

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

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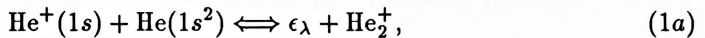
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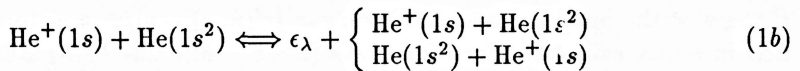
**Abstract.** The influence of the processes of radiative charge transfer and photoassociation during  $\text{He}^+ + \text{He}$  collisional processes, as well as the process of the photodissociation of  $\text{He}_2^+$  molecular ion, on the formation of continuous spectrum of the DB white dwarf atmospheres 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  $\text{He}^+ + \text{He}$  radiative processes is particularly pronounced in the ultra violet range.

## 1. INTRODUCTION

Radiative  $\text{He}^+(1s) + \text{He}(1s^2)$  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



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



where  $\text{He}_2^+ = \text{He}_2^+(1\Sigma_u^+)$ , and  $\epsilon_\lambda$  is the energy of photon with the wavelength  $\lambda$ . 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  $\lambda$  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.

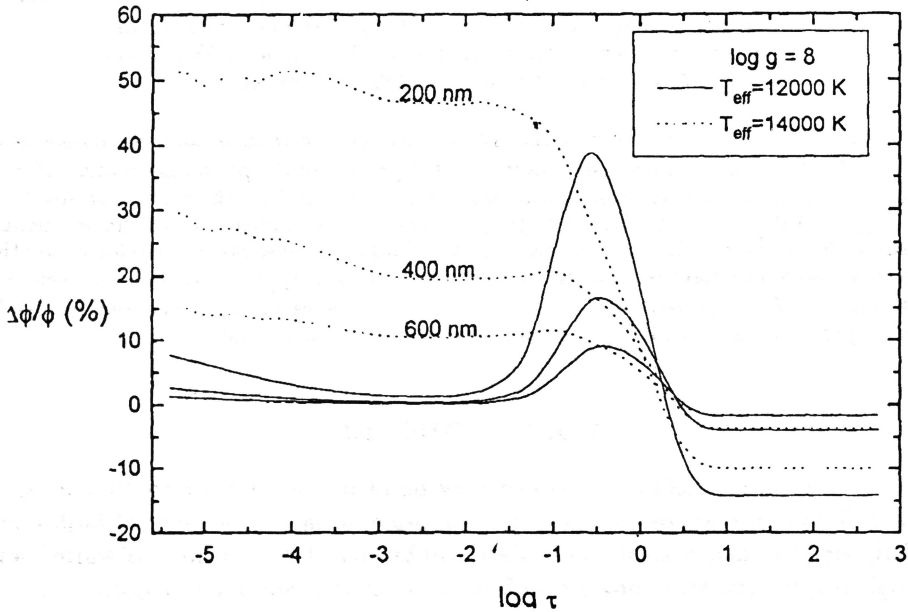


Fig. 1. Behaviour of the ratio  $\Delta\Phi/\Phi$  as a function of Rosseland optical depth logarithm.

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  $\tau$ , 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  $\lambda$  decrease, especially at the transition from the visible to the UV spectral range. Our calculations show as well, that the transition from

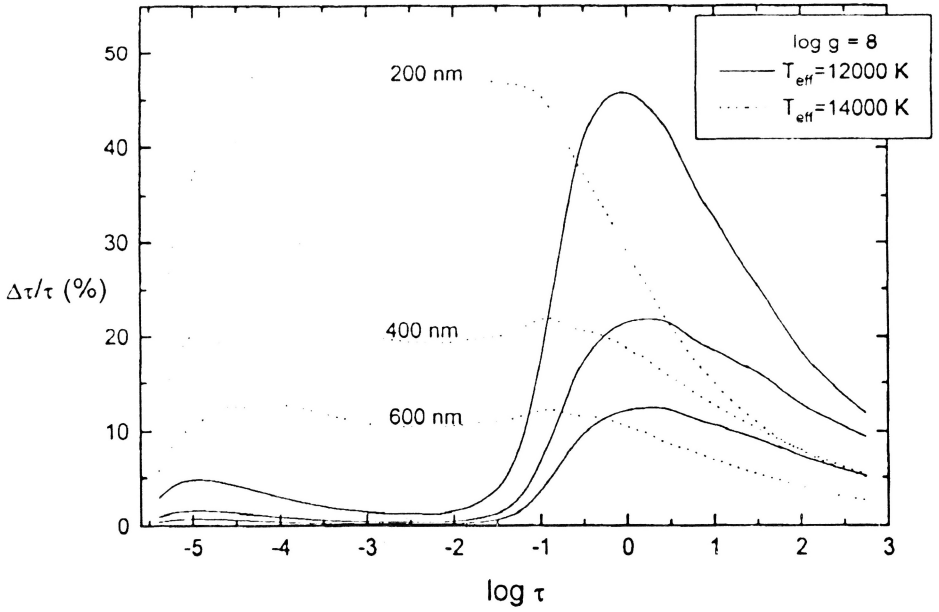


Fig. 2. Behaviour of the ratio  $\Delta\tau/\tau$  as a function of Rosseland optical depth logarithm.

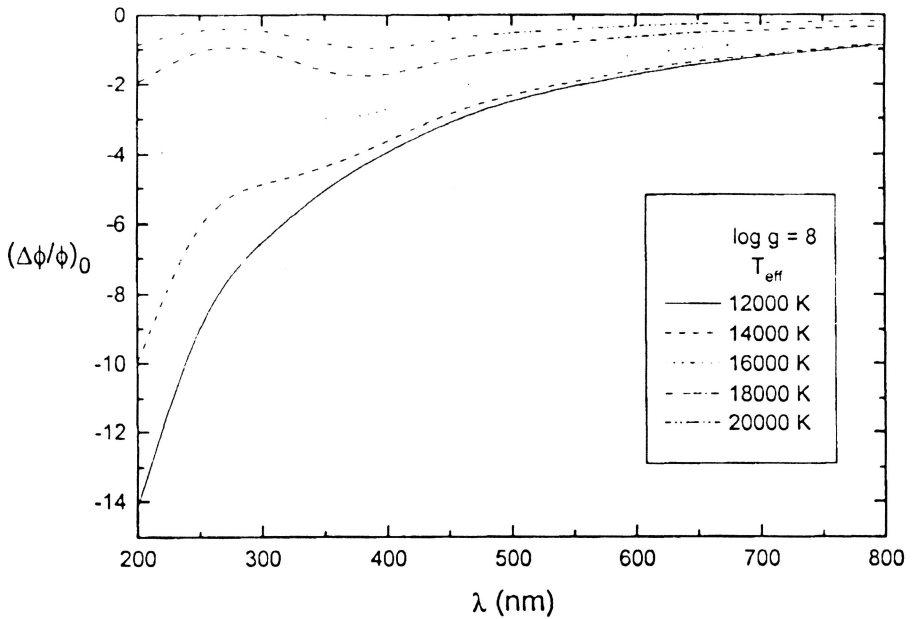


Fig. 3. Behaviour of the ratio  $(\Delta\Phi/\Phi)_0 = \Delta\Phi/\Phi$  for  $\log \tau = 0$  as a function of  $\lambda$ .

$\log g = 8$  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  $\tau$  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  $\lambda$  within  $200 \text{ nm} \leq \lambda \leq 800 \text{ nm}$  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  $\tau$  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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