nature, multiplicity and/or the intrinsic variability of pulsating variable stars. Altogether 577 new radial velocity measurements are presented. For ADS 7651 the first RV curve is published.

Key words: stars – binary – spectroscopic – radial velocities – ADS 7651

1. Introduction

The determination of the radial velocities of the components of visual binaries was one of the programs conducted at the David Dunlap Observatory of the University of Toronto (hereafter DDO) and the University of Waterloo, Canada, for a long time. The results were published, e. g., by Doucet and Bakos (1972), Bakos (1974a) and Bakos (1974b). The aim of these studies at the beginning was mainly the calculation of the velocity components of the solar motion in the Galaxy using radial velocities, proper motions and parallaxes of selected stars. For the search for possible radial velocity variability several stars were tested. The observations were conducted until December 1988.

There is strong evidence that the radial velocity variations are very often present in the evolved stars of the luminosity I-IV. Altogether 1609 evolved stars were observed by de Medeiros and Mayor (1999). Among them 304 were spectroscopic binaries and 64 suspected spectroscopic binaries. For 138 spectroscopic binaries their orbits were already known or calculated by these authors. A large part of this sample indicates radial velocity variations. Also the percentage of the spectroscopic binaries is surely higher.

Massarotti et al. (2008) measured rotational and radial velocities of 761 giants selected from the Hipparcos catalogue. They also derived the $P(\chi^2)$ values.

($P(\chi^2)$ is a probability that the radial velocity of a star is constant.) In their experience, stars with $P(\chi^2) < 0.001$ often prove to be spectroscopic binaries. However, the $P(\chi^2)$ value itself is a feeble parameter for the search of spectroscopic binaries.

In the last decades a lot of work has been done in the field of double and multiple stars. The results and extensive lists of papers can be found in the references of Eggleton and Tokovinin (2008) and Tokovinin (2008).

The aim of this paper is to present new spectroscopic observations obtained within the DDO program, search for the radial velocity variations and an effort to interprete them.

2. Observations and reduction

The observational material was obtained at the DDO 1.88 m reflecting telescope Cassegrain focus with the use of two different spectrographs. At the beginning of the observations a one-prism spectrograph with a 63.5 cm camera and a dispersion of 33 $\text{Å}\,\text{mm}^{-1}$ was used with Kodak 103a-O photographic plates. Starting from July 1969 (JD 2 440 405) a grating spectrograph with a reciprocal dispersion of 12 $\text{Å}\,\text{mm}^{-1}$ and Kodak IIaO-B photographic plates were used. Measurements and reduction were carried out at the Waterloo University with a digitized Mann comparator. More than 95% of plates were measured by one of us (G.A.B.). The number of measured spectral lines varied from 6 to 33 on a plate and the number of the observations per star varied from 1 to 28. Radial velocities were computed by the method adopted at DDO using a computer of the Waterloo University. The standard error for a single measurement on the well-exposed plates with a sufficient number of measured lines for a 33 $\text{Å}\,\text{mm}^{-1}$ dispersion was in 22% higher than 2.0 $\text{km}\,\text{s}^{-1}$, and only in 20% of spectra above the 1.0 $\text{km}\,\text{s}^{-1}$ limit for the 12 $\text{Å}\,\text{mm}^{-1}$ dispersion spectra. The extreme values of the standard errors are not regularly distributed among the measurements of different stars. For some stars all these values are below the 1.0 $\text{km}\,\text{s}^{-1}$ limit and for the others all values are above this limit. The lowest values of σ were 0.58 $\text{km}\,\text{s}^{-1}$ for 33 $\text{Å}\,\text{mm}^{-1}$ spectra and 0.2 $\text{km}\,\text{s}^{-1}$ for the 12 $\text{Å}\,\text{mm}^{-1}$ ones. A full description of the instrument and its changes during the observational period can be found in Kamper et al. (1992).

3. Results

We present our radial velocity measurements for stars with ADS numbers in Table 1 (ADS catalogue numbers are typed in the Italics font). Column 1 contains the HD and ADS numbers, column 2 the heliocentric Julian data of the observations, column 3 the measured radial velocity values, column 4 the standard mean error of a single measurement and the last column contains the number of the measured lines. The designation of the primary component A was omitted except for the case when 2 or 3 components of the multiple system were observed. In Table 2 data for visual double stars without the ADS number and other type stars are listed (HIPPARCOS Catalogue numbers are typed in the Italics font). In the first column the Hipparcos number of the stars is used instead of the ADS designation.

Notes to Tab. 1 and Tab. 2 (only reliable data) were adopted from the literature, some beeing added by us. The references were numbered and their numbers are in square brackets in Notes to Tab. 1 and Tab. 2. For the spectroscopic binaries with known orbits (based on spectroscopic observations) only their orbital periods and eccentricities are given. For some of the stars values of probabilities $P(\chi^2)$ are given, as they serve as a parameter to qualify the reality of the observed radial velocity variations. These probabilities were adopted from de Medeiros and Mayor (1999). Notes were mainly created in order to draw the readers'/observers' attention to stars worth further observation. Notes on photometric variability were taken mainly from the Hipparcos Input Catalogue (ESA, 1992).

4. Summary and Discussion

In addition to data contained in Tables 1 and 2 information on radial velocities was available from other sources. These, in many cases, go back to the year 1900. Although the time intervals between observations show big gaps and in some cases the systematic errors surely exist and these errors may be involved in comparing observations from different spectrographs, the old observations were helpful in deciding whether a given star is constant or variable in the radial velocity. It has been found that systematic errors in radial velocities from different instruments play a much smaller role than it might have been expected. Usually radial velocity variations were found from a longer series of observations made at one place and confirmed by a similar series from another place (Bakos, 1974a).

The visual binaries listed here are wide pairs (separation 15 arcsec or more) and, therefore, taking into account the accuracy of our observations, no appreciable change in the radial velocity of the primary component resulting from the orbital motion is expected. The standard mean error of our observations is mostly between 0.3 $\mathrm{km\,s^{-1}}$ and 1.0 $\mathrm{km\,s^{-1}}$. However, a part of our observations has a standard mean error above the upper value of this interval. The higher accuracy of the radial velocity and longer series in the future will make it possible to find the higher percentage of spectroscopic binaries among the visual binary stars. As this program contains a large percentage of the stars of luminosity classes I – IV and of late type stars, it is reasonable to suppose that in some cases also pulsational variations are present. The information on the specific behaviour of some interesting systems is summarized in the Notes to Tables 1 and 2.

Table 1. RV measurements of stars from the ADS Catalogue.

Star	JD_{Hel}	V_r	σ	N	Star	JD_{Hel}	V_r	σ	N
HD/*ADS*	2400000+	(kms^{-1})	(±)		HD/*ADS*	2400000+	(kms^{-1})	(±)	
225009	35357.770	–13.2	1.5	18	7927	40461.814	–27.90	0.40	22
1 A	35359.770	-17.3	0.9	16	*1073*	44097.891	–28.03	0.84	16
	35389.726	–36.4	1.2	18	9546	35391.708	–30.30	1.20	21
	40475.791	–17.10	0.40	24	*1233*	35749.731	–30.5	1.2	18
	42312.759	–16.99	0.60	18	9774	40502.731	–5.20	0.44	18
	42717.507	–17.67	0.64	24	*1268*	43390.903	–7.08	0.62	26
225276	35371.783	–4.8	1.2	15	11049	35362.863	–13.0	3.3	10
42	42732.601	–3.90	0.56	27	*1435*	35375.878	–20.2	2.2	14
895	41640.554	–6.20	0.40	23		35383.815	–17.8	1.8	15
161	42340.652	–6.84	0.47	26		35741.812	–16.5	2.2	13
3165	41583.713	–8.4	0.4	25	11092	35368.821	–13.9	1.8	11
486	43012.848	–10.82	0.59	12	*1459*	35391.794	–16.8	2.2	13
	43054.771	–8.45	0.56	26		35401.712	–17.2	1.6	13
	43080.482	–11.94	0.68	23		35417.699	–19.1	1.5	15
3531	42753.563	–43.35	0.56	27		35468.560	–23.7	2.5	10
538	45210.853	–48.56	0.58	27		35480.522	–26.3	3.0	9
3574	41543.713	–8.45	0.46	26		35710.835	–33.0	1.6	19
546						43446.679	–20.00	0.93	7
3627	41605.617	–11.08	0.59	24	11727	35389.808	+4.4	1.5	18
548	42592.857	–12.25	0.65	20	*1534 B*	35390.906	+0.7	1.5	14
	42741.896	–11.30	0.88	16		35400.758	+3.1	2.1	16
	43341.844	–12.72	0.40	25		35736.808	+4.1	2.4	17
	43439.737	–14.65	0.83	20		35743.854	+5.5	1.8	22
	43501.520	–12.64	0.46	27		35749.776	+2.2	1.8	22
	43544.516	–15.01	0.49	22		35751.251	+3.2	1.5	18
	43810.704	–14.67	0.44	24	12533	40454.892	–10.6	0.3	26
	43852.532	–13.05	0.55	20	*1630*	40468.894	–10.9	0.3	26
	44475.908	–12.03	0.55	26		41605.640	–12.0	0.3	25
	45378.465	–13.31	0.50	29		42312.797	–11.00	0.34	27
	45608.739	–13.10	0.46	29		43501.445	–12.46	0.28	26
6540	35364.956	+8.3	1.5	21		44097.902	–12.00	0.42	27
915	35367.885	+7.4	1.0	10	13994	40461.844	–12.1	1.2	12
	35743.778	+6.7	0.9	15	*1753*	41955.825	–11.9	0.4	31
7864	42732.669	–27.25	0.50	25		42340.716	–14.1	0.4	25
1053	44615.556	–29.06	0.46	27		43501.652	–13.28	0.42	24
7927	35364.909	–17.08	1.19	20		43880.539	–14.53	0.44	26
1073	35401.583	–21.04	1.80	25		44202.672	–13.06	0.33	27
	40440.870	–25.09	0.70	15	15524	42753.623	+10.08	2.61	6
	42312.839	–29.09	1.67	14	*1904*	43194.581	–6.86	3.44	10
	42424.497	–26.01	0.92	18		43390.867	–3.61	2.42	11
	43501.585	–26.67	0.95	17		43810.792	–14.03	3.04	9
	43810.737	–30.90	1.01	20		45203.879	–23.27	4.42	22
						45217.911	–27.27	3.41	22

Table 1. Continued.

Star HD/*ADS*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N	Star HD/*ADS*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N
16028	41583.874	–6.3	0.3	24		45392.529	+45.66	0.45	29
1964					46328	41955.907	+32.21	1.16	25
16895	42424.459	+23.85	0.33	27	*5176*				
2081	42755.950	+25.24	0.43	22	48329	40915.714	+6.76	0.58	28
	43501.556	+23.17	0.42	27	*5381*	40915.812	+7.27	0.37	28
	43831.583	+21.52	0.44	27		40985.636	+7.18	0.61	28
	44251.674	+25.22	0.42	27	57044	43880.682	–34.50	2.16	11
	45210.900	+24.10	0.62	26	*6028*				
	45231.939	+23.78	0.59	28	62509	40915.788	+1.66	0.67	28
17506	41955.864	–0.9	0.4	28	*6335*	40957.900	+3.69	0.41	28
2157	42424.470	–0.46	0.43	26		40985.647	+2.74	0.47	28
	44475.897	–2.58	0.49	27		41408.583	+3.07	0.62	28
	45210.906	–2.15	0.66	25	71115	45420.626	+15.16	0.74	27
	45231.929	–0.63	0.89	27	*6805*				
22963	35358.894	–33.8	1.9	16	71152	41703.753	+14.09	1.63	24
2701	35377.857	–37.5	1.3	22	*6811 A*	42753.860	+19.48	1.75	22
	35743.907	–39.0	1.0	21		42851.564	+8.33	1.78	28
	42753.736	–35.51	0.50	27		43159.734	+17.20	1.85	27
	45608.833	–35.68	1.10	28		43558.673	+11.04	1.88	28
22912	43446.745	–22.08	0.70	25		43880.745	+14.63	0.81	23
2718	43880.604	–28.62	0.44	27		44216.852	+14.49	1.90	20
25893	41976.845	+26.54	0.53	27		44279.844	+15.36	1.93	27
2995	43054.878	+25.53	0.53	25		44335.719	+15.65	2.21	24
	44615.704	+27.88	0.44	25		44608.796	+19.47	2.00	21
	45608.916	+25.75	0.37	26		44678.649	+14.88	1.38	26
	45637.795	+23.86	0.35	27		45378.747	+19.12	1.27	27
26965	40822.906	–42.22	0.52	27		45392.647	+17.47	1.16	25
3093	40866.798	–43.70	0.47	26		45637.929	+18.59	1.64	23
	41583.905	–45.24	0.43	27	71153	42851.651	+14.54	1.90	23
	41668.682	–43.25	0.40	26	*6811 B*	44216.807	+15.39	1.05	26
	41955.886	–43.93	0.34	27		44279.755	+17.83	1.24	27
	42340.824	–43.62	0.43	27		44335.634	+16.01	1.94	26
32092	41976.923	–6.71	0.33	26		44678.649	+15.94	1.04	25
3608	42102.503	–6.39	0.38	27		45378.691	+19.42	0.78	27
	42823.588	–6.82	0.38	27	71369	43501.803	+17.88	0.77	28
	43544.563	–8.31	0.62	24	*6830*				
	43572.551	–7.12	0.62	24	74442	42717.690	+18.36	0.38	21
	44202.871	–9.13	0.70	27	*6967*	42885.389	+16.26	0.36	22
	44216.715	–7.54	0.52	27	82381	44251.699	+18.42	0.56	26
	45378.567	–7.18	0.98	28	*7416*				
	45420.533	–8.28	0.62	28	87822	41345.783	–14.10	0.62	27
	45637.888	–6.59	0.58	29	*7651*	41380.681	–11.95	0.80	23
36044	41976.891	+43.45	0.44	27		42060.821	–8.98	0.38	27
4086	43446.889	+41.50	0.70	27		42753.914	–5.64	0.53	27

Table 1. Continued.

Star HD/*ADS*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N	Star HD/*ADS*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N
87822	42837.732	–6.77	0.47	25	106365 B	35979.640	+5.9	3.1	15
7651	43229.645	–6.69	0.68	20	*8470 B*				
	43243.609	–7.51	0.61	21	106690	40600.815	–17.7	0.6	18
	43558.740	–7.95	0.58	23	*8489*	40677.826	–12.4	1.2	19
	43572.711	–7.41	0.71	20		40684.847	–17.2	2.4	15
	43628.682	–6.42	0.67	22		40691.715	–19.1	1.5	21
	43915.782	–13.65	0.37	26		40747.603	–14.7	0.4	19
	44678.716	–9.22	0.31	27		40950.865	–14.6	0.3	26
	44692.607	–9.00	0.40	27		40992.776	–14.5	0.4	25
	45049.688	–7.42	0.33	29		41048.740	–15.2	0.3	24
	45378.770	–4.20	0.42	29		41345.863	–15.5	0.3	26
	45392.681	–5.68	0.35	29		41443.691	–16.8	0.3	22
	45637.963	–6.36	0.46	28	107341	42921.620	+1.70	0.64	31
	47554.808	–15.07	0.98	19	*8516*				
	47565.812	–15.86	1.53	21	107700	35207.722	+6.5	1.9	11
	47575.793	–13.91	1.11	26	*8530*	35281.601	+6.1	2.5	10
	47582.715	–16.45	1.87	25	109511	41020.717	+1.28	0.33	20
	47587.644	–15.72	1.62	27	*8600 A*	41331.960	+1.85	0.55	23
	47593.654	–15.66	0.76	29		42172.665	+2.53	0.46	24
	47594.695	–15.11	1.13	29		43159.823	+3.74	0.46	24
	47598.661	–12.66	1.19	25		45378.839	+2.15	0.55	28
	47612.656	–14.52	1.05	29	109510	40992.836	–45.42	4.51	12
101177	42060.859	–18.13	0.62	28	*8600 B*		+42.90	0.70	23
8250	42753.958	–17.68	0.56	29		41020.761	–10.20	4.28	6
	43558.808	–16.89	0.46	28			+72.19	0.59	25
	43880.843	–20.95	0.46	27		42060.959	–44.20	0.61	11
	44692.662	–16.38	0.67	28			+61.53	4.37	11
	44727.636	–17.53	0.37	29		42172.651	–91.91	5.28	8
	45049.750	–16.78	0.28	29			+73.70	0.40	25
	45378.793	–17.62	0.30	29		43159.906	–51.36	0.68	25
	47554.881	–18.34	0.44	23			+58.68	3.85	14
	47575.896	–17.10	0.61	26	112033	41020.805	–7.68	0.38	25
	47582.807	–16.82	0.50	26	*8695*	41034.785	–8.67	0.44	24
	47593.730	–16.62	0.52	27		41331.933	–9.22	0.59	22
	47594.757	–17.25	0.95	27		42165.641	–6.76	0.56	25
	47598.765	–17.83	0.73	27		43243.658	–6.52	0.47	25
	47612.743	–19.15	0.92	26		43943.759	–10.66	0.40	27
103483 B	42060.892	–13.07	1.13	23		43978.656	–9.52	0.40	27
8347 B	43558.909	–10.13	1.63	27		44279.889	–8.26	0.42	27
103498	41331.890	–12.53	1.85	24		44363.651	–8.19	0.50	28
8347 D						45503.607	–3.47	0.76	31
106365	35392.746	–13.86	0.67	31	113022	42851.710	+4.25	0.74	25
8470 A					*8735*	42926.956	–2.70	1.38	21
						43194.807	+0.35	0.71	25

Table 1. Continued.

Star HD/*ADS*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ ($\pm$)	N	Star HD/*ADS*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ ($\pm$)	N
113022	43271.672	–1.72	0.71	24	*9626 A*	45503.646	–8.03	3.96	13
8735	43915.837	–11.69	0.67	27	137392	41048.819	–8.94	0.51	29
	43978.697	+0.19	0.64	24	*9626 BC*	42171.767	–8.66	0.53	29
	44363.684	+0.86	0.53	28		44363.786	–7.54	0.27	25
	45196.795	–5.3	1.3	23		44727.737	–8.47	0.44	29
	45245.635	+3.7	1.3	17		45378.978	–10.05	0.58	29
119124	42851.782	–12.55	0.44	27		45503.696	–9.26	0.50	29
8992	42922.542	–13.07	0.84	17	144064	43271.791	+ 8.71	1.0	31
	43194.901	–13.10	0.64	26	*9908*				
	43229.705	–13.98	0.36	25	145931	40691.750	–24.5	1.18	15
	44678.760	–13.49	0.42	29	*9962*				
123408	35197.860	–4.6	1.5	14	147165	40426.576	+2.91	5.03	12
9112	35240.688	–1.7	1.6	16	*10009*	40670.836	–21.98	2.60	9
	45392.828	–5.39	0.40	31	149930	45392.895	–45.28	0.50	28
126129	41331.982	–23.16	1.64	8	*10127*				
9247	41380.829	–26.20	7.78	7	150450	35244.692	–57.7	1.8	15
	41464.701	–16.21	6.05	7	*10144*	35302.607	–56.7	1.6	19
	41471.575	–30.85	2.10	8		35351.573	–59.3	1.9	15
	43159.978	–30.15	2.64	7	152863	41843.694	–0.1	0.4	23
127665	35207.764	–14.6	1.2	18	*10259*	42164.834	–1.74	0.33	29
9296	35245.649	–16.6	1.8	19		42851.870	–1.28	0.45	27
131041	41020.876	–38.70	0.74	31		42976.000	–0.34	0.39	29
9406 A	42172.684	–31.15	0.83	31		44727.778	–2.05	0.42	27
	44335.770	–32.52	0.80	27		45392.941	–2.29	0.42	29
	45378.950	–31.61	1.23	31	153882	41048.874	–31.36	1.84	17
131041	41020.907	–5.96	1.23	31	*10310*	43628.845	–34.26	2.12	17
9406 B	42172.702	–29.28	0.67	31	155103	41034.933	–32.86	1.45	10
	45378.924	–30.23	0.65	30	*10360*	43229.910	–31.34	3.08	15
135364	43243.831	–20.30	0.83	30		43628.803	–31.02	3.25	16
9539	45496.683	–22.45	0.59	31		43943.942	–29.05	1.76	12
135722	41478.578	–10.4	0.4	23		44041.743	–33.39	2.18	18
9559					157910	42961.922	–18.59	0.65	20
136202	42557.732	+50.88	1.36	22	*10535*	44678.907	–17.66	0.74	31
9584	42581.827	+52.88	0.47	25	159466	36100.559	–53.8	1.6	16
	42886.507	+53.77	0.37	24	*10633*	42976.672	–59.65	0.62	31
	42907.711	+52.18	0.70	27	160835	35907.883	–37.1	1.9	7
	43194.970	+53.60	0.46	27	*10715*	41843.767	–36.35	2.77	22
	43355.574	+52.95	0.38	30		42164.858	–40.48	0.56	31
	43628.736	+53.64	0.28	27		44727.817	–40.05	0.42	27
	43943.813	+52.10	0.38	27	161797	42200.715	–18.11	0.67	31
	44229.966	+53.58	0.37	27	*10786*	42969.630	–15.84	0.68	31
137391	42171.788	–11.69	3.74	11		43229.928	–18.21	0.56	31
9626 A	44342.877	–7.35	3.76	10		44041.680	–20.36	0.58	31
	44363.825	–10.62	5.08	13		44118.541	–15.41	0.56	31

Table 1. Continued.

Star HD/*ADS*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N	Star HD/*ADS*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N
10786	45217.517	–18.91	0.50	31	186704	35401.538	–10.0	1.5	11
165590	42164.885	–20.39	2.83	13	*12882*	44083.786	–5.80	0.79	28
11060	43355.660	–17.67	2.71	12	187013	42592.786	+4.48	0.44	26
	45217.562	–27.76	2.61	12	*12913*	42886.606	+3.74	0.49	23
	45559.665	–26.26	2.49	13		42891.543	+2.63	0.34	23
168092	35369.578	–39.4	6.7	3		42969.671	+3.81	0.37	25
11213	35373.583	–86.0	6.2	6		43341.738	+4.93	0.50	26
168656	40412.614	+6.4	0.6	17		44041.763	+0.74	0.36	28
11271						44363.837	+5.08	0.43	26
171586	42977.698	+4.71	2.71	17		44552.472	+4.95	0.52	27
11477	43327.671	–1.04	1.81	13		45224.646	+3.11	0.40	33
	45496.785	+0.50	4.83	13		45496.858	+6.70	0.44	27
171767	35343.647	–39.6	1.5	10	187638	42200.828	+7.00	0.46	29
11494	40747.704	–24.9	2.2	15	*12992*	43012.632	+8.24	0.62	29
	42977.775	–21.25	0.83	28		44041.809	+2.20	0.47	29
	43327.354	–23.60	0.86	27		44783.745	+7.87	0.38	27
172748	40412.657	–42.60	0.87	29		45147.811	+6.38	0.50	29
11581	40454.592	–34.57	1.22	26		45503.796	+6.80	0.56	29
	40468.540	–30.36	0.99	29		45637.489	+6.32	0.46	29
	41583.505	–30.74	1.05	29	187691	45231.607	–0.14	0.55	29
	42200.852	–41.16	2.71	29	*13012*				
174897	42921.837	+12.34	0.76	27	187849	40468.578	–40.1	0.3	24
11773	44727.858	+10.79	0.33	27	*13014*	40796.705	–37.3	0.6	16
175588	35373.604	–33.8	1.2	16		42634.751	–39.98	0.56	25
11825	40405.674	–29.2	0.4	22		44041.839	–41.59	0.52	26
	40412.688	–26.5	0.7	22		44433.779	–41.32	0.37	27
182955	40691.782	–30.4	2.4	18		44783.772	–40.81	0.58	24
12445	40440.653	–32.0	0.4	21		45608.559	–38.36	0.53	25
	40454.648	–32.6	0.3	24	189577	40468.619	–18.15	0.74	26
	40461.572	–32.2	0.6	13	*13230*	40813.678	–21.02	1.56	16
	40712.824	–32.0	0.4	16	190147	42613.742	+0.38	1.38	17
	40733.754	–31.4	0.4	17	*13278*	42962.901	+1.05	0.68	21
	40755.792	–31.4	0.6	21		44363.858	–1.35	0.40	27
	40813.593	–31.5	0.6	19	194093	31377.565	–3.39	1.56	16
	45553.740	–30.64	0.55	27	*13765*	38667.556	–9.19	0.58	19
183589	41548.671	–12.1	0.3	20		38669.535	–7.54	0.77	19
12520	41843.835	–9.87	1.62	19		38670.527	–7.00	0.65	20
185194	35245.861	–34.5	1.2	19		42200.861	–6.05	0.80	23
12693	35377.591	–38.8	0.9	17		42592.803	–5.40	0.77	20
	35707.571	–34.4	1.3	20		42717.224	–7.62	0.62	22
	42963.394	–33.11	0.61	23		42891.586	–7.22	0.92	25
	45496.837	–32.69	0.58	29		42897.570	–7.96	4.45	23
185622	40677.890	–3.0	1.9	16		42969.708	–7.36	0.38	25
12750						42969.713	–6.26	0.80	26

Table 1. Continued.

Star HD/*ADS*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N	Star HD/*ADS*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N
194093	43327.858	–8.28	0.68	26	204599	35369.675	–24.1	1.8	15
13765	43439.599	–7.54	0.73	26	*14998*	41906.757	–22.7	0.6	28
	43831.536	–8.52	0.49	21	206778	35389.646	+4.48	2.67	21
	44041.673	–9.39	0.63	25	*15268*	35392.577	+5.7	1.8	16
	44097.821	–8.10	0.40	25		40502.605	+6.6	0.4	20
	44118.562	–6.80	0.42	27		40747.847	+4.1	0.9	19
	44202.500	–7.65	0.47	26		41162.822	+4.7	0.2	27
	44342.910	–6.29	0.44	26		41548.742	+8.3	0.4	25
	44363.871	–5.83	0.43	28	208202	45608.601	+1.35	1.33	24
	44475.716	–8.20	0.46	27	*15431*				
	44587.461	–7.87	0.52	25	209166	42709.867	+4.81	0.43	26
	44783.864	–5.67	0.37	27	*15543*	42976.857	+5.29	0.56	25
	44943.480	–5.05	0.33	27		43355.763	+4.04	0.37	27
	45203.649	–7.71	0.40	27		44202.522	+3.57	0.37	27
	45210.686	–8.99	0.59	27		44433.824	+4.76	0.36	27
	45217.602	–9.34	0.74	27	209693	43012.700	–22.27	0.31	27
	45496.864	–6.01	0.61	27	*15602*	43054.654	–22.26	0.44	27
196197	44783.831	+7.27	0.44	27		44475.735	–23.35	0.38	27
14027						44587.505	–22.82	0.38	27
196758	42976.737	–47.25	0.76	27		45553.847	–22.19	0.67	28
14108	43341.772	–45.20	0.77	28	210461	41906.794	–43.88	0.40	27
198134	40412.795	–25.17	0.68	29	*15690*	43446.505	–44.99	0.49	27
14290	40747.829	–21.29	1.22	22	211073	41927.716	–9.71	0.64	25
	40813.747	–24.43	1.19	26	*15758*	42592.840	–11.23	0.56	26
	41216.662	–25.66	0.68	29		42976.829	–11.52	0.61	27
198387	42962.959	–36.53	0.67	22		43001.525	–11.44	0.60	18
14322	44097.853	–44.46	0.28	27		43390.737	–9.35	0.58	26
	44475.694	–43.28	0.44	27		44943.495	–11.43	0.33	29
	45210.720	–43.61	0.50	29		45147.852	–10.80	0.33	27
	45559.754	–43.56	0.38	28		45224.678	–12.00	0.63	24
198624	41642.465	–16.40	1.13	26		45503.862	–10.13	0.42	29
14345						45637.554	–10.49	0.50	25
199442	42976.787	–26.96	0.65	28	211153	44475.778	+17.67	0.40	27
14457	45231.669	–25.81	0.80	28	*15771*	45608.649	+14.75	0.41	28
200465	41885.757	–8.45	0.74	23	211300	41878.765	–3.20	0.47	27
14567	45203.697	–10.51	0.74	29	*15764*	42963.517	–2.88	0.62	21
	45217.639	–10.55	0.58	29		45637.609	–4.20	0.62	29
203504	40468.699	–77.51	0.52	29	214665	40454.744	+7.7	0.3	26
14909	42592.817	–77.46	0.50	27	*16140*	40468.730	+7.8	0.3	26
	42927.541	–76.50	0.77	19		43439.652	+8.59	0.64	23
	43000.976	–79.01	0.59	18	215373	40454.769	+11.6	0.4	26
	43355.737	–77.98	0.70	26	*16227*	41927.736	+14.12	0.46	26
	44433.870	–76.83	0.40	27		42753.465	+13.34	0.47	27
	45503.845	–77.09	0.50	29					

Table 1. Continued.

Star HD/*ADS*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N	Star HD/*ADS*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N
215373	43390.783	+11.49	0.40	26	218452	42753.501	–8.49	0.62	26
16227	45559.804	+12.81	0.26	28	*16526*	44083.835	–12.66	0.40	27
215549	45231.764	–2.11	0.40	29	219139	35302.848	+18.0	1.8	19
16248					*16603*	35368.734	+16.5	1.0	16
216397	41878.846	–17.3	0.6	31	219449	40822.826	–26.39	0.46	20
16325	41927.757	–18.4	0.9	25	*16633*	42964.557	–26.37	0.90	18
	45224.697	–17.12	0.68	25		43852.512	–23.28	0.61	18
216916	40433.857	–29.28	1.32	25		44202.552	–29.36	0.44	27
16381	40822.753	–33.75	1.72	22		44608.452	–26.19	0.38	27
	41640.527	+10.43	1.32	25	220007	41906.845	–4.7	0.7	24
	41878.808	+20.34	1.29	26	*16681*				
	41927.772	–10.86	1.44	22	222399	41955.721	–20.6	0.7	27
217906	42200.788	+9.13	0.47	27	*16913*	42340.685	–21.45	0.67	26
16483						42732.560	–23.64	0.93	20
218321	43446.574	–23.40	0.82	27		44083.864	–19.95	0.82	26
16520	44475.864	–17.69	0.47	27		44202.620	–21.36	0.73	26
	45217.753	–16.17	0.54	27		45224.799	–20.29	0.98	29
218535	45224.728	–14.72	0.89	22		45623.720	–21.15	0.99	27
16525					223582	45637.685	+11.63	1.05	23
					17038				

Notes to Table 1.

1 A component: Var [29], $P(\chi^2) = 0.133$ [9]
42 Var [9], SB?, $P(\chi^2) = 0.001$ [9]
161 The system is at least quadruple [25]
Var? [3] C component: Var, $P = 6.02628$ d, $e = 0.025$ [25]
486 B component: Var [5]
546 Var [5]
548 Var: $P = 20157.7$ d, $e = 0.34$ [24], $P = 21022.0$ d, $e = 0.512$ [23]
1073 Var [1], [29], quintuple system, A component: spectroscopic binary [17]
1268 Var [5], SB? [9], Suspected photometric var. NSV 567, Var 5: [12]
1459 Var [29]
1534 B component: Var? [29]
1630 B component: Var: $P = 2.67$ d, $e = 0.29$, the system is at least quadruple [25]
1753 Var? [5], $P(\chi^2) = 0.840$ [9]
1904 Var? [5]
1964 Var? [5], $P(\chi^2) = 0.155$ [9]
2081 Suspected photometric variable NSV 902 [12]

2157	A component: spectroscopic binary [22]
2701	Var? [29]
2995	V 491 Per, photometric variable BY Dra type, $P = 7.37$ d, B component: suspected photometric variable NSV 1463 [12]
3093	C component: flare star DY Eri, a strong X-ray source [22]
3608	C component: Var, $P = 186.28$ d, $e = 0.343$ [25]
5176	Var [2], photometric variable of β Cep type [12], [22]
5381	Var [2], suspected photometric variable NSV 3183 [12]
6335	Var, $P = 597$ d [18], often used as a RV standard [29]
6805	$P(\chi^2) = 0.378$ [9]
6830	$P(\chi^2) = 0.134$ [9], suspected photometric variable NSV 4093 [12], [19]
6967	$P(\chi^2) = 0.000000$ [23]
7416	A component: spectroscopic binary [22]
7651	Triple system, var [29], $P = 17.765$ y, $T_0 = 1989.133$ [16]
8250	Var [29], SB, $P = 1.730418$ d, B component: spectroscopic binary, $P = 23.54167$ d, $e = 0.4021$ [25]
8347	SB [24], B component: Var [2], multiple system [13]
8470	A component Var? [5], B component: Var [22], $P = 100.26$ d, $e = 0.45$ [4], erroneous identification of the components in [25]
8489	A component: spectroscopic binary [22]
8516	A component: spectroscopic binary [22]
8530	A component: spectroscopic binary, $P = 396.54$ d, $e = 0.566$ [25]
8600	Ambiguous designation of the A and B components by different authors [1]. B component: spectroscopic binary, $P = 7.3361$ d, $e = 0.26$ [25], A and B components: suspected photometric variables (NSV 5745, NSV 5748) [12]
8695	Spectroscopic binary, $P = 2914$ d, $e = 0.67$ [14]
8735	Var [2]
9112	Var? [29]
9247	Var? [29]
9296	Var [2], $P(\chi^2) = 0.055$ [9], $P(\chi^2) = 0.716359$ [23]
9406	A component: Var [2], B component: spectroscopic binary, $P = 12.822$ d, $e = 0.39$ [25]
9559	Var [5] $P(\chi^2) = 0.000$ [9], $P(\chi^2) = 0.04107$ [23], const. RV [28], SB [21], A component: suspected photometric var. NSV 7002 [12]
9584	Photometric variable MQ Ser
9626	A component: spectroscopic binary, $P = 298.75$ d [17], suspected photometric variable NSV 7063 [12]
9962	SB $P(\chi^2) = 0.000$ [9]
10009	Spectroscopic binary $P = 34.23$ d, $e = 0.36$ [25], A component: β Cep-type variable [17]
10144	Suspected photometric variable NSV 7896 [12]
10259	Var [5], A comp.: spectroscopic binary [22], $P(\chi^2) = 0.665$ [9]

10310	Var [2], Photometric variable V451 Her [22]
10535	Var? [5], $P(\chi^2) = 0.855$ [9]
10633	Var? [5]
10715	Var [29], [5], $P(\chi^2) = 0.780$ [9], spectroscopic binary [22]
10786	Var [29], $P(\chi^2) = 0.451$ [9]
11060	Quintuple system: A component: $P = 0.8795$ d, $e = 0.05$, photometric var. V772 Her, AB component: $P = 7397.54$ d, $e = 0.96$, C component: $P = 25.7631$ d, $e = 0.565$, photometric variable V885 Her [25]
11213	Spectroscopic binary, $P = 2.0476$ d, $e = 0.04$ [25]
11271	$P(\chi^2) = 0.412$ [9], $P(\chi^2) = 0.000013$ [23]
11477	Photometric variable FR Ser
11494	Spectroscopic binary, $P = 1510.3$ d, $e = 0.272$ [25]
11581	Prototype of δ Sct variables
11773	Var [5]
11825	Var [29], Photometric variability [12]
12445	Var? [5], [12]
12520	Var? [29], [5], Suspected photometric variable NSV 12088 [12]
12693	Var? [29], A component: suspected photometric variable NSV 12213 [12], $P(\chi^2) = 0.466$ [9]
12750	A component: spectroscopic binary [22], unknown period [5]
12882	Var? [5], B component: flare star [22],
12913	Var [2]
12992	Var? [29], [5]
13014	Var [5], A component: photometric variable V1509 Cyg.
13230	A component: irregular photometric variable VZ Sge.
13278	Var? [29]
13765	Var [29], [5], Suspected photometric variable NSV 13048 [12]
14108	SB [21]
14290	$P(\chi^2) = 0.514$ [9], A component: irregular photometric var. T Cyg
14322	Var? [13]
14567	Var? [5]
14909	B component: spectroscopic binary, $P = 1111$ d, $e = 0.29$ [25]
14998	Var? [5]
15268	Photometric variable ϵ Peg [12]
15431	A component: Var [2], $P(\chi^2) = 0.053$ [9]
15543	Var? [5]
15602	Var? [5]
15690	Var? [5], $P(\chi^2) = 0.762$ [9]
15758	Spectroscopic binary [22], $P = 612$ d [18], suspected photometric variable NSV 14076 [12]
15764	Var? [5], suspected photometric variable NSV 14078 [12] $P(\chi^2) = 0.897$ [9]

16140	Var? [5], suspected photometric variable NSV 14260 [12]
16227	Var [5], $P(\chi^2) = 0.310$ [9], $P(\chi^2) = 0.000000$ [23]
16325	Var? [5], photometric variable [12]
16381	Spectroscopic binary $P = 12.096864$ d, $e = 0.0539$. [25], photometric variable EN Lac
16483	Var [2], $P(\chi^2) = 0.401472$ [23], irregular photometric variable β Peg [12]
16520	Var [29]
16526	Var? [29], $P(\chi^2) = 0.183$ [9]
16603	Short period photometric variable [29]
16633	Spectroscopic binary, $P = 181$ d [18], suspected photometric variable [29]
16681	Spectroscopic binary, $P = 1520$ d, $e = 0.51$ [25], suspected photometric variable NSV 14506 [12]
16913	Var? [5], photometric variable ST And

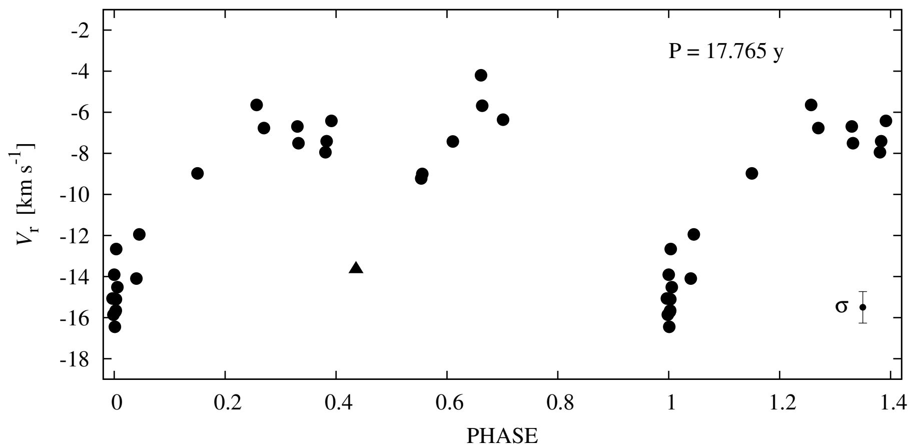

Figure 1. Measured radial velocities of ADS 7651 arranged in the phase diagram according to ephemeris from Hartkopf et al. (1996), see notes to Table 1. A typical error value of one measurement is depicted in the lower right corner.

In Figure 1 we demonstrate the accuracy of our data in the case of ADS 7651, for which no spectroscopic RV curve has been published up to now. The period ($P = 17.765$ y) and time of periastron passage were taken from the interferometrically determined orbit by Hartkopf et al. (1996). The triangle represents our observation at JD 2 443 915.782, when probably the B component was observed, as the brightness difference between the A and B components is only

0.3 mag. Another possible explanation of the odd position of our measurement at phase 0.436 is that the period value is half of that published by Hartkopf et al. (1996). The alternative RV curve with the half period value (P = 8.882 y) is shown in Figure 2.

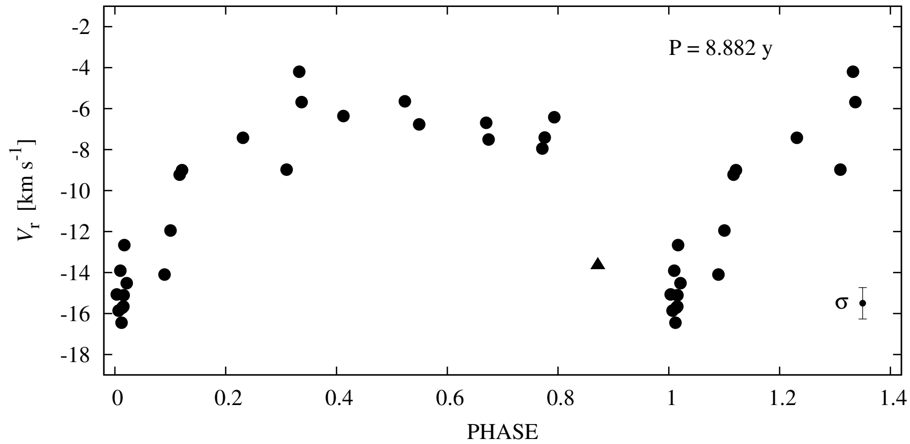

Figure 2. Measured radial velocities of ADS 7651 arranged in the phase diagram according to ephemeris with the half value of the orbital period.

Table 2. Stars not included in the ADS catalogue.

Star HD/*HIP*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N	Star HD/*HIP*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N
26	41216.806	−210.37	3.71	14	77247	40950.793	−21.11	0.67	31
447					*44464*	40992.705	−20.55	0.65	30
6833	40812.847	−246.47	1.93	14		41048.569	−11.46	0.65	30
5458	40831.869	−244.02	0.40	24		41703.806	−11.36	0.55	28
12929	43810.756	−16.01	0.42	27	101013	40950.938	−11.14	0.65	27
9884					*56731*	41048.674	−12.52	0.33	25
22649	40915.755	−23.94	0.86	20	101501	40950.988	−6.60	0.53	30
17296	40950.486	−19.83	0.52	24	*56997*	40985.792	−8.07	0.58	30
	40985.485	−17.35	0.38	20		41048.618	−6.36	0.55	30
28033	45378.508	+26.26	0.39	29		41422.693	−6.06	0.65	30
20712						41443.564	−3.95	0.67	29
31487	40957.685	−7.14	0.62	21	139195	41048.911	+0.70	0.76	30
23168					*76425*	41345.974	+1.43	0.50	31
44033	40950.562	+31.08	0.95	26		41380.868	+0.93	0.53	30
30099	40985.685	+30.47	1.22	25	140283	42164.799	−171.57	1.26	22
	41583.924	+29.49	1.10	25	*76976*				

Table 2. Continued.

Star HD/*HIP*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N	Star HD/*HIP*	JD_{Hel} 2400000+	V_r (kms^{-1})	σ (±)	N
	41668.820	+32.48	0.58	28	171955	42249.714	–19.59	1.85	14
44537	40957.753	+5.33	0.74	26	*91342*				
30520	40985.730	+5.69	1.30	27	173853	42172.856	–19.52	0.98	29
45829	40992.629	+12.54	0.84	27	*BD–16 5034*				
30970	41331.733	+12.71	0.79	28	199939	40915.479	–45.07	1.65	21
	41668.746	+11.03	0.65	27	*103546*				
76294	40957.889	+21.46	0.56	28	210745	41216.676	–17.08	0.42	27
43813	40985.766	+21.39	0.79	28	*109492*				
	41048.531	+21.49	0.59	28	222404	41216.731	–41.92	0.28	27
					116727				

Notes to Table 2.

12929 Var? $P = 10.96$ d, ampl. 0.24 km/s [26], $P(\chi^2) = 0.000000$ [23]
Suspected photometric variable NSV 725 [12]
22649 Spectroscopic binary, $P = 596.21$ d, $e = 0.088$ [25]
Photometric variable [8]
28033 Spectroscopic binary $P = 8.55037$ d, $e = 0.222$ [25]
31487 Spectroscopic binary $P = 1066.4$ d, $e = 0.045$ [25]
44033 Suspected photometric variable NSV 2917 [12]
44537 Var [2], photometric variable ψ Aur [12]
45829 Var [14]
77247 Spectroscopic binary $P = 80.53$ d, $e = 0.09$ [25]
101013 Spectroscopic binary $P = 1710.9$ d, $e = 0.195$ [25]
101501 Var [29], [12], suspected photometric variable NSV 5291 [12]
139195 Spectroscopic binary $P = 5324.0$ d, $e = 0.345$ [25]
140283 Var? [7], suspected photometric variable NSV 7210 [12]
171955 Photometric variable EW Sct
199939 Spectroscopic binary $P = 584.9$ d, $e = 0.284$ [25]
210745 Spectroscopic binary $P = 533$ d [18],
Suspected photometric variable NSV 14066 [12]
222404 Spectroscopic binary $P = 24\,135$ d, $e = 0.389$ [25],
Suspected photometric variable NSV 14566 [12]

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