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STARK BROADENING OF F III LINES IN STELLAR PLASMA

Z. SIMIĆ, M. S. DIMITRIJEVIĆ and L. Č. POPOVIĆ
Astronomical Observatory, Volgina 7, 11160 Belgrade – 74, Serbia and Montenegro
E–mail zsimic@aob.aob.bg.ac.yu
E–mail mdimitrijevic@aob.aob.bg.ac.yu
E–mail lpopovic@aob.aob.bg.ac.yu

Abstract. Using the modified semiempirical approach, Strak broadening data for 9 F III multiplets have been calculated. Moreover, for the additional, F III $2s^22p^3$ $^4S^o$ - $3s^4P$ resonant transition, calculations have been performed within the semiclassical perturbation approach. The obtained results will be used also for the investigation of the influence of Stark broadening effect on F III lines in stellar atmospheres. In this contribution, as a sample of obtained results, Stark widths for 3 F III multiplets are presented.

1. INTRODUCTION

With the development of space technology and satellite born astronomical instruments, astrophysical interest for data on trace elements increases. Here, we investigate the Stark broadening in F III spectrum for stellar atmospheres plasma conditions. Fluorine spectral lines were observed in Solar (Moore et al, 1966), as well as in stellar spectra (Merrill, 1956). In Trimble (1991) was reported that fluorine was found in the ejecta of SN 1987A supernova. This element is a product of hydrogen burning in stellar interiors and envelopes. Consequently, the data on the spectral line broadening parameters of this element in various ionization stages are of interest at considering and modelling of stellar plasma, subphotospheric layers and radiative transfer in stellar interiors.

By inspecting bibliographies on atomic line shapes and shifts (Fuhr et al. 1972, 1974, 1975, 1978, Fuhr and Lesage 1993, Lesage and Fuhr 1998, 2000) covering the period from the first paper relating to this topic (Lord Rayleigh 1889) on the limit to interference when light is radiated from moving molecules, and the first paper where line broadening mechanisms including line broadening due to interactions with charged particles is treated (Stark broadening) (Michelson 1905), up to 1999, one can see that the first, qualitative, experimental investigation of the Stark broadening of F III spectral lines was made by Sarma (1961). The first quantitative theoretical determination of F III Stark widths and shifts (5 transitions from 3s-3p and 3p'-3d' transition arrays) was made by Dimitrijević and Konjević (1981), by using four different theoretical methods: the semiempirical method (Griem 1968), the modified semiempirical method (Dimitrijević and Konjević 1980), the symplified semiclassical method (Griem 1974) and its modification (Dimitrijević and Konjević 1980). These data have been presented within a theoretical study of Stark broadening of doubly- and triply-charged ions. Moreover, Stark broadening data obtained in this study have been recalculated later with updated atomic energy levels (Dimitrijević 1988ab), and up to now they are the only theoretical data on the Strak broadening of F III spectral lines. The first quantitative experimental data on the Stark broadening in F III spectrum, were obtained in 1988 by Purić et al. (1988). Since then, two additional experimental works on the F III Stark broadening have been published (Djeniže et al. 1991a, Blagojević et al 2000).

By using the modified semiempirical approach, originally formulated in Dimitrijević and Konjević (1980) for Stark line widths, in Dimitrijević and Kršljanin (1986) for Stark line shifts and later adapted for low-temperature (adiabatic) limit (Dimitrijević and Konjević 1987) and for complex spectra (Popović and Dimitrijević 1996, see also review paper of Dimitrijević and Popović 2001), Strak broadening data for additional 9 F III multiplets, not investigated before and belonging to the 3s-4p, 3p-4s and 4s-4p transition arrays (quartets) have been calculated in order to complete the existing data on the Stark broadening within this spectrum. Moreover, for the F III $2s^2 2p^3$ $^4S^o$ - $3s^4P$ resonant transition, usually the astrophysically most important one, calculations were performed within the semiclassical perturbation approach (Sahal-Bréchot 1969ab). In view of the incompletness of the data on F III atomic energy levels, these are the only transitions with a sufficient set of atomic data for the application of the full semiclassical perturbation method with the usual accuracy. For other transitions tretaed here, there is no a sufficient set of atomic data for such calculations. However the modified semiempirical method, where the needed set of atomic data is minimized, can be applied successfully, and in this study are chosen all the transitions without published Stark broadening data, where this method is applicable in its full form. We note that if necessary, the symplified version of this method (Dimitrijević and Konjević 1987) and the estimates and interpolations by using regularities and systematic trends (see e.g. Wiese and Konjević 1982, 1992, Dimitrijević 1982, Lakićević 1983, Djeniže et al. 1991b, Dimitrijević and Sahal-Bréchot 1996, Dimitrijević and Tankosić 2000), can provide additional data.

The obtained results have been used also for the investigation of the influence of Stark broadening effect on F III lines in stellar plasma by the calculation of Stark widths of F III spectral lines through the different models of stellar atmospheres. The obtained results are also of importance not only for diagnostics, analysis and modelling of astrophysical and laboratory plasmas, but also for the investigations of regularities and systematic trends particularly along isoelectronic sequences and within homologous ion spectra.

It should be noted as well that this contribution is the continuation of our efforts to provide needed data for the analysis of laboratory and astrophysical plasmas (see e.g. Dimitrijević 1996, Dimitrijević and Popović 2001, Dimitrijević and Sahal-Bréchot 1996, 1998 and references therein).

2. RESULTS AND DISCUSSION

A summary of the modified semiempirical method is given in Dimitrijević and Popović (2001) and of the semiclassical perturbation method with all updates and inovations in Dimitrijević et al. (1991) and Dimitrijević and Sahal- Bréchot (1996).

Atomic energy levels for F III transitions have been taken from Bashkin and Stoner (1975). Oscillator strengths have been calculated by using the method of Bates and Damgaard (1949) and the tables of Oertel and Shomo (1968). For higher levels, the method described by Van Regemorter *et al.* (1979) has been used. Our results for 9 F III multiplets, obtained within the modified semiempirical method and for one (resonant) multiplet within the semiclassical perturbation method, and the analysis of the influence of Stark broadening mechanism on the stellar line shapes, will be published in Simić et al. (2003).

Table 1: This Table shows electron-impact broadening full half-widths (FWHM) of F III spectral lines for a perturber density of 10^{17} cm^{-3} and temperatures from 10000 up to 300000 K.

TRANSITION	$T(K)$	WIDTH(Å)	TRANSITION	$T(K)$	WIDTH(Å)
FIII	10000	2.72	FIII	10000	4.43
	20000	1.93		20000	3.13
4s ^4P-4p ^4S	50000	1.43	4s ^4P-4p ^4P	50000	2.32
λ =6285.0Å	100000	1.31	λ =8263.0Å	100000	2.09
	200000	1.22		200000	1.94
	300000	1.16		300000	1.86
FIII			FIII		
	10000	5.11		100000	2.43
4s ^4P-4p ^4D	20000	3.61	4s ^4P-4p ^4D	200000	2.26
λ =8890.0Å	50000	2.68	λ =8890.0Å	300000	2.15

Here, in Table 1, we present only a sample of results obtained.

We hope that the present results will be of interest in the stellar, laboratory, fusion and laser produced plasma investigation and modelling, as well as in the investigation and development of Stark broadening theory of multicharged ions and research of Stark broadening parameter regularities and systematic trends. We hope as well that the new theoretical results will stimulate new experimental determinations.

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