PRELIMINARY STUDY OF RED SUPERGIANT RM_1-667 IN THE LARGE MAGELLANIC CLOUD

V.Gopka[1], A.Shavrina[2], S.Vasilyeva[1], A.Yushchenko[1,3], S.Andrievsky[1], V.Yushchenko[1]

[1] Astronomical observatory, Odessa National University, T.G. Shevchenko Park, Odessa 65014, Ukraine, *gopkavera@mail.ru*
[2] Main Astronomical observatory, NAS of Ukraine, Kyiv, 03680, Ukrai
[3] Department of Astronomy & Space Sciences, Sejong University, Gunja-dong, Seoul, 143-747, Korea

ABSTRACT. The observed lines of hydrogen and another strong lines in the spectrum of RM_1-667 (red region of spectra, 5900-7100 Å, spectral type is K7 I) are discussed. Analysis of these lines indicates the presence of mass outflow from the star at a significant velocity. Using the iron lines and the model atmospheres of supergiants (Teff = 3750 K – 4300 K) of the Kurucz' grid, we obtained the iron abundance lg ε (Fe) = 6.75-7.08, which is equivalent to [Fe/H] equal -0.75 to -0.42.

1. Introduction

Red supergiants are short evolutionary phase of the He-burning of moderately massive stars from 10 to 25 solar masses [1]. Large size of the stars, very cool effective temperature, the dusty circumstellar environments, the mass loss of those stars, the huge number of atomic and molecular lines in their spectra – all these facts made the investigation of those objects be very complicated. Supergiant RM_1-667 from the Large Magellanic Cloud is an example of such object.

2. Observations

The observation of this K-supergiant was carried out by Hill [2] at the European Southern Observatory (ESO) at La Silla. The spectral resolution of the spectra is near 30 000, the range of wavelengths is 5900-7100 Å. According to study [3], RM_1-667 has the following photometric data: V=13.126, B=14.634, U=14.933.

3. Choice of the model atmosphere and the specific characteristics of the Hα 6563 Å line and Na I lines 5890 and 5896 Å.

The atmospheric parameters of supergiant RM_1-667 were determined by the method of modeling of equivalent widths of lines of neutral and ionized iron. On the basis of preliminary calculations of iron lines equivalent widths, and Kurucz' models with effective temperatures in the range of 4300-3750 K, we found the iron abundance of RM_1-667 [Fe/H] from -0.4 to -0.8 dex. We should note the wide spread of iron abundances, determined with the "solar" oscillator strengths [4] and the Kurucz' atmosphere models [5]. One of the reasons of the indicated spread is the actual difficulties in the constructing of extended supergiant atmospheres. Strong lines in the spectrum of supergiant RM_1-667 indicate the difference of observed temperatures and element abundance distribution with depth in the atmosphere from modeled ones. The Hα line and the strong lines of sodium doublet profiles indicate the significant evidence of that stratification. Comparing the Hα line profiles in the spectra of two supergiants of the Large Magellanic Cloud, namely RM_1-390 and RM_1-667, we can see that RM_1-390 has a symmetric strong line profiles in contrast to the line profiles in the spectrum of RM_1-667. Note, that RM_1-390 was studied previously as PMMR39 [6]. In RM_1-390 (Teff =4250 K, lg g=0.16, υmicro =3.1 km/s) all 20 studied chemical elements are underabundant with respect to solar values. An emission component is obvious in the center of Hα profile of RM_1-667. It can be interpreted as the possible hydrogen outflow both towards us (blue part of the line profile) and from us (red component). Also the emission in the central part of Hα line profile (Fig. 1, Fig. 3) could be explained by the temperature inversion in the layers of Hα formation. The sodium lines 5890 and 5896 Å are very strong and show a blue shift of profile central parts of

0.32 Å, that corresponds to the outflow from star with velocity 16 km/sec (Fig. 2). Strong iron lines could also have distorted profiles that results in iron abundances spreading. The temperature, determined from the modeling of the Hα profile, is higher than that determined using the iron lines. Figures 2 and 3 show the synthetic spectra

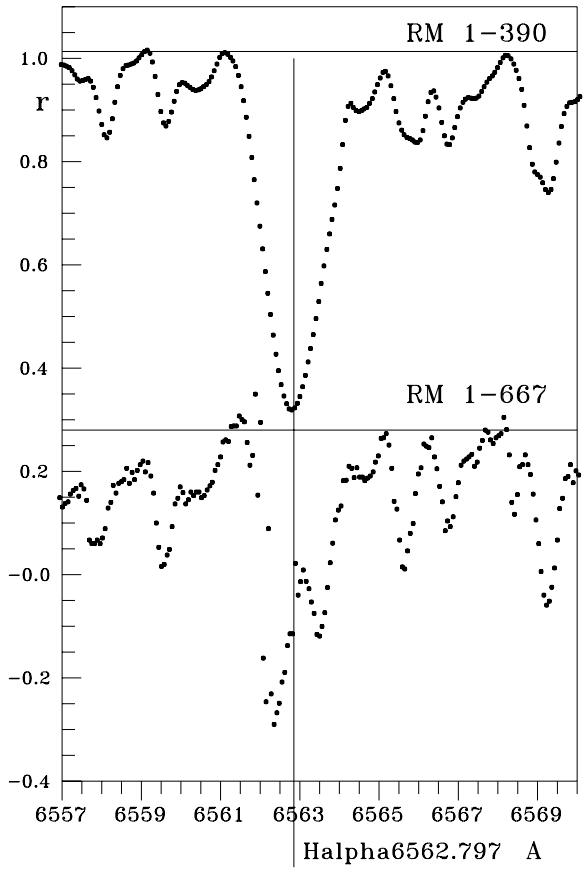

Fig.1. The Hα profiles of two supergiants of the Large Magellanic Cloud: RM_1-667 and RM_1-390

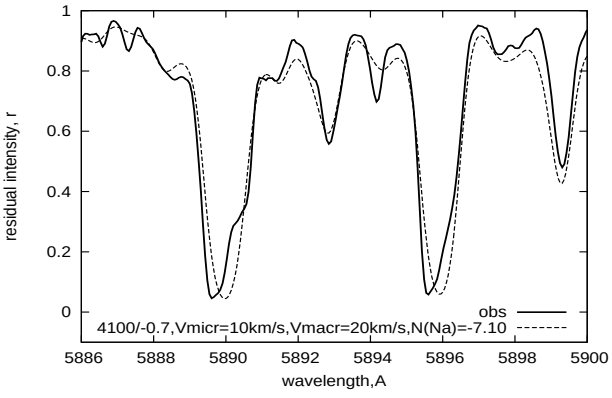

Fig.2. Observed and modeled sodium lines 5890 and 5896 Å in the spectrum of RM_1-667

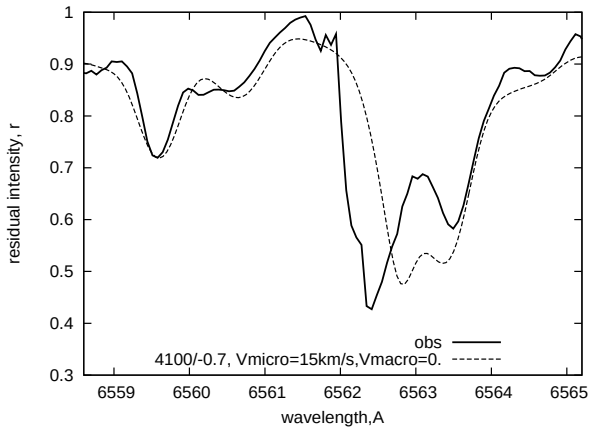

Fig.3. Observed and modeled Hα line in the spectrum of RM_1-667.

near the sodium and hydrogen lines (5890, 5896, and 6563 Å), calculated with the effective temperature Teff=4100 K and the surface gravity lg g=-0.7. The observed spectrum is blue-shifted from the calculated line profiles by 0.4 Å or 18 km/sec. The emission component in the observed Hα profile is fitted with the temperature inversion in the upper layers of stellar atmosphere.

3. Conclusions

The analysis of the hydrogen H_α (6563 Å) line and the sodium lines (5890, 5896 Å) detects the evidence, first of all, of the specific conditions of the upper atmospheric layers of supergiant star RM_1-667. The preliminary analysis of iron abundances shows the metallicity in the range of [Fe/H]=-0.8 to -0.4 dex being determined with different models.

Acknowledgments. This work was partly supported by Mid-career and General Researcher Programs, and Science and Technology grant 2011-0028001 and 2011-00106996 respectively, through the National Research Foundation (NRF) funded by the Ministry of Education of Korea. Two of the authors were granted by the Swiss National Science Foundation (SCOPES project No. IZ73Z0-128180/1).

References

1. Levesque E.: 2010, *NewAR*, **54**, 1.
2. Hill V.: 1999, *A&A*, **324**, 435.
3. Bonanos A.Z., Messa D.L., Sewilo M., et al.: 2009, *Astron. J.*, **138**, 1003.
4. Gurtovenko E.A., Kostik R.I.: 1981, *A&AS*, **46**, 239.
5. Kurucz R.: 1993, CD-ROMs 1-23.
6. Gopka V.F., Yushchenko A.V., Goriely S., et al.: 1995, *IAUS*, **228**, 535.