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THE IMPORTANCE OF RADIATIVE $He^+(1s) + He(1s^2)$ PROCESSES FOR THE DB WHITE DWARF ATMOSPHERE EM-CONTINUOUS SPECTRA

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Abstract. The influence of the processes of radiative charge transfer and photoassociation during $He^+ + He$ collisional processes, as well as the process of the photodissociation of He_2^+ molecular ion, on the formation of continuous spectrum of the DB white dwarf atmospheres with $T_{eff} = 12000 - 20000$ K, for $\log g$ (gravity) = 8, is studied within the wavelength range $\lambda = 200-600$ nm. It is shown that the contribution of these processes relative to other relevant radiative processes is particularly important for $T_{eff} \leq 16000$ K, and increases with the decrease of T_{eff}. Moreover, it is found that the influence of the considered $He^+ + He$ radiative processes is particularly pronounced in the ultra violet range.

1. INTRODUCTION

Radiative $He^+(1s) + He(1s^2)$ processes may be of importance for continuous spectra of helium-rich star low temperature atmospheric layers (see e.g. Mihajlov and Dimitrijević 1992 and Stancil 1994). Here will be considered within DB white dwarf atmospheres, the ion-atom processes of photoassociation and photodissociation

$$\mathrm{He}^+(1s) + \mathrm{He}(1s^2) \Longleftrightarrow \epsilon_\lambda + \mathrm{He}_2^+, \qquad (1a)$$

as well as the processes of the photoemission and photoabsorption charge exchange

$$\mathrm{He}^+(1s) + \mathrm{He}(1s^2) \Longleftrightarrow \epsilon_\lambda + \begin{cases} \mathrm{He}^+(1s) + \mathrm{He}(1s^2) \\ \mathrm{He}(1s^2) + \mathrm{He}^+(1s) \end{cases} \qquad (1b)$$

where $\mathrm{He}_2^+ = \mathrm{He}_2^+(1\Sigma_u^+)$, and ϵ_λ is the energy of photon with the wavelength λ. These processes will be considered here within the semiclassical approach (Mihajlov and Popović 1981; Mihajlov and Dimitrijević 1986, 1992). Our objective here is to estimate the importance of the ion-atom processes of photoassociation and photodissociation (1a) and, photoemission and photoabsorption charge exchange (1b) in comparison with the processes of emission and absorption connected with the free-free transitions of an electron in the field of atoms and atomic ions, as well as the processes of electron - ion photorecombination and photoionization of excited atoms (*i.e.* the relevant electron - atom and electron - ion processes), in order to clarify the nature of DB white dwarf photosphere continuous spectrum for different λ and T ranges. Such results may be of significance for DB white dwarf photosphere modelling.

2. RESULTS AND DISCUSSION

All details of calculations will be given in Mihajlov *et al.* (1995). We will note here only that the present calculations are performed by using the DB white dwarf atmospheric structures of Koester, 1980.

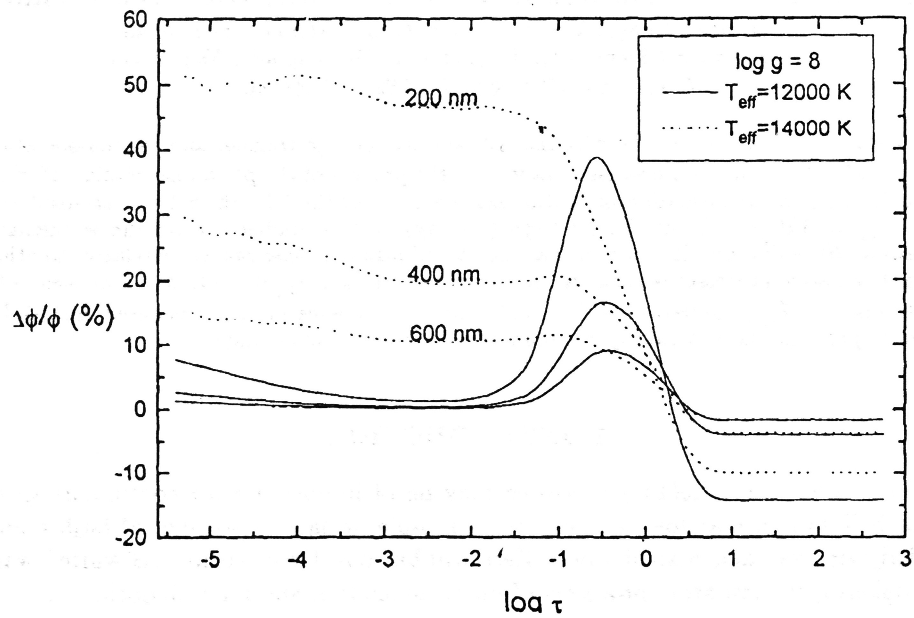

Fig. 1. Behaviour of the ratio $\Delta\Phi/\Phi$ as a function of Rosseland optical depth logarithm.

The influence of the ion - atom radiative processes (1) on the optical characteristics of the considered atmospheric layers we will illustrate here with the relative changes of the optical depth $\Delta\tau(\lambda,\tau)/\tau = [\tau'(\lambda,\tau) - \tau]/\tau$, and the emergent radiation intensity calculated for radial rays (see e.g. Mihalas 1978) $\Delta\Phi(\lambda,\tau)/\Phi(\lambda,\tau) = [\Phi'(\lambda,\tau) - \Phi(\lambda,\tau)]/\Phi(\lambda,\tau)$. Here, $\Phi'(\lambda,\tau)$ and $\Phi(\lambda,\tau)$ are emergent radiation intensities determined with and without ion-atom radiative processes (1a,b), and $\tau'(\lambda,\tau)$ is the optical depth determined with the ion-atom radiative processes (1a,b) included. In Figs. 1 and 2 the behavior of the ratios $\Delta\tau/\tau$ and $\Delta\Phi/\Phi$ as a function of τ, for $\lambda = 200$, 400 and 600 *nm* is demonstrated. Curves in these Figs. are for $T_{eff} = 12000$ and 14000 K, and $\log g = 8$. These curves show the quick increase of the ion-atom processes influence with the λ decrease, especially at the transition from the visible to the UV spectral range. Our calculations show as well, that the transition from

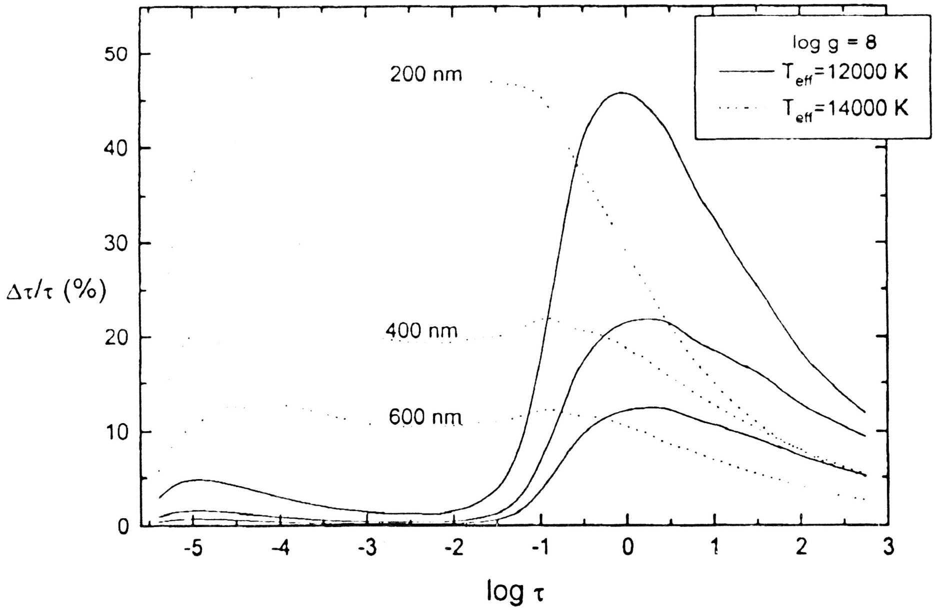

Fig. 2. Behaviour of the ratio $\Delta\tau/\tau$ as a function of Rosseland optical depth logarithm.

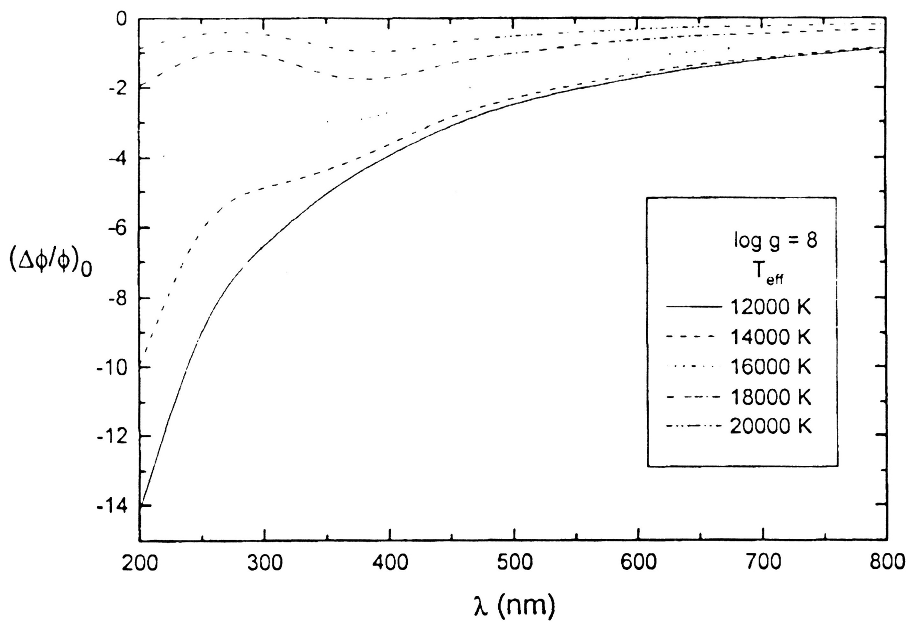

Fig. 3. Behaviour of the ratio $(\Delta\Phi/\Phi)_o = \Delta\Phi/\Phi$ for $\log\tau = 0$ as a function of λ.

$\log g = 8$ on $\log g = 7$ is not connected with considerable changes of $\Delta\tau/\tau$ and $\Delta\Phi/\Phi$. It has been found namely, that these changes are not larger than several percents in the largest part of the considered τ range (only for particular layers these changes approach to 20%).

The influence of the considered ion-atom radiative processes (1a,b) on the optical characteristics of the atmosphere as the whole might be illustrated by the quantity $\Delta\Phi/\Phi$, determined for $\log\tau = 0$, characterizing the whole outer layer with the optical depth $\tau = 1$. Namely, we found numerically that the further increase of the layer depth, does not change the $\Delta\Phi/\Phi$ value, which is shown as well in Fig. 2. The quantity $\Delta\Phi/\Phi$ for $\log\tau = 0$, denoted as $(\Delta\Phi/\Phi)_o$, is shown in Fig. 3 as a function of λ within 200 nm $\leq \lambda \leq$ 800 nm range, for $12000K \leq T_{eff} \leq 20000K$ and $\log g = 8$. One can see that the relative intensity change is negative and changes up to -14 percents. This denotes that in the contribution of the ion - atom radiative processes (1a,b) the influence of the absorption channels dominates. This change is not negligible and in order to have the real picture on the ion-atom radiative processes influence one must take into account that the final $(\Delta\Phi/\Phi)_o$ values characterize in the same time the influence of the absorption channel which decreases this value, and the emission channel which leads to its increase. In Fig. 1 is shown that changes of the optical depth, $\Delta\tau$ represent the significant disturbance of the reference τ greed for the tabular presentation of the white dwarf model and not a small perturbation. One can see in Fig. 2 as well that $\Delta\Phi$ is a strong perturbation for energetic balance considerations. Consequently, the ion-atom radiative processes (1) must be taken into account during the white dwarf atmosphere modelling and not added *a posteriori* as a correction to the result obtained by using the model when such processes have been neglected.

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