SPECTROSCOPIC INVESTIGATIONS OF CEPHEIDS IN CARINA

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ABSTRACT. Spectroscopic investigations of seven southern Cepheids WW Car, SX Car, UZ Car, UY Car, GX Car, HW Car and YZ Car have been performed. It was founded out six objects have metallicities, close to solar one and their CNO-, odd elements and Mg content indicate that these objects are on the stage after the first dredge-up. Cepheid WW Car is an unusual objects because it has noticeable overabundance of [C/H] = +0.3 dex, [N/H] = +0.95 dex, whereas sodium in deficient ([Na/H] = -0.46 dex), and magnesium content is the largest ([Mg/H] = -0.12 dex) in comparison with other objects from this list having close pulsation periods.

Key words: Stars: Cepheids; stars: individual: WW Car, SX Car, UZ Car, UY Car, GX Car, HW Car, YZ Car.

1. Introduction

Region in Carina is still insufficiently explored among ones contained the classical Cepheids. Especially it concern to the faint objects. To fill up the gap in thise explorations we have obtained some spectra of seven faint Cepheids (see Table 1). At that only two objects from this list have been more or less investigated in detail, - SX Car and YZ Car. SX Car have been regarded as a possible member of Ruprecht 91 open cluster in Carina, located on the its periphery, nevertheless it assumption was omitted (Turner et al., 2005). This Cepheid is a possible binary with companion of $B6.5$ spectral type (Turner, 1996). Its pulsational period is very stable, and O-C diagram do not shows any significant increasing or decreasing. Instead YZ Car is a well-known binary system with orbital period 657.3 days (Petterson, Cottrell & Albrow, 2004). Its Companion is a main-sequence star $B8\ V - A0\ V$ with mass range from 2.2 - 2.9 $M_{\odot}$. (Evans & Butler, 1993). According to Petterson et al. (2004) this Cepheid has $T_{eff} = 5900$ K; $L = 9350\ L_{\odot}$, and $M = 7.7\ M_{\odot}$. It, probably, is a supergiant on the stage of second crossinng of Cepheids instability strip (Petterson, Cottrell & Albrow, 2004).

2. Observations

Observations of these objects have been realized using 1.5m Hexapod telescope equipped by Bochum Echelle Spectrograph for OCA (BESO) (ESO, Chile): $\lambda\lambda$ 4961-8861 Å in 65 orders, and resolving power R = 48 000, and S/N ratio from 25 to 75 (see Table 1). The exposition time consists 1800 s for the each spectrum.

The reduction was made using IRAF software, the MIDAS context ECHELLE modified for extraction of echelle spectra obtained with an image slicer (Yushkin & Klochkova 2005) , DECH20 software (Galazutdinov, 1992).

3. Atmosphere parameters and chemical composition

Atmosphere parameters were determined:

1. T_{eff}: line depth ratio (Kovtyukh & Gorlova, 2000).

Table 1: Program stars spectra

Star	Period (days)	V (mag)	Spectral type	Num. of spectra	S/N
WW Car	4.67	9.748	$F0$	1	25
SX Car	4.86	9.090	$F5II$	1	50
UZ Car	5.20	9.331	$G0$	1	30
UY Car	5.54	8.949	?	3	75
GX Car	7.20	9.341	$F8II$	1	35
HW Car	9.20	9.128	$G2-G3Ib-II$	1	65
YZ Car	18.16	8.711	$G5$	2	75

Table 2: Observations and atmosphere parameters

Star	Spectrum	HJD 2450000+	T_{eff} (K)	$\log g$	V_t (km s^{-1})
WW Car	042206	4944.597	5012±46	1.70	4.50
SX Car	042205	4944.574	5433±43	2.00	4.70
UZ Car	041705	4939.630	5374±58	2.00	4.20
UY Car	041503	4937.623	5900±30	2.20	4.20
	041807	4940.606	5550±30	2.10	4.20
	042204	4944.551	5700±30	2.00	3.40
GX Car	040709	4929.688	5451±26	2.00	5.40
HW Car	041808	4940.649	5702±28	1.70	4.50
YZ Car	041502	4937.600	5323±31	1.25	4.50
	041806	4940.584	5600±30	1.90	5.50

2. $\log g$: by adopting the same iron abundance for Fe I and Fe II lines (accuracy: 0.15 dex).

3. V_t - by assuming abundances of the Fe II lines independent of the W_λ (accuracy: 0.25 km/s).

The mean atmosphere parametrs are given in Table 2.

4. Chemical composition

All the atmosphere models and chemical composition for each spectrum were calculated using our version of the WIDTH9 code on the basis of the Kurucz (1992) grid with the “solar” log gf values, adopted from Kovtyukh & Andrievsky (1999). All the data about the element abuundances for these Cepheids are given in Tables 3, 4, 5 and 6.

5. Conclusions

1. All these objects have metallicities, close to solar one (or slightly deficient), excepting WW Car with [Fe/H] = -0.3 dex.

2. Judging from the CNO-, odd elements, and Mg content, six Cepheids from the list are the objects on the stage after the first dredge-up.

3. Cepheid WW Car shows noticeable overabundance of carbon [C/H] = +0.3 dex nitrogen ([N/H]= +0.95 dex), whereas sodium demonstrate significant deficient in comparison with other ones having close pulsation periods ([Na/H] = -0.46 dex), and magnesium content is the largest ([Mg/H] = -0.12 dex)! Therefore, WW Car is an unusual object among Cepheids.

4. α - elements abundances for these objects are close to solar ones, excepting Ca (small deficient), thereas Fe-group, ””light ” and ”heavy” - s- process and r-process elements demonstrate either slight enhance or slight deficient.

5. Atmospheric parameters, obtained for YZ Car are close to ones derived from the model of Petterson et al. (2004).

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Table 3: Elemental abundance for WW Car, SX Car and UZ Car. NL - number of elements.

El.	WW Car			SX Car			UZ Car		
	[El/H]	σ	NL	[El/H]	σ	NL	[El/H]	σ	NL
C I	+0.30	0.38	8	-0.41	0.19	10	-0.43	0.15	9
N I	+0.95	0.07	6	+0.62	0.31	5	+0.64	0.13	6
O I	+0.22	0.26	3	+0.12	0.11	2	+0.07	0.10	5
Na I	-0.46	0.18	4	-0.07	0.14	2	-0.14	0.14	3
Mg I	-0.12	0.28	7	-0.27	0.17	7	-0.28	0.13	7
Al I	-0.16	0.14	7	+0.11	0.10	7	-0.06	0.11	5
Si I	-0.07	0.21	36	-0.15	0.20	38	-0.12	0.24	41
Si II	+0.16	-	1	+0.07	0.28	2	-0.18	0.05	2
S I	+0.16	0.18	6	+0.04	0.22	6	+0.03	0.18	7
K I	+0.66	-	1	+0.63	-	1	+0.70	-	1
Ca I	-0.44	0.29	8	-0.30	0.20	11	-0.44	0.30	12
Sc I	+0.01	0.29	4	+0.30	0.24	3	-0.06	0.06	3
Sc II	-0.90	0.18	9	-0.42	0.17	7	-0.21	0.17	6
Ti I	-0.27	0.38	38	-0.13	0.33	59	-0.14	0.33	55
Ti II	-0.23	0.28	6	-0.54	0.09	7	-0.19	0.26	5
V I	-0.01	0.28	7	-0.23	0.32	14	-0.24	0.18	12
V II	-0.29	0.05	3	-0.07	0.08	4	-0.21	0.23	4
Cr I	-0.21	0.25	21	-0.15	0.27	27	+0.04	0.29	22
Cr II	-0.35	0.27	14	-0.12	0.19	12	-0.00	0.39	11
Mn I	-0.61	0.29	9	-0.38	0.29	13	-0.46	0.14	7
Fe I	-0.30	0.25	237	-0.16	0.20	264	-0.02	0.27	268
Fe II	-0.33	0.21	33	-0.18	0.17	42	-0.01	0.22	42
Co I	-0.33	0.35	19	-0.05	0.28	20	+0.04	0.31	31
Ni I	-0.32	0.31	73	-0.29	0.29	96	-0.32	0.31	85
Cu I	-0.53	0.33	3	-0.42	0.30	4	-0.26	0.47	4
Zn I	-0.50	-	1	-0.17	-	1	+0.21	-	1
Sr I	+0.18	0.31	3	+0.68	-	1	+0.40	0.05	2
Y I	-0.71	-	1	-0.16	-	1	-0.07	-	1
Y II	-0.17	0.30	6	+0.02	0.29	7	-0.07	0.09	6
Zr II	-0.11	0.09	3	+0.02	0.17	2	+0.00	0.16	4
Ru I	+0.34	-	1	+0.29	0.62	2	+0.03	-	1
La II	-0.29	0.29	2	-0.60	0.01	2	+0.01	0.02	3
Ce II	-0.55	0.11	5	-0.22	0.32	7	-0.13	0.13	4
Pr II	-0.30	0.20	2	-0.37	-	1	-0.17	0.01	3
Nd II	-0.36	0.19	9	-0.16	0.21	4	+0.09	0.24	11
Eu II	+0.09	0.20	2	+0.10	0.21	4	+0.24	0.43	2
Gd II	-0.36	-	1	-0.80	-	1	+0.01	0.00	1

Table 4: Elemental abundance for YZ Car.

Element	041502		041806		Mean		
	[El/H]	σ	[El/H]	σ	[El/H]	σ	NL
C I	-0.23	0.13	-0.55	0.16	-0.41	0.15	17
N I	+0.31	0.17	+0.25	0.25	+0.28	0.21	6
O I	+0.10	0.08	-0.01	0.16	+0.04	0.14	7
Na I	-0.13	0.17	-0.10	0.39	-0.05	0.26	7
Mg I	-0.33	0.13	-0.22	0.15	-0.25	0.15	12
Al I	+0.10	0.12	-0.13	0.19	-0.05	0.20	14
Si I	-0.08	0.17	-0.06	0.14	-0.07	0.15	78
Si II	+0.06	0.36	+0.05	-	+0.06	0.26	3
S I	+0.05	0.28	-0.06	0.17	-0.00	0.23	12
Ca I	-0.35	0.25	-0.32	0.15	-0.36	0.18	20
Sc I	-0.35	0.08	-0.11	0.12	-0.25	0.15	5
Sc II	-0.29	0.24	-0.23	0.09	-0.25	0.15	7
Ti I	-0.08	0.24	-0.11	0.28	-0.10	0.25	96
Ti II	-0.16	0.31	-0.16	0.15	-0.16	0.22	8
V I	-0.11	0.23	+0.03	0.19	-0.08	0.22	24
V II	-0.07	0.28	-0.06	0.18	-0.06	0.21	6
Cr I	-0.15	0.20	+0.04	0.26	-0.08	0.23	46
Cr II	-0.07	0.30	-0.04	0.13	-0.03	0.21	25
Mn I	-0.21	0.13	-0.29	0.29	-0.28	0.20	20
Fe I	-0.04	0.20	-0.08	0.24	-0.06	0.22	561
Fe II	-0.04	0.12	-0.10	0.15	-0.07	0.14	61
Co I	-0.06	0.22	+0.06	0.22	-0.00	0.23	51
Ni I	-0.16	0.27	-0.25	0.26	-0.20	0.26	172
Cu I	-0.23	0.15	-0.03	0.32	-0.21	0.13	7
Zn I	+0.07	-	-0.01	-	+0.03	0.05	2
Sr I	+0.57	-	+0.20	-	+0.39	0.26	2
Y I	+0.24	-	-	-	+0.24	-	1
Y II	+0.04	0.22	+0.05	0.19	+0.05	0.19	12
Zr II	+0.15	0.19	+0.17	0.12	+0.16	0.15	8
Ru I	+0.30	-	-	-	+0.30	-	1
La II	-0.19	-	+0.40	0.01	+0.21	0.34	3
Ce II	+0.02	0.28	-0.03	0.25	-0.00	0.26	9
Pr II	-0.23	0.11	-0.09	0.16	-0.16	0.15	6
Nd II	-0.10	0.16	+0.01	0.16	-0.05	0.16	26
Eu II	+0.21	0.05	+0.12	0.04	+0.17	0.06	6
Gd II	-	-	-0.76	-	-0.76	-	1

Table 5: Elemental abundance for GX Car and HW Car

Element	GX Car			HW Car		
	[El/H]	σ	NL	[El/H]	σ	NL
C I	-0.44	0.24	15	-0.48	0.27	15
N I	+0.46	0.20	4	+0.53	0.21	4
O I	+0.06	0.18	6	-0.17	0.14	4
Na I	-0.12	0.19	4	+0.07	0.07	2
Mg I	-0.44	0.27	6	-0.41	0.21	6
Al I	-0.03	0.14	7	+0.15	0.21	5
Si I	-0.09	0.19	49	-0.18	0.21	57
Si II	-0.07	0.07	2	-0.19	0.49	2
S I	-0.10	0.25	7	-0.02	0.17	7
K I	-	-	0	+0.57	-	1
Ca I	-0.35	0.19	11	-0.20	0.14	8
Sc I	+0.24	0.22	4	+0.03	0.19	4
Sc II	-0.14	0.21	7	-0.21	0.28	6
Ti I	-0.12	0.26	50	-0.04	0.23	63
Ti II	-0.25	0.25	4	-0.15	0.15	8
V I	-0.05	0.45	19	-0.11	0.12	13
V II	-0.11	0.17	5	-0.33	0.38	4
Cr I	-0.13	0.24	21	+0.03	0.28	32
Cr II	-0.05	0.23	13	-0.13	0.22	13
Mn I	-0.34	0.28	13	-0.15	0.22	15
Fe I	-0.12	0.24	294	-0.15	0.22	303
Fe II	-0.13	0.19	46	-0.16	0.12	42
Co I	-0.06	0.22	26	+0.14	0.41	31
Ni I	-0.23	0.31	90	-0.22	0.26	102
Cu I	-0.25	-	1	-0.00	0.32	4
Zn I	-0.25	-	1	-0.07	-	1
Sr I	+0.46	0.40	2	+0.44	-	1
Y I	-0.18	0.01	2	+0.14	-	1
Y II	-0.01	0.17	6	+0.01	0.06	6
Zr II	-0.05	0.18	5	+0.01	0.18	4
Ru I	+0.45	-	1	-	-	0
La II	+0.11	0.21	3	+0.27	0.07	3
Ce II	-0.12	0.23	4	-0.22	0.24	7
Pr II	-0.08	0.01	2	+0.04	0.01	2
Nd II	+0.02	0.16	15	-0.14	0.20	13
Eu II	-0.03	0.25	3	-0.12	0.10	2
Gd II	-0.07	-	1	-0.57	0.00	1

Table 6: Elemental abundance for UY Car

Element	041503		041807		042204		Mean		
	[El/H]	σ	[El/H]	σ	[El/H]	σ	[El/H]	σ	NL
C I	-0.47	0.27	-0.52	0.16	-0.31	0.17	-0.45	0.23	25
N I	+0.41	0.26	+0.35	0.04	+0.47	0.31	+0.39	0.21	14
O I	+0.01	-	+0.11	0.32	+0.11	0.13	+0.06	0.14	10
Na I	+0.03	0.29	-0.13	0.08	-0.02	0.07	-0.04	0.09	12
Mg I	-0.38	0.18	-0.27	0.08	-0.33	0.30	-0.33	0.25	16
Al I	-0.09	0.19	+0.08	0.16	-0.03	0.15	-0.01	0.18	19
Si I	-0.04	0.20	+0.04	0.23	+0.02	0.20	-0.00	0.20	134
Si II	-0.08	0.19	-0.07	0.21	-	-	-0.08	0.210	4
S I	+0.01	0.20	+0.05	0.23	-0.03	0.14	+0.01	0.18	21
K I	+0.12	-	+0.61	-	+0.71	-	+0.48	0.32	3
Ca I	-0.24	0.22	-0.18	0.35	-0.14	0.25	-0.18	0.27	35
Sc I	-	-	+0.08	0.05	+0.08	-	+0.08	0.05	3
Sc II	-0.20	0.18	-0.15	0.22	-0.17	0.07	-0.16	0.25	22
Ti I	-0.03	0.38	+0.08	0.24	-0.00	0.21	+0.03	0.27	143
Ti II	-0.15	0.15	-0.17	0.15	-0.10	0.20	-0.14	0.16	17
V I	+0.02	0.22	+0.02	0.24	-0.12	0.18	-0.01	0.22	33
V II	-0.12	0.18	-0.06	0.25	+0.10	0.18	-0.03	0.21	13
Cr I	+0.18	0.37	-0.02	0.33	-0.06	0.22	+0.03	0.32	77
Cr II	-0.02	0.22	-0.01	0.27	+0.09	0.23	+0.02	0.24	39
Mn I	-0.43	0.22	-0.24	0.27	+0.10	0.43	-0.22	0.33	34
Fe I	-0.07	0.23	-0.05	0.25	-0.06	0.22	-0.06	0.23	879
Fe II	-0.06	0.22	-0.06	0.22	-0.06	0.21	-0.06	0.22	138
Co I	-0.02	0.22	-0.04	0.27	+0.02	0.19	-0.00	0.21	69
Ni I	-0.15	0.24	-0.19	0.24	-0.09	0.27	-0.15	0.24	231
Cu I	-0.30	0.07	-0.18	0.21	-0.29	0.37	-0.21	0.17	14
Zn I	-0.08	-	-0.24	-	-0.04	-	-0.12	0.11	3
Sr I	+0.59	0.26	-	-	+0.59	0.22	+0.59	0.24	2
Y I	-	-	+0.67	0.14	+0.67	-	+0.67	0.14	3
Y II	+0.11	0.10	+0.03	0.08	-0.16	0.15	+0.01	0.13	15
Zr II	+0.01	0.18	+0.19	0.36	-0.01	0.11	+0.03	0.21	16
Ru I	-	-	+0.20	-	-	-	+0.20	-	1
La II	+0.24	0.06	+0.18	0.08	-0.07	0.25	+0.15	0.14	12
Ce II	-0.18	0.24	+0.06	0.16	+0.07	0.25	-0.02	0.25	20
Pr II	-	-	+0.29	0.28	+0.04	0.16	+0.17	0.22	4
Nd II	-	-	+0.09	0.25	+0.04	0.22	+0.07	0.24	26
Eu II	+0.02	0.09	+0.21	0.19	+0.18	0.35	+0.14	0.22	9
Gd II	+0.05	-	-0.13	-	-	-	-0.04	0.12	2