DETERMINATION OF THE ELECTRONIC CONCENTRATION IN A BRIGHT SOLAR PROMINENCE

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A spectrum of a bright prominence on April 1, 1970 is analysed. The prominence partly projected onto the solar disc near the limb where many emissive spectral lines were observed. The spectral intensity distributions in prominence and outside it were compared to derive the pure emission of prominence. Such obtained observed spectra were compared with theoretical ones calculated for the spectral region from the 18th Balmer line to series limit, and for different electronic concentrations. It was found that reliable determined electronic concentrations were in the range 10^{17}–10^{18} m^{-3}, *i.e.*, 3–4 order more than in quiet solar corona. It is argued that our method for the electron concentration determination is more reliable than one proposed before by Kurochka [3], based on the analysis of the intensity increase of the continuum spectra in range of the Balmer pre-continuum.

INTRODUCTION

Electronic concentration represents a very important parameter of astrophysics objects. The most employed method for determination of the electronic concentration bases on the Inglis–Teller formula [2]:

$$\log N_e = 22.7 - 7.5 \log N, \tag{1}$$

where N is the last spectrally resolved line of the Balmer hydrogen spectrum.

Another method for this purpose was proposed earlier by Kurochka [3], who used a character of energy increase in spectral continuum near to region of transformation of the discrete Balmer spectrum into continuous emission. To obtain such energy increase, an interpolation curve was constructed using spectral intensities between the spectral Balmer lines. This interpolate curve was named pre-continuum in [3]. It was supposed that the following observational data would allow one to determine not only mean electronic concentration but also distribution of the measure emission versus electronic concentration. However, as it was shown later in [5], only two first moments of distributions really could be determined with this approach taking into account the ordinary accuracy of the observations.

At present paper we use a more adequate method based on an approximation of the full observed Balmer spectrum with several tens of spectral lines of wavelengths from 3660 to 3700 Å by synthetic spectrum. Moreover, we analyse unique spectral data related to spectral peculiarities of the exclusively bright prominence.

MODEL AND METHOD OF CALCULATION

We try to determine the electronic concentration in solar prominence using the comparison of the real observed spectrum with the calculated synthetic Balmer spectrum. As an observed spectrum, we used the Balmer spectrum of a bright solar prominence which was observed by Dr. A. S. Rakhubovsky on April 1, 1970 at the Main Astronomical Observatory of the Academy of Sciences of Ukraine.

The brightnest part of prominence projected partly onto solar disc was analysed. To obtain the spectrum of proper solar prominence, the photometry of a place close to prominence was carried out, but outside one. After this photometry, the second spectral distribution was subtracted from the first one giving a pure emission of prominence.

The spectral region from 3660 to 3700 Å was investigated by a step of 0.04 Å. Observed and calculated spectra are given in Fig. 1 in units of I/I_c, where I is the energy in an arbitrary point of spectrum, and I_c is the energy at the Balmer series limit.

The synthetic Balmer spectrum was calculated for the temperature $T = 7000$ K, a probable velocity of hydrogen atom of 10 000 m/s, and for the electronic concentration N_e from $\log N_e = 16$ to $\log N_e = 19.25$, with a step of 0.25.

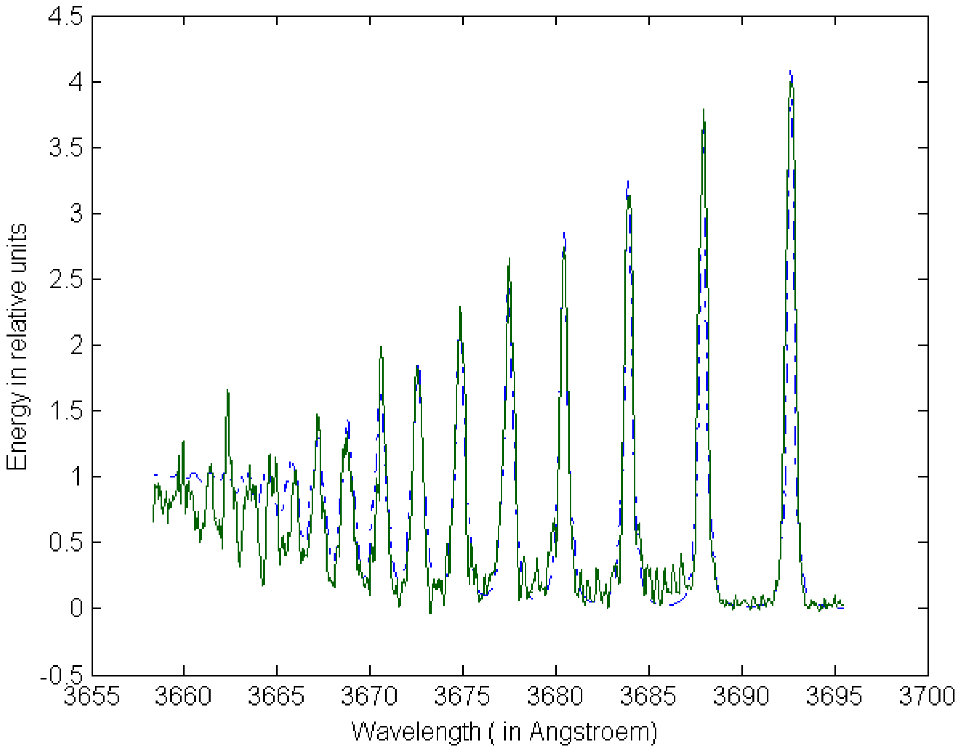

Figure 1. Observed and theoretical spectra: solid line denotes observations and dash-dot line is for the synthetic Balmer spectrum. Energy is given in units of the Balmer continuum level jump

In order to calculate the profiles of the Balmer lines by charged particle influences, the quasistatic widening from ions and blow expansion from electrons [4] (for central parts of lines) were taken into account. For wings of the lines, the gradual conversion from blow extension to quasistatic one was calculated [1]. After these calculations, a convolution of obtained profiles with Doppler ones were made. Contribution of the partial electronic concentrations was determined by the least-squares method using the limitation of non-negative spectral intensities.

As a result, non-zero contribution in line profiles was found the following parameters: $\log N_e = 17.25$ (6.2%), $\log N_e = 17.5$ (8.2%), $\log N_e = 17.75$ (50.8%), $\log N_e = 18.0$ (33.3%), and $\log N_e = 19.25$ (1.5%). The last value, $\log N_e = 19.25$, is maximum in our calculations, and likely one does not influence the Balmer spectrum because such high electronic concentrations give the forming contributions in spectral continuum only.

Formal presence of such a high value of $\log N_e$ could explain the Tompson dispersion. We can not take into account this value as likely unreliable. In this case, the middle value of $\log N_e$ is 17.78.

As it was pointed above, only two first moments of distributions really could be determined taking into account the ordinary accuracy of the observations. Therefore, it is possible to replace above presented distribution of $\log N_e$ by the rectangular one, using the middle value of $\log N_e = 17.78$ and the range of dispersion from $\log N_e = 17.53$ to $\log N_e = 18.03$.

Thus, as the dispersion range is relatively narrow, it is acceptable to calculate theoretical spectra using one middle value of $\log N_e$ only.

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