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STARK WIDTHS OF FOUR- AND FIVE-TIMES CHARGED ION LINES FOR ASTROPHYSICISTS

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Important astrophysical applications of Stark broadening of multiply charged ion spectral lines are in the physics of stellar interiors (Seaton 1987). In subphotospheric layers, the modelling of energy transport requires radiative opacities and thus, certain atomic processes must be known with accuracy. At these high temperatures (10^5 K or more) and densities (10^{17} -10^{22}cm^{-3}) Stark broadening of strong multicharged ionic lines plays a non-negligible role in the calculation of the opacities, especially in the UV. Moreover, with the development of spectroscopy investigations from space, UV and extreme UV spectral line research has been further stimulated. The aim of this paper is to provide Stark broadening data of astrophysical interest for four- and five-times charged ion lines. In such a way, our intention is to complete such data, together with the published studies for N V and O VI lines (Dimitrijević and Sahal-Bréchot 1992ab) and with studies of C V, O V, P V and S VI lines, which are in preparation. Consequently, in the case of C V and O V, data calulations have been performed only for such cases for which atomic data set is not sufficient for semiclassical perturbation calculations. Since theoretical errors for shifts are considerably larger than for line widths, and since the astrophysical importance of multiply charged ion Stark widths is greater, only width calculations have been performed.

Stark line widths(FWHM) for 3 C V, 50 O V, 12 F V, 9 Ne V, 3 Al V, 6 Si V, 11 N VI, 28 F VI, 8 Ne VI, 7 Na VI, 15 Si VI, 6 P VI, and 1 Cl VI multiplet calculated using the modified semi-empirical approach (Dimitrijević and Konjević 1980) - (WMSE) will be published in Dimitrijević 1993a. A sample of results is presented in Table 1. Data are presented for an electron density of 10^{17}cm^{-3} and temperatures from 50,000 to 800,000 K. Data are linear with electron density, but at very high densities Debye screening should be considered (see e.g. Griem 1974). Moreover, for lines with very near perturbing levels broadening by inelastic proton collisions may be also important. Comparison of the present values with values calculated by using Eq. (526) in Griem (1974) have been performed, and the obtained agreement is satisfactory. As an example, the comparison for C V $3s^1S$ - $3p^1P^0$, N VI $2s^1S$ - $2p^1P^0$ and O V $4p^1P^0$ - $4d^1D$ cases is presented in Table 2. In comparison with the experiment of Purić et al (1988) for two O V lines, both approaches give about two times smaller values.

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Table 1. Stark width (FWHM) in Åunits calculated by using the modified semiempirical approach (Dimitrijević and Konjević 1980), at an electron density of 10^{17} cm^{-3}.

Transition	Lambda(A)	T(K)=50000	100000	200000	400000	800000
C V 1s21S - 3p1P	35.0	0.100E-04	0.881E-05	0.846E-05	0.700E-05	0.660E-05
C V 2s1S - 3p1P	247.3	0.431E-03	0.372E-03	0.362E-03	0.298E-03	0.266E-03
N VI 1s21S - 2p1P	28.8	0.418E-06	0.307E-06	0.248E-06	0.208E-06	0.176E-06
N VI 2s3S - 3p3P	161.2	0.951E-04	0.792E-04	0.676E-04	0.588E-04	0.575E-04
N VI 2p3P - 3d3D	173.9	0.553E-04	0.447E-04	0.367E-04	0.311E-04	0.312E-04
N VI 2p3P - 4d3D	130.3	0.368E-03	0.295E-03	0.239E-03	0.199E-03	0.159E-03
N VI 2p3P - 5d3D	116.8	0.846E-03	0.697E-03	0.577E-03	0.467E-03	0.374E-03
N VI 3p3P - 4d3D	500.9	0.616E-02	0.499E-02	0.408E-02	0.342E-02	0.283E-02
N VI 3p3P - 5d3D	346.7	0.780E-02	0.644E-02	0.534E-02	0.434E-02	0.352E-02
O V 2s21S - 3p1P	172.2	0.148E-03	0.115E-03	0.978E-04	0.838E-04	0.723E-04
O V 2s21S - 4p1P	135.5	0.424E-03	0.370E-03	0.320E-03	0.284E-03	0.271E-03
O V 2p1P -5d1D	154.0	0.153E-02	0.131E-02	0.110E-02	0.921E-03	0.766E-03
O V 3s1S - 4p1P	566.2	0.627E-02	0.543E-02	0.475E-02	0.419E-02	0.398E-02
O V 3p1P -4s1S	662.9	0.606E-02	0.510E-02	0.437E-02	0.394E-02	0.370E-02
O V 3p1P -4d1D	604.4	0.641E-02	0.546E-02	0.474E-02	0.433E-02	0.395E-02
O V 3p1P -5d1D	439.5	0.130E-01	0.111E-01	0.931E-02	0.782E-02	0.652E-02
O V 3d1D - 4p1P	798.3	0.887E-02	0.756E-02	0.649E-02	0.579E-02	0.559E-02
O V 2p21S -3s'1P	265.6	0.324E-03	0.282E-03	0.246E-03	0.210E-03	0.237E-03
O V 2p21S -3d'1P	231.8	0.940E-04	0.757E-04	0.617E-04	0.502E-04	0.495E-04
O V 2p21D -3s'1P	231.1	0.246E-03	0.214E-03	0.187E-03	0.159E-03	0.179E-03
O V 2p21D -3d'1P	205.1	0.841E-04	0.685E-04	0.564E-04	0.463E-04	0.455E-04
O V 2p21D -3d'1D	216.0	0.107E-03	0.861E-04	0.808E-04	0.691E-04	0.574E-04
O V 2p21D -3d'1F	207.8	0.796E-04	0.633E-04	0.516E-04	0.427E-04	0.390E-04
O V 3s3S -4p3P	529.2	0.508E-02	0.432E-02	0.373E-02	0.333E-02	0.310E-02
O V 3s3S -5p3P	390.8	0.790E-02	0.686E-02	0.594E-02	0.529E-02	0.454E-02
O V 3p3P -5s3S	469.1	0.940E-02	0.820E-02	0.722E-02	0.626E-02	0.566E-02
O V 3p3P -5d3D	447.3	0.110E-01	0.944E-02	0.826E-02	0.724E-02	0.609E-02
O V 2p23P -3d'3D	203.9	0.110E-03	0.894E-04	0.744E-04	0.624E-04	0.569E-04
O V 2p23P -3d'3P	202.3	0.107E-03	0.853E-04	0.716E-04	0.603E-04	0.532E-04
O V 2p23P -3s'3P	227.5	0.177E-03	0.141E-03	0.122E-03	0.106E-03	0.910E-04
F V 2p3s2P-2p3p2S	154.2	0.734E-04	0.543E-04	0.447E-04	0.384E-04	0.342E-04
F V 2p3s2P-2p3p2P	162.0	0.710E-04	0.590E-04	0.509E-04	0.439E-04	0.376E-04
F VI 2s21S -2p1P	535.2	0.295E-03	0.209E-03	0.148E-03	0.105E-03	0.830E-04
F VI 2s21S -3p1P	126.9	0.606E-04	0.462E-04	0.381E-04	0.324E-04	0.276E-04
F VI 2s21S -4p1P	99.2	0.173E-03	0.150E-03	0.132E-03	0.119E-03	0.104E-03
F VI 2p1P -3s1S	173.1	0.841E-04	0.667E-04	0.570E-04	0.491E-04	0.417E-04
F VI 2p1P -4s1S	123.3	0.169E-03	0.149E-03	0.130E-03	0.111E-03	0.106E-03
F VI 2p1P -3d1D	121.2	0.232E-04	0.173E-04	0.148E-04	0.121E-04	0.102E-04
F VI 2p1P -4d1D	121.1	0.140E-03	0.121E-03	0.102E-03	0.931E-04	0.857E-04
F VI 3s1S -4p1P	410.7	0.266E-02	0.228E-02	0.201E-02	0.184E-02	0.158E-02
F VI 3p1P -4s1S	476.5	0.297E-02	0.257E-02	0.224E-02	0.191E-02	0.180E-02
F VI 2p21S -3s'1P	183.9	0.111E-03	0.961E-04	0.831E-04	0.699E-04	0.694E-04
F VI 2p21S -4s'1P	129.5	0.263E-03	0.228E-03	0.198E-03	0.195E-03	0.159E-03
F VI 3s'1P -3p'1S	117.6	0.374E-04	0.288E-04	0.242E-04	0.208E-04	0.178E-04
F VI 3s'1P -3p'1P	123.3	0.364E-04	0.300E-04	0.256E-04	0.217E-04	0.202E-04
F VI 3s'1P -3p'1D	118.9	0.471E-04	0.384E-04	0.330E-04	0.330E-04	0.270E-04
F VI 3s'1P -4p'1D	413.5	0.627E-02	0.496E-02	0.392E-02	0.309E-02	0.250E-02
F VI 3s'1P -4p'1P	431.6	0.275E-02	0.241E-02	0.210E-02	0.188E-02	0.172E-02
F VI 2p3P -3s3S	153.8	0.566E-04	0.408E-04	0.326E-04	0.285E-04	0.248E-04
F VI 2p2'3P-3s'3P	161.3	0.685E-04	0.502E-04	0.409E-04	0.354E-04	0.307E-04
Ne V 2p21S -3s1P	184.7	0.895E-04	0.684E-04	0.575E-04	0.494E-04	0.428E-04
Ne V 2p21D -3s1P	173.9	0.790E-04	0.605E-04	0.509E-04	0.437E-04	0.379E-04
Ne V 2p23P -3s3P	167.7	0.686E-04	0.494E-04	0.393E-04	0.342E-04	0.298E-04
Ne VI 2p34S-2p23s4P	142.5	0.471E-04	0.344E-04	0.278E-04	0.241E-04	0.209E-04
Ne VI 2p2P -3s2S	138.6	0.404E-04	0.288E-04	0.229E-04	0.196E-04	0.169E-04
Na VI 2p21S -3s1P	134.5	0.356E-04	0.252E-04	0.186E-04	0.153E-04	0.131E-04
Na VI 2p21D -3s1P	127.8	0.321E-04	0.227E-04	0.168E-04	0.138E-04	0.118E-04
Na VI 2p23P -3s3P	123.9	0.301E-04	0.213E-04	0.168E-04	0.141E-04	0.121E-04
Al V 2p52P -3s2P	130.9	0.325E-04	0.229E-04	0.170E-04	0.139E-04	0.119E-04

Table 2. Comparison of Stark widths calculated here by using the modified semiempirical approach (Dimitrijević and Konjević 1980) (WMSE), with values obtained by using the Eq. (526) in Griem (1974) (WG). The electron density is 10^{17} cm^{-3}.

ELEMENT/TRANSITION LAMBDA(A)		T(K)	WMSE(A)	WG(A)
C V	3s1S - 3p1P	50000.	1.79	1.63
		100000.	1.57	1.36
	12202.6	200000.	1.46	1.18
	X=56.5	400000.	1.22	1.05
		800000.	1.21	0.949
N VI	2s1S - 2p1P	50000.	0.700E-02	0.812E-02
		100000.	0.516E-02	0.607E-02
	2833.7	200000.	0.420E-02	0.475E-02
	X=2.95	400000.	0.357E-02	0.395E-02
		800000.	0.305E-02	0.349E-02
O V	4p1P -4d1D	50000.	4.35	4.16
		100000.	3.79	3.43
	11913.1	200000.	3.30	2.96
	X=29.2	400000.	2.98	2.64
		800000.	2.81	2.41

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