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ON THE IONIZED IRON LINES STARK BROADENING IN STELLAR SPECTRA

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Abstract. Stark broadening parameters for singly-ionized iron a^6D - z^6P^o, a^6D - z^6D^o and a^6D - z^6F^o multiplets, have been calculated by using the semiclassical-perturbation approach. The obtained results have been compared with experimental data and simpler estimates.

1. INTRODUCTION

The research of neutral and ionized iron spectra is of great astrophysical importance due to high abundance of this element and its role in various processes in stellar plasma. Fe II lines are present in solar and stellar spectra and for their analysis or the calculations of synthetic spectra corresponding Stark broadening data are of importance. In spite of the astrophysical meaning of iron, we found only two published experimental investigations of Stark broadening parameters of Fe II lines. Manning *et al.* (1990) have investigated shifts of Fe II a^4D - z^4F^o 2755.73 Å line and Purić *et al.* (1993) widths of 14 lines from a^6D - z^6D^o and a^6D - z^6F^o multiplets. Electron-impact widths for 3 solar multiplets (a^4H - z^4F^o, a^6D - z^6D^o and a^4F - z^4F^o) and 3 multiplets observed in the spectrum of 15 Vulpeculae (Yo-ichi Takeda, 1984) b^4P - z^4F^o, b^4F - z^4D^o and b^4P - z^4D^o), have been calculated by Dimitrijević (1988) within the modified semiempirical approach (Dimitrijević and Konjević, 1980). Simple estimates based on the regularities and systematic trends, by Lakićević (1983) and Purić *et al.* (1993) exist as well.

The strongest Fe II lines correspond to 4s-4p and 3d-4p transitions in $3d^6nl$ and $3d^54snl$ configurations, covering some 1500 observed lines and accounting for the main part of the intensity of the Fe II spectrum (Johanson, 1984). However, if one wishes to perform a more sophisticated calculations it is not easy to collect the sufficiently complete energy level set and to avoid the additional difficulties due to configuration interaction and violation of the LS selection rules. The best situation is just with 4s-4p sextets, measured by Purić *et al.* (1993), where the sufficiently complete energy level set exists and there is not pronounced configuration interactions or critical violations of the LS selection rules (Fawcet, 1987), so that the semiclassical calculations may provide more reliable Stark broadening parameters.

By using the semiclassical-perturbation formalism (Sahal-Bréchot 1969ab), we have calculated Stark broadening parameters for singly-ionized iron a^6D - z^6P^o, a^6D - z^6D^o and a^6D - z^6F^o multiplets. Perturbers are electrons, protons and a singly charged perturber with the mass equal to 35 a.u. corresponding to the averaged mass of perturbing ions in Solar atmosphere. A summary of the formalism is given in Dimitrijević *et al.* (1991). The obtained results have been compared with experimental data and simpler evaluations.

2. RESULTS AND DISCUSSION

All details of calculations and results for a^6D - z^6P^o, a^6D - z^6D^o and a^6D - z^6F^o multiplets, covering 34 lines within 2328.11-2632.108 $\AA$ range, will be published in Dimitrijević (1995), for a perturber density of $10^{17}cm^{-3}$ and temperatures T = 5,000 - 150,000 K.

In Table 1 the present theoretical full half-widths have been compared with experimental results (Purić *et al.* 1993a) as well as with the calculations of Dimitrijević (1988) performed by using the modified semiempirical approach (1980) and with simple theoretical estimates of Purić *et al.* (1993b) based on regularities and systematic trends. For the experiment of Purić *et al.* (1993a) SF_6 has been used as a working gas. At T = 30,000 K and electron density of $10^{17}cm^{-3}$ full half width for F II-impact broadening of Fe II 2392.9 $\AA$ line is 0.00606$\AA$ and for S II-impact broadening 0.00618$\AA$. Since the difference is negligible in comparison with electron-impact broadening, and since the ionized sulphur has the lower ionization potential and the corresponding linewidth is larger, full half width due to S II- impacts has been presented in Table 1 as an upper limit of ion broadening contribution. We can see that semiclassical calculations with the ion broadening contribution included, give larger widths than experiment but within the error bars of theory and experiment. Taking into account the complexity of the Fe II spectrum, the results (Dimitrijević, 1988) obtained by using the modified semiempirical method (Dimitrijević and Konjević, 1980) are in satisfactory agreement with the experimental values. The agreement of simple estimates of Purić *et al.* (1993b) with experimental and semiclassical values is encouraging as well. Simple estimate of Lakićević (1983) gives for a^6D - z^6D^o Fe II multiplet for a perturber density of $10^{17}cm^{-3}$ and the temperature of 20,000 K, full width = 0.068 $\AA$ which is in encouraging agreement with experimental and semiclassical results. On the other hand the shift of 0.032 $\AA$ has the different sign. New experimental data for Fe II Stark broadening parameters will be of interest for astrophysics as well as for theoretical investigations of Stark broadening for complex spectra.

TABLE I

Comparison of experimental and theoretical Stark widths (FWHM) at corresponding electron densities N, and temperatures T. WM - experimental widths(FWHM) of Purić *et al.* 1993a; We - present semiclassical widths(FWHM) for electron-impact broadening; WSII - present semiclassical widths (FWHM) for SII- impact broadening; WDK - Dimitrijević (1988); WP - Purić *et al.* 1993b.

Transition	Wavelength [A]	T [10^4K]	N [10^{17}cm^{-3}]	W_M[A]	W_e[A]	W_{SII} A]	W_{DK}[A]	W_P[A]
a^6D-z^6D^o	2598.37	3.00	1.95	0.070	0.117	0.0130	0.068	0.126
		2.90	1.64	0.058	0.100	0.0109	0.059	0.108
		2.80	1.06	0.044	0.066	0.0070	0.038	0.072
	2607.52	3.00	1.95	0.100	0.117	0.0130	0.068	0.126
		2.90	1.64	0.076	0.100	0.0109	0.059	0.108
		2.90	1.27	0.058	0.077	0.0084	0.045	0.084
	2611.87	3.00	1.95	0.096	0.117	0.0130	0.068	0.126
		2.90	1.64	0.090	0.100	0.0109	0.059	0.108
		2.80	1.06	0.072	0.066	0.0070	0.038	0.070
	2613.82	3.00	1.95	0.088	0.117	0.0130	0.068	0.126
		2.90	1.64	0.072	0.100	0.0109	0.059	0.108
		2.80	1.06	0.044	0.066	0.0070	0.038	0.070
	2617.62	3.00	1.95	0.084	0.117	0.0130	0.068	0.126
		2.90	1.64	0.072	0.100	0.0109	0.059	0.108
		2.80	1.06	0.050	0.066	0.0070	0.038	0.070
a^6D-z^6F^o	2373.74	2.80	1.06	0.062	0.057	0.0065	0.034	0.064
	2382.04	3.00	1.95	0.090	0.101	0.0121	0.060	0.114
		2.90	1.64	0.080	0.086	0.0101	0.051	0.098
		2.80	1.06	0.048	0.057	0.0065	0.034	0.064
	2388.63	3.00	1.95	0.076	0.101	0.0121	0.060	0.114
		2.80	1.06	0.044	0.057	0.0065	0.034	0.064
	2404.43	2.70	0.63	0.030	0.034	0.0038	0.020	0.038
	2404.89	3.00	1.95	0.086	0.101	0.0121	0.060	0.112
		2.90	1.64	0.066	0.086	0.0101	0.051	0.096
		2.80	1.06	0.042	0.057	0.0065	0.034	0.064

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