CONTEMPORARY PROBLEMS OF ASTRONOMY: THE CHEMICAL COMPOSITION OF CEPHEIDS AND RELATED STARS

S.M. Andrievsky[1], V.G. Klochkova[2]
[1] Department of Astronomy, Odessa State University, Odessa 270014 Ukraine
[2] Special Astrophysical Observatory, N. Arkhys, Stavropol Territory, 357147, Russia

ABSTRACT. In the short form we present the main results of spectroscopic analysis of the different kind of Cepheids and related stars: double-mode Cepheids, s-Cepheids, non-variable supergiants situated inside the Cepheids instability strip and Cepheids first time crossing the instability strip.

Key words: Stars: abundances - stars: supergiants

Introduction

In spite of rather great number of works devoted to the Cepheid abundances, this thematic remains essential nowadays too. There are several reasons:
a) new CCD observations enable to get the high-resolution spectral material with high signal-to-noise ratio in the wide spectral region;
b) updated numerical codes applied for abundance determination, spectral synthesis, new grids of the atmosphere models, modern data on the oscillator strengths and recent more accurate solar abundances (as a reference point) make it possible to obtain for Cepheids the results of the high quality.

Present short review is based on the results of series of works devoted to a systematical investigation of classical Cepheids' chemical composition which have been carried out in Astronomical Observatory of Odessa State University during several years.

Double-mode Cepheids

These are Cepheids having unusual pulsational activity that consists of the excitation of two pulsational modes: fundamental one (period P_0) and first overtone (period P_1). For the solution of double-mode Cepheids (DMC) problem (the discrepancy between observed period P_1/P_0 ratios and those predicted by pulsation theory), the revision of the opacities, which are used in model calculation, has been proposed by several authors. The calculations with new opacities have shown the strong sensitivity of the resulting period ratio to the adopted elements' abundances.

Taking this into account, we have checked the supposition that differences in P_1/P_0 ratios among the DMC may be caused by differences in their metallicities. For this aim we derived abundances for EW Sct, VX Pup, BQ Ser TU Cas and estimated [Fe/H] values for 7 additional DMC (Andrievsky et al., 1993; Andrievsky et al., 1994a). The main result was following: P_1/P_0 ratio correlates with iron content. With [Fe/H] decreasing, the period ratio has a tendency to increase.

For four detaily investigated stars we obtained: carbon is deficient (a sign of the dredge-up phase) and sodium shows a normal abundance (that is unusual for supergiants).

s-Cepheids

s-Cepheids are small-amplitude pulsating stars with almost sinusoidal light, color and radial velocity curves. Rather weak pulsational activity could be caused by the small helium content in the atmosphere of the star that is crossing the instability strip towards the red supergiant region.

In order to check this hypothesis, we investigated chemical composition of 18 s-Cepheids paying more attention to CNO-abundances. The results on abundance analysis are given in Andrievsky et al.,1994b; Andrievsky et al., 1996 and Kovtyukh et al., 1996. From that works it is obviously seen that carbon is deficient, while nitrogen is overabundant.

Surface C abundance must be decreased and N abundance increased if the star has evolved from a red supergiant. Taking this into account, we conclude that s-Cepheids are probably not crossing the instability strip for the first time.

If s-Cepheids are not crossing the instability strip for the first time, then we should expect the helium content in their envelopes to be comparable with that of the classical Cepheids. This means that there exists another origin of the weak pulsational activity (small amplitudes) of these stars than merely low helium content (lower than for usual Cepheids), expected for the stars of the first time crossing the instability strip.

Non-variable supergiants inside the instability strip

An extremely weak pulsational activity is demonstrated by non-variable supergiants (NVS) situated inside the instability strip. In spite of their location, they practically do not pulsate (or pulsate with an amplitude under the detection limit).

It is interesting to know the physical reasons of such behaviour and to find the most important stellar parameters that could crucially affect a pulsational activity.

Before answering a question about possible origin of the pulsational activity suppression in these stars, it is worth to compare their chemical composition with that of the Cepheids. Such a comparison can give us an important information about NVS evolutionary stage.

We have investigated 17 NVS from the instability strip and two hotter supergiants (Andrievsky and Kovtyukh, 1996). The comparable analysis of the program stars' chemical composition and that of the small-amplitude Cepheids has shown that there is no essential differences in the elemental abundances of two stellar groups. It means that NVS are probably at the same evolutionary stage as s-Cepheids: i.e., these stars have already undergone the first stage of core helium burning.

The Young Cepheids

The Cepheids crossing the instability strip for the first time can be considered as young Cepheids. In our survey, we have found three possible candidates. In addition, two similar stars were found among the NVS. All these stars have normal or increased carbon abundance. It means that CNO-processed material has not been mixed with the atmosphere gas and these stars have never been in the red giant phase. All results concerning this kind of stars will be presented in the special paper.

Acknowledgements. The authors are thankful to V.V. Kovtyukh, I.A. Usenko and Dr. V.E. Panchuk for their important contribution in the realization of this study.

References

Andrievsky S.M., Kovtyukh V.V.: 1996, *Astrophys. Space Sci.,* subm.

Andrievsky S.M., Kovtyukh V.V., Makarenko E.N., Usenko I.A.: 1993, *MNRAS,* **265**, 257.

Andrievsky S.M., Kovtyukh V.V., Usenko I.A., Klochkova V.G., Galazutdinov G.A.: 1994a, *As.Ap. Suppl.,* **108**, 433.

Andrievsky S.M., Kovtyukh V.V., Usenko I.A.: 1994b, *As.Ap.,* **281**, 465.

Andrievsky S.M., Kovtyukh V.V., Usenko I.A.: 1996, *As.Ap.,* **305**, 551.

Kovtyukh V.V., Andrievsky S.M., Usenko I.A., Klochkova V.G.: 1996, *As.Ap.,* **316**, 155.