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PROGRESS REPORT ON THE RADIAL VELOCITY MEASUREMENT PROGRAMME OF POPULATION II STARS

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Abstract. The Population II radial velocity measurement programme was started in 1988 and was carried out during six observing runs. Metal-deficient stars, components of Population II visual binaries or common proper motion pairs, suspected radial velocity variables, HIPPARCOS programme stars are included into the observing programme. The measurements were made with the 1-m reflector at the Maidanak Observatory (h = 2400 m, Uzbekistan). Mean precision for a single measurement is about 0.6 km s^{-1}, but for stars as faint as 13^m or for extreme metal-deficient stars it drops down to 2.5 km s^{-1}. 1140 measurements for 208 stars were made. Among them 29 radial velocity variables have been detected.

Key words: techniques: radial velocities – stars: Population II – stars: variables

1. Introduction

The importance of radial velocity investigations of Population II stars is well known and evident: they are necessary not only for the determination of kinematical parameters, but also are used for distance determinations by the statistical parallax method. It is very important that radial velocity measurements can directly be used in kinematical population segregation – many stars with large radial velocities are included into high-velocity and other catalogues of Population II stars. Another very important domain of radial velocity application is the detection of Population II spectroscopic

binaries. These stars are crucial for our understanding of the formation of the Galaxy and its early dynamical and chemical evolution.

Long-term radial velocity surveys of Population II stars (especially orbit determinations of long period spectroscopic binaries) were started only in the last decade, when the CORAVEL-type (Mayor 1985) or digital (Latham 1985) radial velocity speedometers became available, allowing one to make fast and precise (better than 1 $\mathrm{km\,s^{-1}}$) radial velocity measures of faint Population II stars. Here we would like to mention some of the largest surveys. The Latham group (Carney and Latham 1987b) with the CfA digital speedometer have measured 914 high-proper-motion stars and presented orbital solutions for 80 metal-deficient subdwarfs (Latham et al. 1988, 1992). A similar survey of metal-deficient field giants was undertaken by Carney et al. (1985) and Carney and Latham (1986), and among them several spectroscopic binaries have been found (Carney and Latham 1986, Latham 1993). Ardeberg and Lindgren (1985a,b) have measured with the CORAVEL spectrometer about 1700 metal-deficient stars. Fouts and Sandage (1986) have measured 889 high-proper-motion stars and found 46 candidates for spectroscopic binaries (Fouts 1987) with a classical coude spectrograph and Reticon detector. McClure and Woodsworth (1990) have published orbital solutions for 8 CH, or Population II carbon stars, as a result of long-term monitoring with their radial velocity spectrometer.

2. Programme and observations

Our programme of Population II star radial velocity measurements was started in 1988. The primary goal of the programme was to study the following types of stars: metal-deficient stars identified photometrically from the MDPH catalogue (Bartkevičius 1983, 1993), HIPPARCOS halo programme stars (Bartkevičius 1994), high-galactic-latitude and high-tangential-velocity stars, components of halo visual binaries, suspected radial velocity variables and some other stars with well defined parameters from the MDSP/MDSPS1 catalogues (Bartkevičius 1980, 1984). In realizing the programme, an unexpectedly large number of radial velocity variables, especially among metal-deficient star candidates from the MDPH catalogue, were found. This fact has changed the priorities of our programme and, therefore, more efforts have been made for observations of such stars.

The measurements were made during six observing runs by one of us (J.S.) with the CORAVEL-type photoelectric radial velocity speedometer built by Tokovinin (1987) at the Sternberg Astronomical Institute in Moscow and attached to the 1 m reflector of the Lithuanian Institute of Theoretical Physics and Astronomy at the Maidanak Observatory ($h = 2400$ m) in Uzbekistan. For the reduction of the measurements to the standard system, some five stars from the Mayor and Maurice (1985) list were observed every night.

3. Results

1140 measurements of 208 programme stars have been made. A typical precision of a single velocity measurement is about ± 0.6 km s^{-1}, but for the faintest stars ($V \approx 13$ mag) and for extreme metal-deficient stars showing a small correlation dip, it drops down to ± 2.5 km s^{-1}. A preliminary comparison of our stars we have in common with Jasniewicz and Mayor (1988) and Carney and Latham (1986) shows good agreement, with the zero-point differences amounting to only 0.5 km s^{-1}, our values being systematically lower by about 1% (Bartkevičius and Sperauskas 1990). Preliminary results of the measurements of 81 stars in 1988 are presented by Bartkevičius et al. (1992), and a discussion of metal-deficient binaries and 15 suspected radial velocity variables is presented in Bartkevičius and Sperauskas (1990).

To this day, 29 suspected spectroscopic binaries have been detected from our data. These are the stars with velocity ranges exceeding a fivefold internal error for one measurement. In Table 1 we list observational data for these stars: the star's number, the 1950 equatorial coordinates, heliocentric Julian Day of the first observation, the time interval between the first and last observation, minimum and maximum values of the radial velocity, the mean internal standard error of one measurement and the number of measurements. In Table 2 we present some data about suspected variables, taken mainly from Population II Star Catalogue POP2 (Bartkevičius and Bartkevičienė 1993) and other catalogues. In this table we repeat the star's name and coordinates and present the V magnitude, colour index $B - V$, spectral type (with PH denoting photometric classification), [Fe/H] value or some metallicity index, star's belonging to one of our programme branches. In the Notes following Table 2, some additional information taken mostly from the Index Catalogue of Visual Double Stars on magnetic tape (IDS; Worley 1977) is given.

Table 1. Stars with variable radial velocities

No.	Star	α (1950)	δ (1950)	JD(first) +2400000	Span (days)	V_r(min) (km·s^{-1})	V_r(max) (km·s^{-1})	σ_{V_r} (km·s^{-1})	N
1.	HD 23439B	$03^h43^m37^s$	+41°17′.4	47572	378	43.54	52.40	0.58	4
2.	HD 26872A	04 13 01	+36 36.6	47567	1495	−41.55	20.23	1.44	33
3.	HD 26872B	04 13 01	+36 36.6	47935	1127	−55.05	68.97	2.17	15
4.	HD 44517	06 19 35	−05 25.8	47569	1107	5.51	41.49	1.79	13
5.	HD 50975	06 53 04	+08 56.6	47572	1493	−7.06	22.93	0.53	32
6.	HD 66948	08 03 38	+22 36.1	47200	1864	−7.39	2.98	0.41	22
7.	HD 68119	08 09 39	+49 22.5	47200	1865	−21.40	6.54	1.29	29
8.	HD 73394B	08 36 43	+51 55.8	47572	1101	−76.85	12.53	2.48	12
9.	HD 107346	12 17 54	+10 15.0	47202	1862	−10.67	−2.40	0.96	20
10.	HD 108693	12 26 38	+31 40.0	47202	1844	−54.59	−41.69	0.62	13
11.	HD 111312	12 45 54	−15 26.8	47213	1829	−10.25	0.54	0.50	11
12.	HD 111908A	12 49 58	+07 28.7	47568	1494	24.35	42.56	0.58	11
13.	HD 111908B	12 49 58	+07 28.7	47568	1494	−7.21	0.66	0.46	11
14.	HD 116204	13 19 17	+39 08.5	47216	1849	−4.59	18.84	0.35	29
15.	HD 118244	13 32 50	+22 45.2	47579	1483	−19.91	−11.08	0.57	9
16.	HD 119944	13 43 34	+27 28.6	47575	1490	11.53	33.42	0.35	23
17.	HD 124605A	14 11 52	+18 18.9	47572	1493	−15.79	72.37	1.13	25
18.	HD 124605B	14 11 52	+18 18.9	48663	398	−11.09	10.88	2.46	7
19.	HD 131040A	14 47 55	+51 34.8	47568	1105	−6.57	5.97	1.10	10
20.	HD 135148	15 10 55	+12 38.6	47565	1497	−95.08	−86.26	0.81	9
21.	BD +14°2519	12 33 26	+13 46.0	47203	1836	−59.44	10.77	2.44	8
22.	BD +18°2757	13 34 07	+18 24.4	47565	1496	−31.23	−15.17	1.35	14
23.	BD +18°2890	14 29 53	+17 38.2	47566	1496	−33.12	−17.71	1.16	9
24.	BD +26°2062	10 14 06	+26 05.2	47564	1450	−14.80	42.42	0.88	33
25.	BD +26°2498	13 47 00	+26 07.8	47572	1486	−27.36	−5.49	0.81	11
26.	BD +38°1670	06 59 40	+38 13.2	47565	1107	43.76	125.71	1.00	18
27.	LDS 936B	12 17 18	+15 35.0	47213	738	25.12	63.78	1.74	4
28.	VA 531	04 26 23	+15 19.0	47567	737	24.98	55.69	1.88	5
29.	VA 677	04 29 38	+13 00.3	47567	754	−31.13	96.87	1.70	7

Notes to Table 1.

1, 2. HD 23439. A: V_r = +49.76 ± 0.27 km s^{-1}, n = 4. B: SB: P = 48.666± 0.026 d, γ = +51.5 ± 0.1 km s^{-1}, K = 10.31 ± 0.17 km s^{-1}, n = 28 (Latham et al. 1988).

4. HD 44517. Variable V_r: $\overline{V}$ = +20.7 ± 13.2 km s^{-1}, range = 43.7 km s^{-1}, span = 861 d, n = 26 (Carney and Latham 1987a). SB: P = 22 d (Latham 1993).

8. HD 73394. A: V_r = -100.96 ± 0.16 km s^{-1}, n = 8.

10. HD 108693. Variable V_r: $\overline{V}$ = -50.7 ± 3.5 km s^{-1}, range = 13.3 km s^{-1}, span = 1065 d, n = 27 (Carney and Latham 1987a). SB: P = 438 d (Latham 1993).

12,13. HD 111908. A: V_r = +19:? km s^{-1}. B: V_r = + 7 km s^{-1} (Eggen 1988).

16. HD 119944. V_r = +13.8 km s^{-1} n = 4 (Abt and Biggs 1972).

17,18. HD 124605. SB2 (Abt 1986).

19. HD 131040. A and B both SB (Hoffleit and Jaschek 1982). B: V_r = -30.18 ± 0.33 km s^{-1}, n = 3.

20. HD 135148. Variable V_r: $\overline{V}$ = -91.9 ± 4.4 km s^{-1}, span = 541 d, n = 6 (Carney and Latham 1986). Variable V_r: $\overline{V}$ = -89.6 ± 3.8 km s^{-1}, range = 10.0 km^{-1}, span = 917 d, n = 12 (Carney and Latham 1987a).

22. BD +18°2757. Variable V_r: $\overline{V}$ = -22.2 ± 5.4 km s^{-1}, span = 478 d, n = 8 (Carney and Latham 1986). Variable V_r: $\overline{V}$ = -26.0 ± 5.5 km s^{-1}, range = 16.0 km^{-1}, span = 893 d, n = 16 (Carney and Latham 1987a).

23. BD +18°2890. Variable V_r: $\overline{V}$ = -22.6 ± 5.3 km s^{-1}, span = 498 d, n = 13 (Carney and Latham 1986). Variable V_r: $\overline{V}$ = -26.3 ± 6.8 km s^{-1}, range = 18.6 km^{-1}, span = 811 d, n = 20 (Carney and Latham 1987a).

24. BD +26°2062. A; HD 89055, BD +26°2065. V_r = -14.63 ± 0.22 km s^{-1}, n = 5.

26. BD +38°1670. V_r = +50.5 ±3.0 km s^{-1}, n = 3. Variable V_r: Other V_r = -37.2 km s^{-1}, +73.1 km s^{-1} (Sandage and Fouts 1987). SB: P = 85.05± 0.10 d, γ = +64.00 ± 0.17 km s^{-1}, K = 22.58 ± 0.28 km s^{-1}, n = 25 (Latham et al. 1992).

27. LDS 936. A: V_r = +48.09 ± 0.40 km s^{-1}, n = 7.

29. VA 677. B: V_r = +15.25 ± 2.07 km s^{-1}, n = 1.

Table 2. Parameters of stars with variable radial velocities

Star	α (1950)	δ (1950)	V	$B-V$	Sp	Programme branch	Metallicity
HD 23439B	$03^h43^m37^s$	+41°17′4	8.75	0.90	sdK3	VB,ST	[Fe/H] = −1.05
HD 26872AB	04 13 01	+36 36.6	8.96	(0.56)	sgF8wl(PH)	PH	δm_1 = 0.108
VA 531	04 26 23	+15 19.0	12.50	(1.21)	MDGE-K2(PH)	PH	[Fe/H] = −3.0:
VA 677	04 29 38	+13 00.3	10.90	1.18:	sd(PH)	PH	[Fe/H] = −1.5:
HD 44517	06 19 35	−05 25.8	8.03	(0.52)	MDG-F7,RHB(PH)	SB?,ST	[Fe/H] = −0.88
HD 50975	06 53 04	+08 56.6	7.55	(0.67)	sdG4(PH)	PH,VB?	δm_1 = 0.075
BD +38°1670	06 59 40	+38 13.2	9.45	0.64	G0	SB?	[Fe/H] = −0.75
HD 66948	08 03 38	+22 36.1	7.22	(0.73)	G3Vwl	PH	Δm_1 = 0.12
HD 68119	08 09 39	+49 22.5	8.3		F5	HV-HPV	
HD 73394B	08 36 43	+51 55.8	10.01	(0.55)	F8V(PH)	VB,ST,HP	[Fe/H] = −0.1
BD +26°2062	10 14 06	+26 05.2	8.8			VB	
LDS 936B	12 17 18	+15 35.0	12.81	(0.60)	MDSGE-G3(PH)	VB,PH	[Fe/H] = −1.1:
HD 107346	12 17 54	+10 15.0	10.34	0.83	K1(V?)PEC(PH)	VB?,PH,HP	$\delta(U-B)$ = 0.40
HD 108693AB	12 26 38	+31 40.0	7.93	0.60	MDSGE-G6(PH)	SB?,VB	[Fe/H] = −1.5
BD +14°2519AB	12 33 26	+13 46.0	10.13	0.97	K0	PH	$\delta(U-B)$ = 0.19
HD 111312	12 45 54	−15 26.8	7.94	0.96	K2V	PH	$\delta(U-B)$ = 0.21
HD 111908A	12 49 58	+07 28.7	9.35	(1.40:)	K2/3III	VB	[Fe/H] = −0.26
HD 111908B	12 49 58	+07 28.7	9.43	1.38	C2,0CH	VB	
HD 116204	13 19 17	+39 08.5	7.21	1.16	K2	PH	$\delta(U-B)$ = 0.16
HD 118244	13 32 50	+22 45.2	6.91	0.43	F5; sd(PH)	PH	δm_1 = 0.06
BD +18°2757	13 34 07	+18 24.4	9.84	0.75	F8; AGB	SB?,ST	[Fe/H] = −2.5
HD 119944	13 43 34	+27 28.6	8.00	1.24	K2III	PH	$\delta(U-B)$ = 0.16
BD +26°2498	13 47 00	+26 07.8	9.79	0.86		PH	$\delta(U-B)$ = 0.17
HD 124605AB	14 11 52	+18 18.9	7.5		F9Vwl	SB?	
BD +18°2890	14 29 53	+17 38.2	9.84	(0.77)	MDGE	SB?,ST	[Fe/H] = −1.9
HD 131040A	14 47 55	+51 34.8	6.41	0.40	F5IV	VB	Δm_1 = 0.01
HD 135148	15 10 55	+12 38.6	9.49	(1.32)	CH; K0	SB?	[Fe/H] = −1.80

Notes to Table 2.

VB: visual binary.
SB: spectroscopic binary.
SB?: variable radial velocity.
PH: photometric classification.
HV: HPV: high velocity star from reduced proper motion diagram.
ST: standard star with known [Fe/H].
HP: HIPPARCOS programme star (Bartkevičius 1994).
UU HER?: suspected UU Herculis-type star.
VA: van Altena W.F. Low Luminosity Members of the Hyades Cluster. I, II. AJ, 71, 482, 1966; AJ, 74, 2 1969.
GH: Giclas H.L., Burnham R., Thomas N.G. A Proper Motion Survey in the Hyades. Bull. Lowell Obs., No. 118, 1962.

HD 23439. B: MDSP 186; ADS 2757, IDS 03401N4110. AB: d= 8.″0, PA = 50°, A: MDSP 185. $V = 8.14$, $B-V = 0.78$, sdK1, [Fe/H] = –1.02.

VA 531. GH 7–239.

VA 677. GH 7–256.

HD 50975. Composite: F8Ib+early type?

HD 73394. ADS 6906, IDS 08330N5166. AB: d = 49.″1, PA = 317°; BC: d = 6.″4, PA = 276°. A: $V = 7.71$, $B-V = 1.07$. G5III:s, MDG. [Fe/H] = –1.45.

BD +26°2062. IDS 10113N2582. AB: d = 852.″4, PA = 261°. A: HD 89055, BD +26°2065. $V = 7.60$, $B-V = 0.59$, $\delta(U-B) = 0.19$.

LDS 936. AB: d = 36″, PA = 221°. A: $V = 11.60$, $B-V = (0.85)$. MDG-K0III. [Fe/H] = –0.6.

HD 108693. ADS 8569, IDS 12242N3157. P = 600 d, a = 0.″61, A: $m = 8.3$, B: $m = 9.9$.

HD 111908. IDS 12474N0745, HJ 2621. AB: d = 34.″7, PA = 84°, AC: d = 38.″5, PA = 130°, BC: d = 28.″2, PA = 190°. C: $V = 11.19$, $B-V = (0.54)$. Description of the system (Eggen 1988).

BD +18°2757. MGGE–F0I/G7II-III(PH).

HD 131040. ADS 9405, IDS 14463N5147. AB: d = 15.″7, PA = 88°. B: $V = 9.86$, $B-V = 0.98$. $\delta(U-B) = 0.18$.

4. Future work

In near future we plan to publish a complete catalogue of radial velocities observed in 1988–1993. In order to confirm the radial velocity variables from the external evidence, a literature search is being made. For variable velocity stars with adequate material, orbital solutions will be made.

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