ABOUT CHEMICAL COMPOSITION OF SUPERGIANT PMMR145 IN SMALL MAGELLANIC CLOUD. OSMIUM.

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ABSTRACT. The abundance analysis of six K-supergiants of the Small Magellanic Cloud (Hill 1997) showed that the heavier elements (La, Ce, Nd, Eu) have the excess relative to iron [El/Fe]=+0.4 dex, on average, for the sample of five stars (PMMR23, PMMR27, PMMR48, PMMR102, PMMR145). We made the identification of spectral lines in the spectrum of PMMR145 based on the comparison of synthetic and observed spectra. The absorption lines of elements heavier than lanthanides including osmium were identified and abundance of osmium was found ([Os/Fe]=0.59 dex).

Key words: Small Magellanic Cloud, star, evolution, supergiants, PMMR145.

1. Introduction

Magellanic Clouds (MC) are the nearest galaxies to us. These are two irregular galaxies, namely the Large Magellanic Cloud (LMC) and Small Magellanic Cloud (SMC), which have smaller sizes and masses comparing to our Galaxy. The study of the objects outside our Galaxy give the possibility to verify the evolutionary theories, such as theories of chemical, stelar and galaxy evolution. That is why the MC objects are of great interest, and the corresponding researches are carried out in the wide range of wavelengths.

The observation of three galaxies (the Galaxy, SMC, and LMC) in X-rays by artificial satellites showed that the smallest galaxy SMC is a strong and stable source in this wavelength range. It proved to be a galaxy riched in such X-ray sources as HMXBs – high mass X-ray binary stars composed of either white dwarfs or neutron stars, or black holes and optical companion (Klus H. et al., 2012). Because the mass of SMC is 50 times lower than that of our Galaxy, and the SMC has almost the same number of HMXBs (Novara et al., 2012), we have the irrefutable proof that at some period of evolution the binary systems are characterized by the special conditions, resulting in unstable configurations for these stars which led to the explosive processes in this galaxy. Such conditions, according to several studies, could be the tidal forces caused by the closeness of the galaxies, and the smallest galaxy experienced the greatest damage, which is being observed. A large number of HMXBs indicates that in the result of explosion of Supernovas the SMC environment should be enriched first of all in r-process elements. Obviously, the neutron processing histories of stars in SMC have been different from our Galaxy. If our ideas are true, then the spectra of stars must exhibit the lines of heavy elements, which have been formed with major contribution of r-processes. Indeed, Hill's study of some SMC K-supergiants, based on spectra obtained at ESO 3.6-meter telescope, showed the excess of elements r- and s-prpcesses as La, Ce, Nd, and Eu (Hill, 1997).

2. About the chemical composition of SMC's K-supergiant PMMR145. R-process elements.

Let's consider shortly the results of investigation of chemical composition of the supergiant star PMMR145. As well as the other SMC supergiants, observed by Hill (1997), PMMR145 is a faint star and it has the photometric characteristics V=13.09, B-V=1.59. For our work we used the same spectra obtained and kindly given to us by Hill. The spectral resolution of used observation is R=30,000, the wavelength range is 5049-6357 A. The synthetic spectra were calculated with the code SYNTHV of V. Tsymbal (1996) and Kurucz' model atmospheres (1993). The atmosphere parameters found in previous papers have been tested and confirmed in this work, namely: the effective temperature T_{eff}=4300 K, the surface gravity logg=0.3, the microturbulent velocity V_{micro}=3km/s. Hill (1997) received the value [Fe/H] = -0.59. The average value of overabundances of the elements heavier than barium, is equal to [El/Fe]=0.4 dex, [Eu/Fe]= -0.39 dex (Hill, 1997).

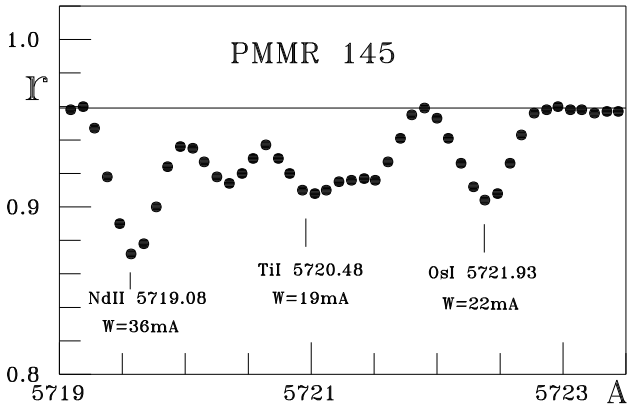

Figure 1: The spectrum of PMMR145 in the region of line OsI 5721.931 A

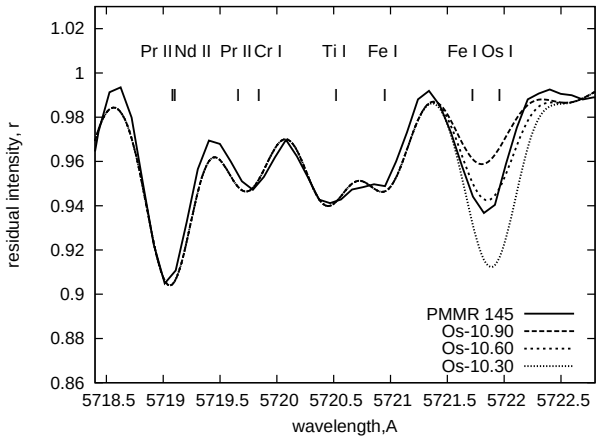

Figure 2: The spectrum of PMMR145 fitting by syntetic spectra for the line OsI

Based on comparing the observed spectra of SMC stars, obtained by Hill (1997), and the synthetic spectra of these stars, we have identified the lines of thorium in the visible part of the spectrum. According to work of Gopka et al. (2005, 2007) the mean values of thorium abundances in the atmospheres of PMMR23, PMMR39, PMRR144 and PMMR145 are equal to $\approx -0.10 \pm 0.13, -0.63 \pm 0.13, -0.69 \pm 0.09$, and $+0.05$ dex (in the scale logN(H)=12), using 6, 2, 4, and 1 thorium lines respectively. Thorium is an element which is formed exclusively by the r-process. Thorium lines in PMMR23 and PMMR144 spectra are clearly identified. The coincidence of the wavelengths and self-agreed result over different lines is the undeniable proof of the presence of r-process elements in the atmospheres of these stars. According to Wanajo et al. (2006), the discovery of thorium is a strong support of the contribution of r-process elements (which cannot be synthesized by s-process). Certainly, some difficulties exist in the abundance analysis of thorium, for example, due to blending by lines of other elements and we can not exclude the presence of lines of alternative elements near the third peak of r-process. The lines of Os, Ir, and Pt cannot be produced by s-process (Wanajo et al., 2006). We identified the osmium line at wave length 5721.931 A, equivalent width is equal E.Q=22mA, lg gf=-2.66 in the spectrum of PMMR145 (Fig. 1). The solar abundance log N(Os)=1.40 in the scale of log N(H)=12 (Asplund, 2009). The abundance of osmium in PMMR145 obtained from synthetic spectra near Os I line 5721.931 line is equal log N(Os)=1.40 also (Fig. 2), therefore, [Os/Fe]=0.59 dex. That value almost the same as [Th/Fe]=0.54 dex.

3. Conclusion

Although the place of r-process is not precisely determined, the most likely one is the outburst of type II Supernova. In this paper, such a scenario for the SMC galaxy, having a high number of detected HXMBs- massive binary stars with relativistic objects, which have enriched the environment in the heaviest elements in the past, is clearly evident. SMC supergiant PMMR145, as well as the other objects under study, showed the presence of lines of heavier elements in the spectra, namely of the elements with a predominant contribution of r-process and pure r-process.

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