Balmer jump variations of HD 215441 (Babcock’s star)

N. A. Sokolov

Central Astronomical Observatory at Pulkovo, St. Petersburg 196140, Russia E-mail: sna@gaoran.spb.su

Abstract. Balmer jump discontinuity of the peculiar star HD 215441 was measured on 14 continuous energy distributions obtained by S. J. Adelman at Kitt Peak National and Palomar Observatories. The results show that the Balmer jump vary by about 0.05 dex over the cycle of the star. A comparison with new Kurucz model atmospheres shown that the Balmer jump for the phase 0.5 corresponds to a 14750 K, log(g)=3.0 and for the phase 1.0 corresponds to a 15750 K, log(g)=3.0.

1 Introduction

Photometric variations in peculiar A (Ap) stars due to variable flux redistribution from the ultraviolet to the visual region of the spectrum. In this model, the variation of line or continuum opacity over the surface of the star produces, as the star rotates, a variation in line blanketing in the ultraviolet and hence in the amount of flux redistributed. A natural consequence of this model is that a star will exhibit photometric and spectrum variations in phase and with the same period.

Leckrone (1974) has presented evidence from ultraviolet photometry and Adelman (1983) has presented evidence from optical region spectrophotometry for variable flux redistribution in the magnetic Ap star HD 215441. This star is one of the outstanding Ap star photometric variables with amplitudes of 0.\(m\)11, 0.\(m\)14 and 0.\(m\)19 in V, B and U respectively (Stepien, 1968). The surface magnetic field oscillates between 32 and 35 kG in phase with the UBV variations (Preston, 1969). Leckrone obtained ultraviolet photometry between 1550 Å and 4250 Å. He found that at the wavelength 2980 Å the variability is in phase with the optical region. On the other hand, Adelman found that around the cycle of variability the Balmer jump discontinuity (BD) exhibits changes and correlate with the feature at \(\lambda\) 5200 Å, but he could not measure the size of the Balmer jumps for this star.

In this work we will derive the Balmer jump discontinuity for the magnetic Ap star HD 215441. We will also reconcile the variations of BD with the conclusions of other authors about photometric variations for this star.

2 Source of the data and reduction

A series of optical energy distributions of the magnetic Ap star HD 215441 obtained by S. J. Adelman at Kitt Peak National and Palomar Observatories were made available to the authors through Strasbourg Data Center by using Internet. These data also have been published by Adelman (1983). The total number of scans was thirty-eight, but such as the period is rather long and the star relatively faint, these scans obtained on the same night were averaged together. The final number of the optical energy distributions was fourteen.

The use of UBV and/or \(uvby\) photometry to deduce the amount of interstellar reddening has been questioned. If one has sufficient ultraviolet photometry especially in the region near \(\lambda\) 2200 Å, then one might have a way to solve this problem, but HD 215441 was not observed by ANS (van Dijk et al., 1978) and Leckrone’s (1974) values also do not cover this region. On the other hand, changing the reddening does not markedly change the size of the Balmer
jump. This fact allows us to correct all data for the interstellar reddening using the values E(B-V)=0.21 obtained by Peterson (1969).

We have computed the size of the Balmer jump by extrapolating the two fitted curves to \( \lambda = 3700 \, \text{Å} \) separately in the Balmer continuum and Paschen continuum as described by Sokolov (1995). As far as, the errors of BD are concerned, we computed them by taking into account the errors of the two fitted curves.

The rotational phase of the optical energy distributions was computed according to the ephemerides given by Leckrone (1974).

\[
\text{JD(max. light } \lambda > 3300 \, \text{Å}) = 2436864.88 + 9.4871^d E
\]

The phase of maximum light (\( \Phi = 0.0 \)) coincides with the phase of maximum magnetic effective field (Borra and Landstreet, 1978).

### 3 Results and discussion

We applied the method of determination of the size of the Balmer jump (Sokolov, 1995) for 14 continuous energy distributions for the magnetic Ap star HD 215441. In the Figure 1 we can see that BD strongly depend on the rotational phase and show a sinusoidal variation. The variation of BD is in antiphase to the surface magnetic field (see Preston, 1969) and to the effective magnetic field (see Borra and Landstreet, 1978). A comparison with UBV photometry show that the BD is smallest when the Paschen continuum the bluest according to B-V (Stepien, 1968). On the other hand, the hydrogen line equivalent widths are bigger when the BD is smallest (Malanushenko et al., 1992).

The Balmer jump discontinuity is one of the key parameters for stellar spectra. Moreover, the Balmer jump is used for stellar classification of the main sequence stars, because there is very good correlation with effective temperature. However, Krautter (1977) claims that the effective temperature is constant over the rotation cycle of Bcock’s star HD 215441, because the amplitudes of the equivalent width variations did not depend on the excitation potential. His argument supports the earlier analysis of the flux variation over a wide spectral range by Leckrone (1974). But, recently, Malanushenko et al. (1992) were found a decreasing amplitude for an increasing order of the Balmer lines. They were also computed the effective temperature from the comparison equivalent line widths with Kurucz model atmospheres. Their equivalent widths would require a low log(g) = 3.0 and a high temperature of about 18 000 K. Moreover, Adelman (1983) has found that the immediate Balmer jump region is fit by the predictions.
of a 18250 K, log\(g\) = 4.0 model for the phase 0.93 and by those of a 16250 K, log\(g\) = 4.0 model for the phase 0.51. Compared to the new Kurucz model atmospheres (Kurucz, 1993), our measured the size of the Balmer jumps shown the predictions of a 14750 K, log\(g\) = 3.0 for the phase 0.5 and those of a 15750 K, log\(g\) = 3.0 for the phase 1.0 with metallicity [M/H]=1.0 which is in the agreement with the temperature of Babcock’s star (Adelman, 1983). However, using Kurucz models which are not designed to simulate the complex nature of magnetic star atmospheres is questionable. The strong magnetic surface field is a prime candidate for causing a severe deviation of the data relative to standard model atmospheres and is not taken into account by Kurucz.

References

Adelman, S. 1983, A&AS 51, 551
Borra, E., Landstreet, J. 1978, ApJ 222, 226
Krautter, A. 1977, ApJ 216, 33
Kurucz, R. L. 1993, data on magnetic tape
Leckrone, D. 1974, ApJ 190, 319
Manalushenko, V., Polosukhina, N., Weiss, W. 1992, A&A 259, 567
Preston, G. W. 1969, ApJ 156, 967
Sokolov, N. 1995, A&AS 110, 553
Stepien, K 1968, ApJ 154, 945
van Dijk, W., Kerssies, A., Hammerschlag-Hensberge, G., Wesselius, P. R. 1978, A&A 66, 187