Stark broadening parameter regularities and interpolation and critical evaluation of data for CP star atmospheres research: Stark line shifts

Milan S. Dimitrijević and Dragana Tankosić

Astronomical Observatory, Volgina 7, 11000 Belgrade, Serbia, Yugoslavia

Abstract. In order to find out if regularities and systematic trends found to be apparent among experimental Stark line shifts allow the accurate interpolation of new data and critical evaluation of experimental results, the exceptions to the established regularities are analysed on the basis of critical reviews of experimental data, and reasons for such exceptions are discussed.

We found that such exceptions are mostly due to the situations when: (i) the energy gap between atomic energy levels within a supermultiplet is equal or comparable to the energy gap to the nearest perturbing levels; (ii) the most important perturbing level is embedded between the energy levels of the supermultiplet; (iii) the forbidden transitions have influence on Stark line shifts.

Key words: line profile – atomic data

1. Introduction

Wiese and Konjević (1982) established that for experimental Stark widths of non-hydrogenic lines, there are similarities (see as well references in Wiese & Konjević 1982 and Dimitrijević 1982) of line widths within a multiplet, a supermultiplet and a transition array, as well as for analogous transitions of homologous atoms and ions. They found as well a systematic behaviour of Stark line widths along spectral series. The exceptions to these similarities and systematic trends have been analyzed by Dimitrijević (1982), who found that the reasons for such exceptions may be divided in two categories: (i) irregular atomic energy level structure and (ii) inadequacy of the model used for the emitter structure. He emphasized as well, that the simple analysis of Grotrian diagrams for corresponding radiator energy levels, may be useful for prediction of mutual relations among Stark widths within multiplets, supermultiplets and transition arrays. Extending their work of 1982 on Stark widths, Wiese & Konjević (1992) carried out the same kind of research on experimental Stark line shifts, and showed numerous examples where the same regularities and systematic trends hold. Similarly as in Dimitrijević (1982) for widths, we want to analyze here the exceptions to the established regularities and systematic trends for Stark line shifts.

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2. Results and discussion

The exceptions to the established regularities have been analysed on the basis of critical reviews of experimental data (Konjević & Roberts 1976; Konjević & Wiese 1976; Konjević et al. 1984ab; Konjević & Wiese 1990). The complete analysis will be published elsewhere. We found that such exceptions are mostly due to the situations when: (i) the energy gap between atomic energy levels within a supermultiplet is equal or comparable to the energy gap to the nearest perturbing levels; (ii) the most important perturbing level is embedded between the energy levels of the supermultiplet; (iii) the forbidden transitions have influence on Stark line shifts.

Table 1. Experimental Stark shifts d[Å] from Djurović and Konjević (1988). Plasma conditions are: Temperature = 9700 - 9800 K; electron density is 10^{17}cm^{-3}.

element	transition (mult.No)	J_L	J_H	λ[Å]	d[Å]
F I	$3s^4P$-$3p^4P^0$	5/2	3/2	7331.96	0.03
		5/2	5/2	7398.69	0.03
	$3s^4P$-$3p^4D^0$	1/2	3/2	6909.82	0.16
		3/2	5/2	6902.48	0.16
		5/2	7/2	6856.03	0.16
	$3s^4P$-$3p^4S^0$	3/2	3/2	6348.51	0.26
		5/2	3/2	6239.65	0.25

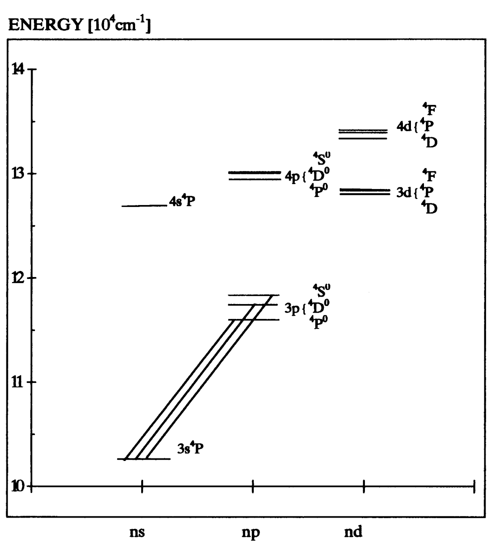

Figure 1. Partial Grotrian diagram for F I 3s, 4s, 3p, 4p, 3d, 4d

The example of Stark line shifts from F I 3s - 3p (quartets) supermultiplet, illustrates the case when the energy gap between upper atomic energy levels for particular members of a supermultiplet is not negligible in comparison to the energy gap to the most important perturbing levels. For the $3p^4S^o$ energy level for instance, the influence of the upper perturbing levels 4s and 3d, is larger in comparison with this influence for the $3p^4P^o$ energy level, and the contribution of the 3s energy level is smaller. The effect of such an energy structure is larger on the shift than on the width, since all partial contributions to the width are positive while the contribution of the level 3s as a perturbing level of 4p to the shift is negative. Consequently, the shift of lines within the $3s^4P$ - $3p^4S^o$ multiplet is larger than the shifts within the $3s^4P$ - $3p^4P^o$ multiplet.

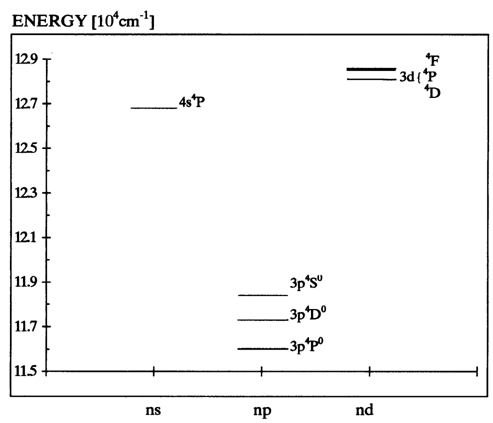

Figure 2. Partial Grotrian diagram for F I 4s, 3p, 3d

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