

Abundance analysis of extreme helium stars

Gajendra Pandey, N. Kameswara Rao

Indian Institute of Astrophysics, Bangalore 560 034, India

David L. Lambert

Dept. of Astronomy, University of Texas at Austin, TX 78712, U.S.A

C. Simon Jeffery

Armagh Observatory, College Hill, Armagh BT61 9DG, Northern Ireland

Martin Asplund

Nordita, Blegdamsvej 17, DK-2100 København Ø, Denmark

Abstract. High resolution spectra were obtained for a sample of hydrogen-deficient stars which are hotter than the R CrB stars and cooler among the extreme helium stars (EHe). We believe that these stars are transition objects evolving either to EHe stars or R CrB stars. We aim to explore the evolutionary link between our program stars, R CrB stars and EHe stars. Distribution of these stars in the $\log g - \log T_{\text{eff}}$ plane shows similar L/M ratios (≈ 4.0). These objects have an abundance pattern like R CrB stars and EHe stars.

Key words : EHe stars, abundance, stellar evolution

1. Introduction

Extreme helium stars are characterized by strong neutral helium lines, singly ionized carbon lines, and weak or absent Balmer lines. Previous studies of extreme helium stars (Jeffery 1996) have revealed that their photospheres are rich in helium and carbon, which are the products of CNO cycling and triple- α burning, respectively. In this paper, we present the results obtained from high-resolution optical spectroscopy of a sample of cool, extreme helium stars. Our large spectral coverage enabled us to study all important elements in two or more stages of ionization. We discuss the elemental abundances and possible evolutionary status of these stars.

2. Observations and reductions

Spectra covering 3700-10175 Å at a resolution of about 50,000 were obtained on 25th and 26th July 1996 with the echelle spectrograph of the 2.7-m McDonald Observatory telescope equipped with a CCD detector (Tull et al. 1995). The reductions have been done using the IRAF software package.

3. Fine analysis

The fine analysis involves the determination of T_{eff} , $\log g$, V_{turb} and photospheric elemental abundances of the star using model atmospheres. We have analysed the high resolution and high S/N ratio optical spectra of our program EHe stars FQ Aqr, LS IV-14° 109, BD - 1° 3438, and LS IV-1° 002. We have used the new line-blanketed model atmospheres described in Asplund (1997) and Jeffery's model atmospheres explained in Jeffery & Heber (1992). We have calculated the contributions of dominant continuum opacity sources in the temperature domain of our cool EHe stars.

4. Results and conclusions

From our analysis of cool EHe stars and a comparison of their abundances with those of R CrB stars and other EHe stars available in the literature, we find that :

1. The C/He ratio determined from carbon and helium lines lies in the range of 0.3% to 1.0% for most of these stars.

2. The dominant sources of continuum opacity for FQ Aqr and LS IV-14° 109 are photoionization of neutral carbon and electron scattering. Most of the carbon is in singly ionized state and contributes 50% of the total free electrons. In the case of BD -1° 3438 and LS IV -1° 002 photoionization of neutral helium is the major source of continuum opacity.

3. FQ Aqr and LS IV -1° 002 belong to the lower metallicity group, while LS IV -14° 109 and BD -1° 3438, belong to the higher metallicity group.

4. The distribution of R CrB stars, EHe stars, and our sample stars in the $\log g$ - $\log T_{eff}$ diagram shows an evolutionary trend. Based on the derived abundances and the location of these stars on $\log g$ - $\log T_{eff}$ diagram, FQ Aqr is likely to evolve towards Minority R CrB (lower metallicity) stars, while LS IV -14° 109 to evolve towards Majority R CrB (higher metallicity) stars.

However, our analysis does not allow us to either explain the cause of hydrogen deficiency, or provide a clear evolutionary link between R CrB stars and EHe stars. There are definitely indications of an evolutionary link and further studies of a larger sample are required to pinpoint the evolutionary status.

References

- Asplund M., 1997, PhD thesis, Univ. Uppsala.
 Jeffery C.S., Heber U., 1992, A&A 25, 261.
 Jeffery C.S. 1996, in : Hydrogen deficient stars, Jeffery C. S., Heber U. (eds). ASP conf. series vol. 96, p. 152.
 Tull. R. G., McQueen, P. J., Sneden, C., Lambert D. L., PASP, 1995, vol. 21, p. 908.