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ELECTRON-IMPACT BROADENING PARAMETERS FOR ASTROPHYSICALLY IMPORTANT Eu II LINES

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Abstract. Electron-impact widths and shifts for four astrophysically important lines of singly ionized europium have been calculated by using the modified semiempirical method. The influence of the electron-impact mechanism on line shape in a hot star atmosphere has been tested.

1. INTRODUCTION

The lines of ionized rare earth elements are present in spectra of hot CP stars (see e.g. Kupka *et al.* 1996, Golbmann *et al.* 1997, Ryabchikova *et al.* 1997, etc). Considering that in the layers of a hot star atmosphere Stark broadening mechanism can be the main impact broadening mechanism, Stark broadening parameters are needed in numerous problems concerning line formation in stellar atmospheres. Here we present the Stark broadening parameters for four astrophysically important Eu II lines. The spectral lines of singly ionized europium are present in solar as well as in stellar spectra (see e.g. Grevesse and Blanquet 1969, Molnar 1972, Adelman 1987, Mathys and Cowley 1992, etc.). Here we direct our attention to several lines which are very strong in CP star spectra.

Due to the lack of known energy levels as well as of realiable transition probabilities for this emitter, the approximative method can be applied for Stark broadening parameter calculations. Here we have applied the modified semiempirical approach – MSE (Dimitrijević and Konjević 1980, Dimitrijević and Kršljanin 1986, Popović and Dimitrijević 1996ab).

2. METHOD OF CALCULATION

Taking into account very complex spectra of Eu II, as well as that higher levels have no designation, we were able to calculate the electron-impact broadening parameters only for 6s-6p transitions by using the modified semiempirical approach (Dimitrijević and Konjević 1980, Dimitrijević and Kršljanin 1986). Due to the complex spectrum we have applied here this method as it was described in Popović and Dimitrijević (1996). We have estimated also the electron-impact width for Eu II $(5d^9D^0_6 - 6p^9P_5)$

λ =6645.064 Å line by using the MSE approach with the estimation of the perturbation of the partialy known $5f$ levels (in accordance with Popović and Dimitrijević (1998)).

Table 1. Stark full widths (FWHM) and shifts for Eu II lines as a function of temperature. The electron density is 10^{23}m^{-3}.

Transition	T (K)	W (nm)	d (nm)
$6s^9S_4^0 - 6p^9P_5$	5000.	0.451E-01	-0.391E-02
	10000.	0.314E-01	-0.278E-02
$\lambda = 381.967$ nm	20000.	0.219E-01	-0.198E-02
	30000.	0.179E-01	-0.161E-02
	40000.	0.158E-01	-0.142E-02
	50000.	0.146E-01	-0.132E-02
$6s^9S_4^0 - 6p^9P_4$	5000.	0.557E-01	-0.169E-01
	10000.	0.388E-01	-0.122E-01
$\lambda = 412.970$ nm	20000.	0.270E-01	-0.897E-02
	30000.	0.221E-01	-0.759E-02
	40000.	0.195E-01	-0.688E-02
	50000.	0.181E-01	-0.654E-02
$6s^9S_4^0 - 6p^9P_4$	5000.	0.570E-01	-0.173E-01
	10000.	0.397E-01	-0.125E-01
$\lambda = 420.505$ nm	20000.	0.276E-01	-0.916E-02
	30000.	0.226E-01	-0.776E-02
	40000.	0.200E-01	-0.705E-02
	50000.	0.185E-01	-0.671E-02

Transition	T (K)	W (nm)
$5d^9D_6^0 - 6p^9P_5$	5000.	0.930E-01
	10000.	0.644E-01
$\lambda = 664.505$ nm	20000.	0.447E-01
	30000.	0.367E-01
	40000.	0.327E-01
	50000.	0.306E-01

Atomic energy levels needed for calculations were taken from Martin *et al.* (1978). Matrix elements have been calculated by using the method of Bates and Damgaard (1949). Since for nonet terms the line factors are not presented in the tables of Oertel and Shomo (1968), they have been calculated as

$$\Re_{\rm line} = \sqrt{2J+1}\sqrt{2J'+1}\begin{Bmatrix} S & J & L \\ 1 & L' & J' \end{Bmatrix}$$

where S is the total spin; J and J' are total angular momentum quantum numbers; while L and L' are total azimuthal quantum numbers. The quantum numbers of perturbing level are denoted with the primes.

3. RESULTS AND DISCUSSION

In Table 1. the results of our calculation are presented as a function of temperature, for an electron density of 10^{23}cm^{-3}. We have tested also the importance of the electron-impact broadening effect in stellar atmospheres. As an example of this influence we have synthesized line profile for Eu II λ=6645.064 Å line using SYNTH code and the Kurucz's model of stellar atmosphere with T_{eff} = 10000 K and $log g$=5.0. The synthesized line profiles are shown in Fig. 1. As one can see from Fig. 1, the electron-impact effect causes that equivalent width is larger. Consequently, for the determination of elemental abundance by comparing the observed to the synthetic spectra one should take into account this effect, especially in the case when europium is overabundant (see e.g. the case of silicon in Lanz *et al.* 1988). The detailed discussion of the electron- impact broadening effect in stellar atmospheres will be discussed elsewhere (Popović *et al.* 1998).

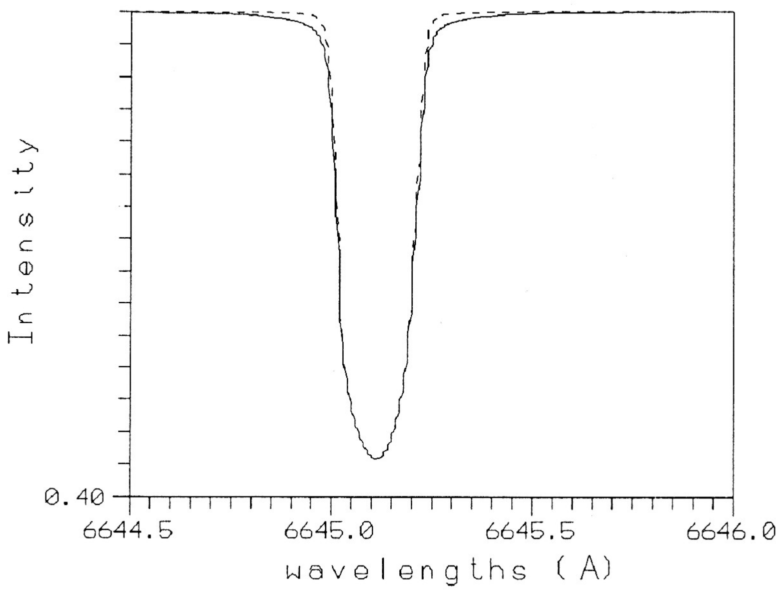

Fig. 1. The synthesized profile of Eu II λ=6645.05 Å: profile shown by full line has been calculated when the electron-impact width is taken into account, and the dashed profile without this width.

References

Adelman, S J.: 1987, *in Elemental Abundance Analyses*, Proc. of the IAU working group on Ap stars Workshop (Eds. S.J. Adelman and T. Lanz) p. 58.

Bates, D.R., and Damgaard, A.: 1949, *Phil. Trans. Roy. Soc. London*, Ser. A, **242**, 101.

Dimitrijević, M.S., Konjević, N.: 1980, *J. Quant. Spectrosc. Radiat. Transfer*, **24**, 451.

Golbmann, M., Kupka, F., Weiss, W.W. and Mathys, G.: 1997, *Astron. Astrophys.* **319**, 630.
Grevesse, N. and Blanquet, G.: 1969, *Solar Phys.* **8**, 5.
Kupka, F., Ryabchikova, T.A., Weiss, W.W., Kursching, R., Rogel, J. and Mathys, G.: 1996, *Astron. Astrophys.* **308**, 886.
Lanz, T., Dimitrijević, M.S., and Artru, M.-C.: 1988, *Astron. Astrophys.* **192**, 249.
Martin, W.C, Zalubas, R. and Hagan, L.: 1978, *Atomic Energy Levels*, NSRDS-NBS, Vol. **60**, Washington D.C.
Mathys, G. Cowley, C.R.: 1992, *Astron. Astrophys.* **253**, 199.
Molnar, H.: 1972, *Astron. Astrophys.* **20**, 69.
Oertel, G.K., Shomo, L.P.: 1968, *Astrophys J. Suppl. Series*, **16**, 175.
Popović, L.Č. and Dimitrijević, M.S.: 1996a, *Phys. Scr.* **53**, 325.
Popović, L.Č. and Dimitrijević, M. S.: 1997, In: The Physics of Ionized Gas, (eds. B. Vujičić, S. Djurović and J. Purić) p.477.
Popović, L.Č., Dimitrijević, M.S.: 1998, *in preparation.*
Ryabchikova, T.A., Landstreet, J.D., Gelbmann M.J., Bogova, G.T., Tsymbal V.V. and Weiss W.W.: 1997, *Astron. Astrophys.* **327**, 1137.