THE ABUNDANCES OF THE ELEMENTS OF THE MAGELLANIC CLOUDS

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ABSTRACT. The results of the spectroscopic researches of classical Chepheids of the Magellanic Clouds (MC) are presented in this paper. 21 spectra for the Large Magellanic Cloud (LMC) and 10 for the Small Magellanic Cloud (SMC) were investigated. I obtained highly accurate values of effective temperatures (T_{eff}), of the logarithm of the surface gravity (*log g*), of the microturbulence velocity (V_t), of abundances of elements for all of the objects. There is a good agreement with previous studies, some data were obtained for the first time.

Key words: Classical Cepheids: parameters of stellar athmosphere; Magellanic Clouds: abundances.

1. Introduction

There were the great telescopes allowing to obtain high–quality spectra of high resolution in recent years. The classical Cepheids are known as yellow supergiants which one of the brightest stars. And modern tools allow to obtain spectra of satisfactory quality for the brightest stars in nearby galaxies. The Magellanic Clouds represent for my research special interest as the most close galaxies. These facts provide an excellent opportunity to explore in detail a variety of abundances of chemical elements there.

Luck et al spent a lot of work to determine the chemical composition of the Magellanic Clouds using 22 Cepheids (Luck, 1998). Atmospheric parameters and abundances for more than 20 chemical elements were identified for all of them. The detailed study with high accuracy was carried out. They got some interesting conclusions which agreed well with data of other authors. But I want to note that previous data were fragmented, while in (Luck, 1998) is collected a good statistic based on a large number of elements. Luck got theoretically predicted content of elements of the CNO and of the iron peak, but it was also found an excess of heavy elements (Z $\geq$ 56).

The new high-dispersion spectra and the results of processing are presented by Romaniello et all (2008). They got the atmospheric parameters and metallicities for 32 Galactic Cepheids and for 36 MC Cepheids and analyzed the influence of chemical composition on the PL-relationship.

In my article I would like to present new data on the chemical composition of MC Cepheids based on high-quality spectra obtained with the help of a new generation tool.

2. Observations and measurements

The spectra of the program stars which I employed were obtained using facilities of 8.2 m VLT Unit 2 (Kueyen) equipped with echelle-spectrograph UVES (Bagnulo et al, 2003). The detector in the Red Arm is a mosaic of two CCDs (EEV + MIT/LL) with 15 micron pixels (2048 x 4096 pixels). The spectral resolution is about 25 000 and the accessible wavelength range is from 4800 to 6800 $\AA$. The signal-to-noise ratios vary between 50 and 70 for most of the spectra. 1-D extracted spectra with primary reduction were download from electronic spectra database of ESO.

The next processing of the spectra (continuum level location, line identification, measuring of line depths and equivalent widths) was carried out using the DECH20 software (Galazutdinov, 1992). Line depths R_λ were measured by means of Gaussian fitting.

Atmospheric parameters were obtained by the agency of last achievements. Thus, effective temperatures were calculated using the original and powerful method proposed by Kovtyukh (2007). The microturbulence velocities V_t and surface gravities *logg* were derived using a modification of the standard analysis proposed by Kovtyukh & Andrievsky (1999). The WIDTH9 code and grids of atmospheric models (Kurucz, 1992) were used to derive the abundances of the chemical elements.

3. Conclusions.

The Table 1 shows comparison of my obtained data

Table 1: Atmospheric parameters and metallicities of Cepheids. Comparison table.

LMC								
HV	T_{eff}	$logg$	V_t	$[FeI/H]$	T^*_{eff}	$logg^*$	V^*_t	$[FeI/H]^*$
877	4831	1.0	6.0	–0.25	4690	0.5	5.4	–0.44
879	5809	1.2	5.3	–0.11	5630	1.0	3.05	–0.14
971	5943	1.9	4.0	–0.36	5930	1.4	2.3	–0.29
997	5782	1.5	6.0	–0.28	5760	1.2	3.1	–0.21
1013	4662	0.3	5.3	–0.40	4740	0.2	5.35	–0.59
1023	5909	1.5	4.5	–0.18	5830	1.1	3.1	–0.28
2260	5898	1.8	4.0	–0.06	5770	1.6	3.4	–0.38
2294	5232	0.9	5.0	–0.16	5080	0.5	3.9	–0.42
2337	5489	1.5	4.5	–0.12	5560	1.6	3.3	–0.35
2352	6300	1.8	5.5	–0.26	6100	1.6	3.65	–0.49
2369	4794	0.15	4.0	–0.11	4750	0.3	6.0	–0.62
2405	5985	1.8	5.0	–0.24	6170	2.3	4.2	–0.27
2580	5461	1.2	3.5	–0.06	5360	0.7	2.75	–0.24
2733	5473	1.6	5.0	–0.25	5470	1.8	2.9	–0.28
2793	5505	1.0	3.5	–0.07	5430	0.9	2.9	–0.1
2827	4892	0.3	4.7	–0.20	4790	0.0	4.0	–0.38
2836	5471	1.1	4.0	–0.13	5450	1.0	2.85	–0.16
2864	5799	1.6	3.7	–0.17	5830	1.5	2.8	–0.19
5497	5206	0.6	6.1	–0.29	5100	0.3	3.4	–0.25
12452	5548	1.5	4.0	–0.16	5460	1.0	2.9	–0.35
12700	5451	1.4	4.1	–0.22	5420	1.4	3.15	–0.36
SMC								
HV	T_{eff}	$logg$	V_t	$[FeI/H]$	T^*_{eff}	$logg^*$	V^*_t	$[FeI/H]^*$
817	5940	1.4	4.7	–0.61	5850	1.0	3.25	–0.82
824	5333	1.1	4.5	–0.54	5170	0.7	3.0	–0.73
829	5350	1.0	7.0	–0.62	5060	0.2	3.3	–0.76
834	6016	1.6	6.0	–0.38	5750	1.2	2.95	–0.63
837	5355	1.0	4.6	–0.55	5140	0.0	2.9	–0.83
847	4817	0.4	4.5	–0.66	4790	0.0	2.8	–0.75
1954	5974	1.6	5.2	–0.61	5890	1.0	2.47	–0.76
2064	5832	1.5	5.3	–0.39	5550	0.7	3.1	–0.64
2195	6211	1.6	6.8	–0.47	5970	1.0	2.9	–0.67
11211	5067	0.8	4.0	–0.58	4830	0.0	2.6	–0.83

* data from (Romaniello et al, 2008)

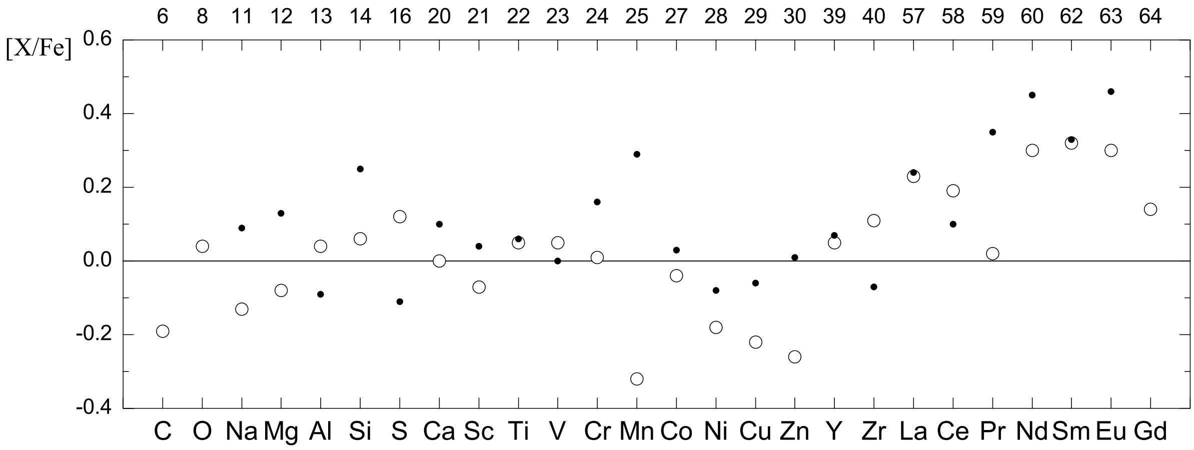

Figure 1: Abundances of the LMC. Open circles – this paper, black points – data from (Luck, 1998).

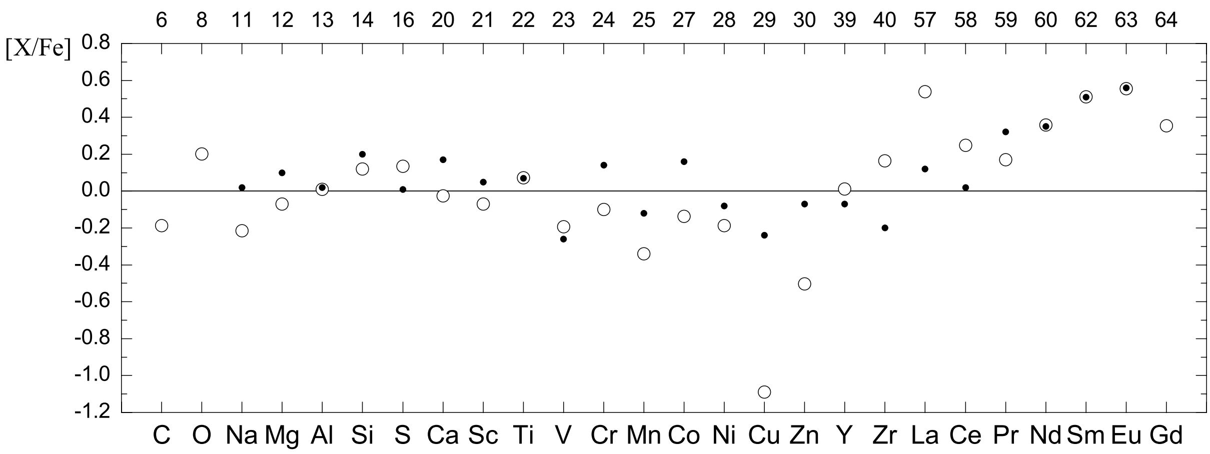

Figure 2: Abundances of the SMC. Open circles – this paper, black points – data from (Luck, 1998).

and data from (Romaniello et al, 2008). The difference in effective temperatures can be explained by the using more outdated method (Kovtyukh & Gorlova, 2000) in (Romaniello et al, 2008), whereas I used newer calibrations of Kovtyukh (2007). But you can also see a big difference in microturbulence velocities V_t and surface gravities $logg$. It also speaks distinctions in methods: still Kovtyukh & Andrievsky (1999) noticed that if find microturbulence velocity along the $Fe\ I$ lines then the values to be considerably underestimated. For this reason, I used the $Fe\ II$ lines as suggested by Kovtyukh & Andrievsky (1999) unlike Romaniollo's research.

In Fig. 1 and Fig. 2 you can see abundances of the MC. Data are presented in comparison with (Luck, 1998) and can note that they are in good agreement. Now, if to compile all the data then I can summarize the following few points:

1. The values of $[Fe/H]$ for the LMC Cepheids vary around the mean value of –0.2, while the SMC have higher deficiency compared with the solar value at about –0.5. The standard error is ±0.2.

2. The α–elements in the SMC and LMC are not overabundant or yield values of excess within the errors of determination.

3. The heavy elements (Z $\geq$ 56) and n-capture elements are in evident excess for the LMC and the SMC which is consistent with the earlier conclusion of Luck (1998).

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