Serb. Astron. J. № 210 (2025), 49 - 59
DOI: https://doi.org/10.2298/SAJ2510049D

UDC 523.316.2 : 535.5 : 539.144 : 539.16 : 546.17
Original scientific paper

STARK BROADENING OF N II SPECTRAL LINES

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(Received: April 21, 2025; Accepted: May 16, 2025)

SUMMARY: The Stark broadening parameters, widths, and shifts, for spectral lines within the 45 N II multiplets, were calculated for collisions with electrons, protons and helium ions, by using the semiclassical perturbation method. The obtained data were compared with other theoretical calculations. They are of interest for interpretation, analysis, and synthesis of stellar spectra and for modelling, diagnostics, and investigation of stellar plasma.

Key words. Line: profiles – Plasmas – Atomic data – Atomic processes

1. INTRODUCTION

Spectral lines broadened by influence of the surrounding charged particles, producing fluctuating electric microfields (Stark broadening), and the corresponding Stark broadening parametes, full line width at half-intensity maximum (FWHM), and line shift, are of interest in numerous topics. In particular in astrophysics (see, for example, Popović et al. 2001), where they are needed in calculations of opacities and radiative transfer for determination and investigation of stellar abundances of chemical elements, interpretation and synthesis of lines in stellar spectra, etc. (see, for example, Dimitrijević and Christova 2021). They are particularly useful for white dwarf and hot subdwarf investigations where many applications exist. For example DO (Dimitrijević et al. 2018, Dimitrijević and Christova 2024), DB (Majlinger et al. 2017, 2018, 2020, Dimitrijević et al. 2025b), DA (Majlinger et al. 2017, 2020, Hamdi et al. 2024, 2022) dwarfs, and (Hamdi et al. 2017, Chougule et al. 2020) for hot subdwarfs. Data on Stark broadening of spectral line profiles may be of interest also for the A (Majlinger et al. 2017, 2020), late B (Smith et al. 1994, Leone and Lanzafame 1997), and early F (Adelman et al. 1991, 1997) type stars, and even for cooler stars such as the Sun. Since the influence of Stark broadening within a spectral series increases with the principal quantum number of the upper level (Dimitrijevic and Sahal-Brechot 1984b), this broadening mechanism may become of interest even in the Solar spectrum. For example, Feldman and Doschek (1977) used profiles of the Balmer series members with the principal quantum number n between 16 and 32 (strongly influenced by the Stark broadening mechanism) to determine the electron density and the temperature over an active Solar region.

The Stark broadening data are of interest and for the laboratory experiments, (Blagojević et al. 1999), in fusion (Iglesias et al. 1997) and laser produced plasma research (Sorge et al. 2000), laser ablation (Shaikh et al. 2008, 2007, Sanz et al. 2011), and laser deposition (Sanz et al. 2011) of material, plasma in technology (Dimitrijević and Sahal-Bréchot 2014), laser design and development (Csillag and Dimitrijević 2004), etc.

Nitrogen belongs to the CNO peak in the distribution of chemical abundances in stellar spectra, where it is present and its spectral lines have been observed in different stars. For example, Mehner et al. (2015) investigated the N II spectral lines in the 3s^{3}P^o - 3p^{3}P multiplet in the spectrum of η Carinae, Romanovskaya et al. (2023) performed the nitrogen abundance analysis in A-B stars γ Gem, o Peg, θ Vir, and ν Cap, by using the N I and N II spectral lines, Dufton et al. (2024) determined the nitrogen abundance for 67 Be type stars in 30 Doradus, and Taguchi et al. (2023) investigated the spectrum evolution of V1405 Cas. The obtained results indicate a low mass ONeMg white dwarf progenitor, where they observed the N II 3s^{3}P$^o_2$ - 3p^{3}D$_3$ (λ = 5679 Å) spectral line. Thus, the Stark broadening data for the N II spectral lines are obviously needed for stellar spectra analysis, and stellar atmosphere modelling.

Another topic where data on Stark broadening of the N II spectral lines are needed is the proton-boron fusion, which has considerable advantages (Belloni and Batani 2022), since there are no radioactive species and neutrons in the reaction, which makes the resulted fusion energy clean, since there is no induced activation by neutrons of the environment surrounding the fuel. Consequently, the α-particle generation during the proton-boron fusion might become a source for medical and industrial applications (Yoon et al. 2014, Giuffrida et al. 2016, Cirrone et al. 2018). According to Schollmeier et al. (2022), the boron-nitride (BN) nanotube targets are more efficient than the nanostructured targets, so that the BN targets are used in experiments. Hegelich et al. (2023) underline that for optimization of the fusion yield, a plasma diagnostic is needed, so that the Stark broadening data for N II may be useful for this purpose.

To provide the corresponding data of interest for the proton-boron fusion experiments with the BN target, we calculated, using the semiclassical perturbation method (Sahal-Bréchot 1969a,b, Sahal-Bréchot, Dimitrijević, & Ben Nessib 2014), the Stark broadening parameters for 45 multiplets of a singly charged nitrogen (N II) for collisions with alpha particles, the B II, B III, and B IV ions (Dimitrijević et al. 2025a). Here, applying the same method, we calculate the Stark broadening parameters for 45 N II multiplets broadened by collisions with electrons, protons, and ionized helium, as the main constituents of stellar plasma. We will compare the obtained results with the calculations of Griem (1974).

2. THEORY

The impact of the semiclassical perturbation theory (Sahal-Bréchot 1969a,b), we applied here is reviewed and explained in detail with all innovations and optimizations in Sahal-Bréchot et al. (2014). As it was briefly described many times, we will provide here only the basic formulas needed to understand the method used for calculations The FWHM (W) and shift (d) of an isolated spectral line of a non-hydrogenic emitter is expressed as:

$$W = N \int v f(v) dv \left(\sum_{i' \neq i} \sigma_{ii'}(v) + \sum_{f' \neq f} \sigma_{ff'}(v) + \sigma_{el} \right)$$

$$d = N \int v f(v) dv \int_{R_3}^{R_D} 2\pi \rho d\rho \sin(2\varphi_p). \quad (1)$$

Here, i and f denote the initial and final energy level of the corresponding transition; i' and f' are their perturbing energy levels; N is the perturber density; v the perturber velocity, and $f(v)$ the Maxwellian velocity distribution of charged particles. The inelastic cross sections $\sigma_{kk'}(v)$, $k = i, f$ are determined by integration of the transition probability $P_{kk'}(\rho, v)$, over the impact parameter ρ as:

$$\sum_{k' \neq k} \sigma_{kk'}(v) = \frac{1}{2}\pi R_1^2 + \int_{R_1}^{R_D} 2\pi \rho d\rho \sum_{k' \neq k} P_{kk'}(\rho, v). \quad (2)$$

The cross section for elastic collisions is:

$$\sigma_{el} = 2\pi R_2^2 + \int_{R_2}^{R_D} 2\pi \rho d\rho \sin^2 \delta,$$

$$\delta = (\varphi_p^2 + \varphi_q^2)^{\frac{1}{2}}, \quad (3)$$

where δ denotes the phase shift with components φ_p (r^{-4}) and φ_q (r^{-3}) describing the contributions due to polarization and quadrupole potentials, respectively. The method of symmetrization and calculation of the cut-off parameters R_1, R_2, R_3, and the Debye cut-off R_D is described in Sahal-Bréchot (1969b).

If we know W and d, it is easy to obtain the line profile $F(\omega)$ (where ω is the angular frequency), by using the expression:

$$F(\omega) = \frac{W/(2\pi)}{(\omega - \omega_{if} - d)^2 + (W/2)^2}. \quad (4)$$

Here:

$$\omega_{if} = \frac{E_i - E_f}{\hbar}$$

where E_i, E_f are energies of the initial and final atomic energy level, respectively.

3. RESULTS AND DISCUSSION

Applying the semiclassical perturbation theory (Sahal-Bréchot 1969a,b, Sahal-Bréchot, Dimitrijević, & Ben Nessib 2014), we obtained the Stark broadening parameters, full width at half-intensity maximum (FWHM - W), and shift (d). The atomic energy levels needed as input parameters for calculations have

Table 1: This table gives Stark Full Width at Half intensity Maximum (FWHM) W, and shifts d for N II spectral lines broadened by electron-, proton- and helium ion-impacts. Calculated wavelength of the transitions (in Å) and parameter C are also given. This parameter, when divided by the corresponding Stark width, gives an estimate for the maximal perturber density at which the line may be treated isolated. The results are for the perturber density 10^{16} cm^{-3} and temperature range from 5 000 K to 200 000 K. A positive shift is towards the red part of the spectrum.

		ELECTRONS		PROTONS		He II	
TRANSITION	T[K]	W[Å]	d[Å]	W[Å]	d[Å]	W[Å]	d[Å]
N II 3s^{1}P^o-3p^{1}P	5000.	0.128	-0.401E-02	0.240E-02	-0.764E-03	0.332E-02	-0.738E-03
6483.8 Å	10000.	0.925E-01	-0.459E-02	0.400E-02	-0.137E-02	0.486E-02	-0.126E-02
C=0.65E+20	30000.	0.607E-01	-0.414E-02	0.610E-02	-0.242E-02	0.647E-02	-0.204E-02
	50000.	0.545E-01	-0.411E-02	0.678E-02	-0.279E-02	0.706E-02	-0.234E-02
	100000.	0.498E-01	-0.367E-02	0.767E-02	-0.337E-02	0.766E-02	-0.276E-02
	200000.	0.460E-01	-0.339E-02	0.815E-02	-0.389E-02	0.819E-02	-0.321E-02
N II 3s^{1}P^o-3p^{1}D	5000.	0.534E-01	0.758E-03	0.145E-02	0.192E-03	0.192E-02	0.187E-03
3996.1 Å	10000.	0.389E-01	0.470E-03	0.223E-02	0.356E-03	0.270E-02	0.332E-03
C=0.21E+20	30000.	0.264E-01	0.471E-03	0.317E-02	0.658E-03	0.338E-02	0.572E-03
	50000.	0.242E-01	0.332E-03	0.346E-02	0.778E-03	0.365E-02	0.658E-03
	100000.	0.226E-01	0.221E-03	0.378E-02	0.932E-03	0.388E-02	0.783E-03
	200000.	0.211E-01	0.215E-03	0.399E-02	0.112E-02	0.402E-02	0.929E-03
N II 3s^{1}P^o-3p^{1}S	5000.	0.687E-01	0.248E-01	0.168E-02	0.149E-02	0.194E-02	0.131E-02
3438.1 Å	10000.	0.463E-01	0.208E-01	0.263E-02	0.219E-02	0.285E-02	0.191E-02
C=0.14E+20	30000.	0.305E-01	0.146E-01	0.401E-02	0.312E-02	0.380E-02	0.260E-02
	50000.	0.283E-01	0.125E-01	0.462E-02	0.359E-02	0.429E-02	0.295E-02
	100000.	0.275E-01	0.998E-02	0.540E-02	0.404E-02	0.468E-02	0.336E-02
	200000.	0.277E-01	0.803E-02	0.591E-02	0.469E-02	0.538E-02	0.377E-02
N II 3s^{1}P^o-4p^{1}P	5000.	0.236E-01	0.295E-02	0.175E-02	0.310E-04	0.207E-02	0.305E-04
1887.4 Å	10000.	0.185E-01	0.206E-02	0.222E-02	0.594E-04	0.239E-02	0.552E-04
C=0.15E+19	30000.	0.151E-01	0.117E-02	0.267E-02	0.114E-03	0.280E-02	0.996E-04
	50000.	0.148E-01	0.108E-02	0.282E-02	0.139E-03	0.288E-02	0.115E-03
	100000.	0.146E-01	0.700E-03	0.294E-02	0.165E-03	0.295E-02	0.138E-03
	200000.	0.140E-01	0.715E-03	0.302E-02	0.198E-03	0.300E-02	0.163E-03
N II 3s^{1}P^o-4p^{1}D	5000.	0.224E-01	0.792E-02	0.209E-02	0.760E-03	0.235E-02	0.666E-03
1780.6 Å	10000.	0.172E-01	0.584E-02	0.257E-02	0.110E-02	0.270E-02	0.914E-03
C=0.15E+19	30000.	0.149E-01	0.397E-02	0.320E-02	0.150E-02	0.320E-02	0.124E-02
	50000.	0.149E-01	0.330E-02	0.343E-02	0.172E-02	0.338E-02	0.138E-02
	100000.	0.150E-01	0.258E-02	0.360E-02	0.193E-02	0.348E-02	0.161E-02
	200000.	0.146E-01	0.205E-02	0.387E-02	0.220E-02	0.347E-02	0.178E-02
N II 3s^{1}P^o-4p^{1}S	5000.	0.451E-01	0.189E-01	0.326E-02	0.255E-02	0.316E-02	0.207E-02
1732.4 Å	10000.	0.359E-01	0.197E-01	0.415E-02	0.332E-02	0.387E-02	0.276E-02
C=0.13E+19	30000.	0.282E-01	0.176E-01	0.563E-02	0.449E-02	0.487E-02	0.365E-02
	50000.	0.273E-01	0.156E-01	0.624E-02	0.506E-02	0.552E-02	0.416E-02
	100000.	0.283E-01	0.128E-01	0.668E-02	0.546E-02	0.607E-02	0.451E-02
	200000.	0.282E-01	0.103E-01	0.734E-02	0.608E-02	0.647E-02	0.561E-02
N II 2p^2 ^{1}D-3s^{1}P^o	5000.	0.102E-02	0.426E-03	0.348E-05	0.154E-04	0.480E-05	0.146E-04
747.0 Å	10000.	0.707E-03	0.323E-03	0.125E-04	0.267E-04	0.140E-04	0.236E-04
C=0.86E+18	30000.	0.412E-03	0.211E-03	0.369E-04	0.442E-04	0.328E-04	0.366E-04
	50000.	0.355E-03	0.180E-03	0.476E-04	0.503E-04	0.409E-04	0.423E-04
	100000.	0.301E-03	0.144E-03	0.612E-04	0.607E-04	0.525E-04	0.494E-04
	200000.	0.259E-03	0.114E-03	0.764E-04	0.677E-04	0.616E-04	0.572E-04

Table 1: Continued.

TRANSITION	T[K]	ELECTRONS W[Å]	d[Å]	PROTONS W[Å]	d[Å]	He II W[Å]	d[Å]
N II 2p^2 ^{1}S-3s^{1}P^o	5000.	0.133E-02	0.563E-03	0.473E-05	0.203E-04	0.653E-05	0.193E-04
858.4 Å	10000.	0.924E-03	0.426E-03	0.167E-04	0.353E-04	0.188E-04	0.312E-04
C=0.11E+19	30000.	0.538E-03	0.278E-03	0.490E-04	0.584E-04	0.436E-04	0.484E-04
	50000.	0.464E-03	0.239E-03	0.630E-04	0.664E-04	0.542E-04	0.558E-04
	100000.	0.395E-03	0.191E-03	0.811E-04	0.801E-04	0.695E-04	0.653E-04
	200000.	0.342E-03	0.152E-03	0.101E-03	0.894E-04	0.817E-04	0.755E-04
N II 2p^2 ^{1}D-3d^{1}D^o	5000.	0.869E-03	0.273E-04	0.280E-04	-0.688E-05	0.374E-04	-0.663E-05
582.2 Å	10000.	0.665E-03	0.189E-04	0.437E-04	-0.122E-04	0.530E-04	-0.112E-04
C=0.30E+18	30000.	0.476E-03	-0.815E-06	0.636E-04	-0.213E-04	0.674E-04	-0.178E-04
	50000.	0.437E-03	0.363E-06	0.697E-04	-0.245E-04	0.732E-04	-0.204E-04
	100000.	0.401E-03	0.454E-06	0.774E-04	-0.291E-04	0.789E-04	-0.244E-04
	200000.	0.371E-03	-0.108E-05	0.841E-04	-0.338E-04	0.819E-04	-0.288E-04
N II 2p^2 ^{1}D-3d^{1}F^o	5000.	0.813E-03	0.179E-03	0.324E-04	0.408E-05	0.425E-04	0.398E-05
574.7 Å	10000.	0.606E-03	0.131E-03	0.493E-04	0.756E-05	0.593E-04	0.705E-05
C=0.50E+18	30000.	0.421E-03	0.830E-04	0.694E-04	0.140E-04	0.738E-04	0.121E-04
	50000.	0.387E-03	0.718E-04	0.756E-04	0.164E-04	0.797E-04	0.139E-04
	100000.	0.355E-03	0.575E-04	0.827E-04	0.197E-04	0.842E-04	0.166E-04
	200000.	0.329E-03	0.444E-04	0.861E-04	0.237E-04	0.883E-04	0.197E-04
N II 2p^2 ^{1}D-3d^{1}P^o	5000.	0.679E-03	0.213E-03	0.347E-04	0.105E-04	0.448E-04	0.985E-05
572.1 Å	10000.	0.547E-03	0.153E-03	0.527E-04	0.178E-04	0.626E-04	0.157E-04
C=0.39E+18	30000.	0.426E-03	0.103E-03	0.745E-04	0.290E-04	0.781E-04	0.242E-04
	50000.	0.409E-03	0.893E-04	0.815E-04	0.332E-04	0.850E-04	0.276E-04
	100000.	0.401E-03	0.711E-04	0.909E-04	0.392E-04	0.906E-04	0.331E-04
	200000.	0.391E-03	0.575E-04	0.971E-04	0.455E-04	0.924E-04	0.381E-04
N II 2p^2 ^{1}S-3d^{1}P^o	5000.	0.831E-03	0.262E-03	0.429E-04	0.129E-04	0.554E-04	0.121E-04
635.2 Å	10000.	0.670E-03	0.188E-03	0.652E-04	0.220E-04	0.774E-04	0.193E-04
C=0.48E+18	30000.	0.523E-03	0.127E-03	0.920E-04	0.357E-04	0.966E-04	0.298E-04
	50000.	0.503E-03	0.111E-03	0.101E-03	0.409E-04	0.105E-03	0.340E-04
	100000.	0.493E-03	0.883E-04	0.112E-03	0.484E-04	0.112E-03	0.408E-04
	200000.	0.482E-03	0.714E-04	0.120E-03	0.561E-04	0.114E-03	0.470E-04
N II 3p^{1}P-3d^{1}P^o	5000.	0.497E-01	0.129E-02	0.234E-02	0.350E-03	0.290E-02	0.336E-03
3920.1 Å	10000.	0.390E-01	0.151E-02	0.340E-02	0.619E-03	0.391E-02	0.558E-03
C=0.18E+20	30000.	0.295E-01	0.137E-02	0.446E-02	0.105E-02	0.473E-02	0.878E-03
	50000.	0.281E-01	0.128E-02	0.486E-02	0.121E-02	0.507E-02	0.102E-02
	100000.	0.274E-01	0.115E-02	0.521E-02	0.144E-02	0.534E-02	0.120E-02
	200000.	0.266E-01	0.104E-02	0.540E-02	0.172E-02	0.549E-02	0.137E-02
N II 3p^{1}P-3d^{1}D^o	5000.	0.745E-01	-0.251E-02	0.261E-02	-0.585E-03	0.328E-02	-0.554E-03
4448.3 Å	10000.	0.564E-01	-0.230E-02	0.386E-02	-0.101E-02	0.450E-02	-0.889E-03
C=0.17E+20	30000.	0.404E-01	-0.238E-02	0.521E-02	-0.165E-02	0.551E-02	-0.138E-02
	50000.	0.372E-01	-0.219E-02	0.568E-02	-0.189E-02	0.594E-02	-0.159E-02
	100000.	0.347E-01	-0.205E-02	0.620E-02	-0.225E-02	0.626E-02	-0.185E-02
	200000.	0.324E-01	-0.186E-02	0.660E-02	-0.259E-02	0.638E-02	-0.216E-02
N II 3p^{1}D-3d^{1}D^o	5000.	0.250	-0.264E-01	0.994E-02	-0.324E-02	0.121E-01	-0.301E-02
7764.4 Å	10000.	0.189	-0.212E-01	0.145E-01	-0.517E-02	0.163E-01	-0.457E-02
C=0.53E+20	30000.	0.136	-0.152E-01	0.192E-01	-0.798E-02	0.199E-01	-0.669E-02
	50000.	0.126	-0.138E-01	0.210E-01	-0.913E-02	0.214E-01	-0.770E-02
	100000.	0.119	-0.121E-01	0.232E-01	-0.108E-01	0.228E-01	-0.895E-02
	200000.	0.112	-0.109E-01	0.250E-01	-0.127E-01	0.242E-01	-0.104E-01

Table 1: Continued.

		ELECTRONS		PROTONS		He II	
TRANSITION	T[K]	W[Å]	d[Å]	W[Å]	d[Å]	W[Å]	d[Å]
N II $3p^1D$-$3d^1F^o$	5000.	0.167	-0.492E-02	0.769E-02	-0.119E-02	0.942E-02	-0.113E-02
6612.4 Å	10000.	0.125	-0.520E-02	0.110E-01	-0.207E-02	0.124E-01	-0.183E-02
C=0.56E+20	30000.	0.899E-01	-0.469E-02	0.142E-01	-0.343E-02	0.151E-01	-0.284E-02
	50000.	0.842E-01	-0.414E-02	0.154E-01	-0.391E-02	0.160E-01	-0.328E-02
	100000.	0.800E-01	-0.343E-02	0.165E-01	-0.472E-02	0.168E-01	-0.386E-02
	200000.	0.756E-01	-0.323E-02	0.174E-01	-0.529E-02	0.171E-01	-0.441E-02
N II $3p^1D$-$3d^1P^o$	5000.	0.133	-0.936E-03	0.714E-02	-0.281E-03	0.875E-02	-0.277E-03
6286.1 Å	10000.	0.105	-0.893E-03	0.102E-01	-0.546E-03	0.115E-01	-0.511E-03
C=0.47E+20	30000.	0.818E-01	-0.127E-02	0.130E-01	-0.107E-02	0.139E-01	-0.941E-03
	50000.	0.791E-01	-0.127E-02	0.141E-01	-0.133E-02	0.147E-01	-0.110E-02
	100000.	0.782E-01	-0.990E-03	0.150E-01	-0.159E-02	0.152E-01	-0.134E-02
	200000.	0.762E-01	-0.103E-02	0.156E-01	-0.189E-02	0.157E-01	-0.159E-02
N II $3p^1S$-$3d^1P^o$	5000.	0.250	-0.767E-02	0.142E-01	-0.206E-02	0.174E-01	-0.195E-02
8441.1 Å	10000.	0.198	-0.745E-02	0.201E-01	-0.356E-02	0.224E-01	-0.314E-02
C=0.84E+20	30000.	0.158	-0.847E-02	0.256E-01	-0.585E-02	0.271E-01	-0.488E-02
	50000.	0.154	-0.766E-02	0.278E-01	-0.667E-02	0.286E-01	-0.561E-02
	100000.	0.153	-0.694E-02	0.295E-01	-0.798E-02	0.300E-01	-0.658E-02
	200000.	0.149	-0.654E-02	0.308E-01	-0.914E-02	0.306E-01	-0.761E-02
N II $3d^1D^o$-$4p^1P$	5000.	0.330	0.674E-01	0.240E-01	0.230E-02	0.280E-01	0.213E-02
6631.6 Å	10000.	0.262	0.516E-01	0.298E-01	0.368E-02	0.321E-01	0.325E-02
C=0.19E+20	30000.	0.213	0.339E-01	0.359E-01	0.568E-02	0.375E-01	0.476E-02
	50000.	0.207	0.283E-01	0.378E-01	0.655E-02	0.387E-01	0.552E-02
	100000.	0.202	0.214E-01	0.390E-01	0.766E-02	0.396E-01	0.639E-02
	200000.	0.194	0.183E-01	0.417E-01	0.898E-02	0.412E-01	0.747E-02
N II $3d^1D^o$-$4p^1D$	5000.	0.240	0.929E-01	0.214E-01	0.789E-02	0.237E-01	0.697E-02
5476.8 Å	10000.	0.186	0.708E-01	0.261E-01	0.114E-01	0.274E-01	0.944E-02
C=0.14E+20	30000.	0.159	0.493E-01	0.323E-01	0.154E-01	0.322E-01	0.130E-01
	50000.	0.157	0.415E-01	0.341E-01	0.176E-01	0.340E-01	0.147E-01
	100000.	0.157	0.325E-01	0.363E-01	0.198E-01	0.343E-01	0.156E-01
	200000.	0.152	0.254E-01	0.388E-01	0.227E-01	0.354E-01	0.185E-01
N II $3d^1F^o$-$4p^1D$	5000.	0.289	0.107	0.279E-01	0.965E-02	0.311E-01	0.851E-02
6244.1 Å	10000.	0.225	0.795E-01	0.339E-01	0.140E-01	0.357E-01	0.116E-01
C=0.18E+20	30000.	0.196	0.542E-01	0.419E-01	0.192E-01	0.418E-01	0.157E-01
	50000.	0.196	0.452E-01	0.448E-01	0.218E-01	0.444E-01	0.179E-01
	100000.	0.198	0.356E-01	0.468E-01	0.244E-01	0.447E-01	0.203E-01
	200000.	0.193	0.279E-01	0.501E-01	0.281E-01	0.450E-01	0.223E-01
N II $3d^1P^o$-$4p^1P$	5000.	0.498	0.812E-01	0.384E-01	0.215E-02	0.447E-01	0.202E-02
8298.5 Å	10000.	0.396	0.586E-01	0.476E-01	0.367E-02	0.512E-01	0.323E-02
C=0.30E+20	30000.	0.326	0.353E-01	0.573E-01	0.598E-02	0.595E-01	0.498E-02
	50000.	0.321	0.307E-01	0.598E-01	0.686E-02	0.615E-01	0.570E-02
	100000.	0.317	0.231E-01	0.627E-01	0.810E-02	0.631E-01	0.673E-02
	200000.	0.306	0.207E-01	0.641E-01	0.948E-02	0.655E-01	0.791E-02
N II $3d^1P^o$-$4p^1D$	5000.	0.333	0.123	0.311E-01	0.109E-01	0.346E-01	0.965E-02
6566.0 Å	10000.	0.259	0.925E-01	0.378E-01	0.158E-01	0.398E-01	0.131E-01
C=0.20E+20	30000.	0.225	0.633E-01	0.466E-01	0.216E-01	0.463E-01	0.179E-01
	50000.	0.224	0.528E-01	0.500E-01	0.246E-01	0.494E-01	0.205E-01
	100000.	0.227	0.416E-01	0.519E-01	0.275E-01	0.491E-01	0.224E-01
	200000.	0.220	0.327E-01	0.561E-01	0.316E-01	0.503E-01	0.251E-01

Table 1: Continued.

TRANSITION	T[K]	ELECTRONS W[Å]	d[Å]	PROTONS W[Å]	d[Å]	He II W[Å]	d[Å]
N II 3d^{1}P^o-4p^{1}S	5000.	0.545	0.225	0.400E-01	0.304E-01	0.390E-01	0.247E-01
5955.9 Å	10000.	0.440	0.235	0.506E-01	0.396E-01	0.477E-01	0.330E-01
C=0.16E+20	30000.	0.352	0.212	0.683E-01	0.535E-01	0.595E-01	0.436E-01
	50000.	0.341	0.188	0.761E-01	0.602E-01	0.676E-01	0.498E-01
	100000.	0.352	0.154	0.796E-01	0.655E-01	0.728E-01	0.540E-01
	200000.	0.352	0.125	0.875E-01	0.727E-01	0.788E-01	0.671E-01
N II 3s^{3}P^o-3p^{3}D	5000.	0.105	-0.249E-02	0.202E-02	-0.480E-03	0.277E-02	-0.466E-03
5680.9 Å	10000.	0.754E-01	-0.274E-02	0.329E-02	-0.874E-03	0.402E-02	-0.813E-03
C=0.57E+20	30000.	0.495E-01	-0.257E-02	0.493E-02	-0.159E-02	0.526E-02	-0.136E-02
	50000.	0.447E-01	-0.276E-02	0.546E-02	-0.184E-02	0.573E-02	-0.155E-02
	100000.	0.411E-01	-0.240E-02	0.608E-02	-0.221E-02	0.617E-02	-0.186E-02
	200000.	0.380E-01	-0.223E-02	0.649E-02	-0.261E-02	0.646E-02	-0.212E-02
N II 3s^{3}P^o-3p^{3}S	5000.	0.827E-01	-0.904E-03	0.176E-02	-0.266E-03	0.240E-02	-0.260E-03
5030.2 Å	10000.	0.595E-01	-0.120E-02	0.281E-02	-0.499E-03	0.344E-02	-0.465E-03
C=0.45E+20	30000.	0.391E-01	-0.128E-02	0.413E-02	-0.935E-03	0.442E-02	-0.817E-03
	50000.	0.355E-01	-0.144E-02	0.453E-02	-0.112E-02	0.480E-02	-0.939E-03
	100000.	0.328E-01	-0.127E-02	0.503E-02	-0.134E-02	0.515E-02	-0.113E-02
	200000.	0.305E-01	-0.119E-02	0.530E-02	-0.158E-02	0.528E-02	-0.132E-02
N II 3s^{3}P^o-3p^{3}P	5000.	0.707E-01	-0.613E-03	0.161E-02	-0.758E-04	0.219E-02	-0.754E-04
4624.5 Å	10000.	0.512E-01	-0.585E-03	0.255E-02	-0.153E-03	0.311E-02	-0.148E-03
C=0.36E+20	30000.	0.342E-01	-0.596E-03	0.369E-02	-0.332E-03	0.396E-02	-0.292E-03
	50000.	0.312E-01	-0.736E-03	0.403E-02	-0.423E-03	0.428E-02	-0.366E-03
	100000.	0.290E-01	-0.723E-03	0.444E-02	-0.524E-03	0.456E-02	-0.439E-03
	200000.	0.270E-01	-0.654E-03	0.464E-02	-0.630E-03	0.473E-02	-0.527E-03
N II 3s^{3}P^o-4p^{3}D	5000.	0.224E-01	0.467E-02	0.181E-02	0.423E-03	0.211E-02	0.374E-03
1859.2 Å	10000.	0.173E-01	0.328E-02	0.228E-02	0.624E-03	0.243E-02	0.543E-03
C=0.21E+19	30000.	0.144E-01	0.216E-02	0.276E-02	0.896E-03	0.287E-02	0.744E-03
	50000.	0.142E-01	0.181E-02	0.293E-02	0.102E-02	0.298E-02	0.848E-03
	100000.	0.143E-01	0.137E-02	0.305E-02	0.117E-02	0.308E-02	0.956E-03
	200000.	0.138E-01	0.126E-02	0.313E-02	0.132E-02	0.312E-02	0.108E-02
N II 3s^{3}P^o-4p^{3}P	5000.	0.221E-01	0.497E-02	0.184E-02	0.446E-03	0.214E-02	0.391E-03
1844.6 Å	10000.	0.171E-01	0.350E-02	0.230E-02	0.655E-03	0.247E-02	0.571E-03
C=0.22E+19	30000.	0.141E-01	0.238E-02	0.283E-02	0.928E-03	0.289E-02	0.776E-03
	50000.	0.140E-01	0.203E-02	0.299E-02	0.106E-02	0.301E-02	0.873E-03
	100000.	0.140E-01	0.154E-02	0.312E-02	0.120E-02	0.307E-02	0.101E-02
	200000.	0.137E-01	0.134E-02	0.325E-02	0.139E-02	0.315E-02	0.112E-02
N II 3s^{3}P^o-4p^{3}S	5000.	0.222E-01	0.559E-02	0.188E-02	0.579E-03	0.218E-02	0.498E-03
1834.0 Å	10000.	0.172E-01	0.387E-02	0.236E-02	0.845E-03	0.251E-02	0.721E-03
C=0.21E+19	30000.	0.146E-01	0.258E-02	0.292E-02	0.117E-02	0.295E-02	0.971E-03
	50000.	0.145E-01	0.221E-02	0.313E-02	0.132E-02	0.310E-02	0.109E-02
	100000.	0.147E-01	0.171E-02	0.329E-02	0.154E-02	0.319E-02	0.125E-02
	200000.	0.142E-01	0.148E-02	0.353E-02	0.179E-02	0.335E-02	0.142E-02
N II 2p^2 ^{3}P-4s^{3}P^o	5000.	0.143E-02	0.855E-03	0.458E-04	0.691E-04	0.442E-04	0.610E-04
508.7 Å	10000.	0.993E-03	0.725E-03	0.834E-04	0.100E-03	0.760E-04	0.825E-04
C=0.16E+18	30000.	0.783E-03	0.523E-03	0.135E-03	0.135E-03	0.114E-03	0.113E-03
	50000.	0.745E-03	0.446E-03	0.165E-03	0.151E-03	0.137E-03	0.127E-03
	100000.	0.704E-03	0.350E-03	0.189E-03	0.173E-03	0.161E-03	0.137E-03
	200000.	0.648E-03	0.276E-03	0.224E-03	0.198E-03	0.177E-03	0.161E-03

Table 1: Continued.

		ELECTRONS		PROTONS		He II	
TRANSITION	T[K]	W[Å]	d[Å]	W[Å]	d[Å]	W[Å]	d[Å]
N II $2p^2$ ^3P-$3d^3D^o$	5000.	0.602E-03	0.141E-03	0.240E-04	0.381E-05	0.321E-04	0.371E-05
533.7 Å	10000.	0.457E-03	0.104E-03	0.373E-04	0.701E-05	0.453E-04	0.653E-05
C=0.44E+18	30000.	0.322E-03	0.659E-04	0.537E-04	0.129E-04	0.572E-04	0.110E-04
	50000.	0.296E-03	0.566E-04	0.587E-04	0.150E-04	0.619E-04	0.127E-04
	100000.	0.272E-03	0.458E-04	0.646E-04	0.182E-04	0.659E-04	0.150E-04
	200000.	0.252E-03	0.360E-04	0.674E-04	0.211E-04	0.693E-04	0.178E-04
N II 2p2 ^3P-$^3D^3P^o$	5000.	0.613E-03	0.225E-03	0.267E-04	0.734E-05	0.351E-04	0.700E-05
529.7 Å	10000.	0.450E-03	0.169E-03	0.411E-04	0.128E-04	0.493E-04	0.114E-04
C=0.39E+18	30000.	0.296E-03	0.110E-03	0.588E-04	0.214E-04	0.620E-04	0.177E-04
	50000.	0.265E-03	0.947E-04	0.645E-04	0.244E-04	0.672E-04	0.204E-04
	100000.	0.234E-03	0.757E-04	0.713E-04	0.293E-04	0.715E-04	0.243E-04
	200000.	0.213E-03	0.599E-04	0.744E-04	0.336E-04	0.759E-04	0.274E-04
N II $3p^3D$-$3d^3F^o$	5000.	0.923E-01	-0.589E-03	0.333E-02	-0.148E-03	0.420E-02	-0.147E-03
5005.9 Å	10000.	0.683E-01	-0.850E-03	0.489E-02	-0.291E-03	0.573E-02	-0.275E-03
C=0.41E+20	30000.	0.461E-01	-0.635E-03	0.653E-02	-0.581E-03	0.697E-02	-0.515E-03
	50000.	0.417E-01	-0.740E-03	0.709E-02	-0.736E-03	0.748E-02	-0.615E-03
	100000.	0.385E-01	-0.735E-03	0.761E-02	-0.887E-03	0.781E-02	-0.737E-03
	200000.	0.360E-01	-0.631E-03	0.796E-02	-0.105E-02	0.803E-02	-0.874E-03
N II $3p^3D$-$3d^3D^o$	5000.	0.807E-01	-0.920E-02	0.318E-02	-0.467E-03	0.399E-02	-0.450E-03
4794.8 Å	10000.	0.603E-01	-0.641E-02	0.467E-02	-0.832E-03	0.543E-02	-0.757E-03
C=0.35E+20	30000.	0.428E-01	-0.448E-02	0.622E-02	-0.145E-02	0.661E-02	-0.121E-02
	50000.	0.402E-01	-0.409E-02	0.676E-02	-0.166E-02	0.710E-02	-0.139E-02
	100000.	0.388E-01	-0.330E-02	0.736E-02	-0.197E-02	0.741E-02	-0.166E-02
	200000.	0.375E-01	-0.272E-02	0.761E-02	-0.230E-02	0.768E-02	-0.195E-02
N II $3p^3D$-$3d^3P^o$	5000.	0.649E-01	-0.630E-05	0.297E-02	0.378E-04	0.370E-02	0.378E-04
4490.7 Å	10000.	0.481E-01	-0.800E-04	0.432E-02	0.779E-04	0.500E-02	0.762E-04
C=0.28E+20	30000.	0.338E-01	0.223E-03	0.567E-02	0.188E-03	0.606E-02	0.167E-03
	50000.	0.313E-01	0.280E-03	0.616E-02	0.241E-03	0.648E-02	0.212E-03
	100000.	0.298E-01	0.241E-03	0.658E-02	0.315E-03	0.677E-02	0.264E-03
	200000.	0.284E-01	0.261E-03	0.686E-02	0.378E-03	0.692E-02	0.318E-03
N II $3p^3S$-$3d^3P^o$	5000.	0.798E-01	0.103E-01	0.385E-02	0.382E-03	0.478E-02	0.370E-03
5002.2 Å	10000.	0.591E-01	0.804E-02	0.558E-02	0.693E-03	0.641E-02	0.644E-03
C=0.35E+20	30000.	0.408E-01	0.511E-02	0.729E-02	0.125E-02	0.776E-02	0.107E-02
	50000.	0.372E-01	0.450E-02	0.793E-02	0.145E-02	0.830E-02	0.122E-02
	100000.	0.340E-01	0.367E-02	0.845E-02	0.174E-02	0.861E-02	0.147E-02
	200000.	0.315E-01	0.294E-02	0.890E-02	0.205E-02	0.894E-02	0.166E-02
N II $3p^3P$-$3d^3D^o$	5000.	0.121	-0.332E-02	0.531E-02	-0.759E-03	0.660E-02	-0.730E-03
5940.2 Å	10000.	0.913E-01	-0.397E-02	0.772E-02	-0.135E-02	0.889E-02	-0.122E-02
C=0.54E+20	30000.	0.660E-01	-0.342E-02	0.101E-01	-0.232E-02	0.108E-01	-0.193E-02
	50000.	0.620E-01	-0.361E-02	0.110E-01	-0.267E-02	0.115E-01	-0.222E-02
	100000.	0.594E-01	-0.307E-02	0.119E-01	-0.318E-02	0.122E-01	-0.264E-02
	200000.	0.567E-01	-0.283E-02	0.123E-01	-0.377E-02	0.125E-01	-0.308E-02
N II $3p^3P$-$3d^3P^o$	5000.	0.980E-01	-0.437E-03	0.478E-02	-0.252E-03	0.591E-02	-0.248E-03
5480.3 Å	10000.	0.730E-01	-0.114E-02	0.690E-02	-0.485E-03	0.790E-02	-0.451E-03
C=0.42E+20	30000.	0.520E-01	-0.737E-03	0.896E-02	-0.933E-03	0.956E-02	-0.817E-03
	50000.	0.485E-01	-0.677E-03	0.973E-02	-0.114E-02	0.102E-01	-0.948E-03
	100000.	0.463E-01	-0.396E-03	0.104E-01	-0.136E-02	0.106E-01	-0.114E-02
	200000.	0.441E-01	-0.358E-03	0.107E-01	-0.162E-02	0.108E-01	-0.134E-02

Table 1: Continued.

TRANSITION	T[K]	ELECTRONS W[Å]	d[Å]	PROTONS W[Å]	d[Å]	He II W[Å]	d[Å]
N II 3d^{3}F^o-4p^{3}D	5000.	0.261	0.659E-01	0.218E-01	0.511E-02	0.253E-01	0.448E-02
6169.8 Å	10000.	0.204	0.486E-01	0.271E-01	0.750E-02	0.289E-01	0.653E-02
C=0.23E+20	30000.	0.167	0.332E-01	0.329E-01	0.106E-01	0.339E-01	0.886E-02
	50000.	0.165	0.271E-01	0.347E-01	0.121E-01	0.352E-01	0.999E-02
	100000.	0.164	0.211E-01	0.366E-01	0.139E-01	0.358E-01	0.116E-01
	200000.	0.159	0.173E-01	0.380E-01	0.158E-01	0.372E-01	0.128E-01
N II 3d^{3}D^o-4p^{3}D	5000.	0.275	0.733E-01	0.245E-01	0.572E-02	0.284E-01	0.501E-02
6523.6 Å	10000.	0.217	0.539E-01	0.304E-01	0.839E-02	0.325E-01	0.730E-02
C=0.26E+20	30000.	0.184	0.366E-01	0.370E-01	0.118E-01	0.380E-01	0.991E-02
	50000.	0.184	0.298E-01	0.390E-01	0.135E-01	0.395E-01	0.112E-01
	100000.	0.184	0.225E-01	0.412E-01	0.155E-01	0.402E-01	0.129E-01
	200000.	0.179	0.191E-01	0.427E-01	0.177E-01	0.418E-01	0.143E-01
N II 3d^{3}D^o-4p^{3}P	5000.	0.262	0.735E-01	0.240E-01	0.575E-02	0.276E-01	0.502E-02
6347.6 Å	10000.	0.206	0.543E-01	0.295E-01	0.842E-02	0.316E-01	0.730E-02
C=0.26E+20	30000.	0.174	0.368E-01	0.360E-01	0.119E-01	0.369E-01	0.986E-02
	50000.	0.173	0.301E-01	0.380E-01	0.134E-01	0.382E-01	0.112E-01
	100000.	0.175	0.235E-01	0.404E-01	0.157E-01	0.392E-01	0.131E-01
	200000.	0.170	0.192E-01	0.431E-01	0.178E-01	0.401E-01	0.142E-01
N II 3d^{3}P^o-4p^{3}D	5000.	0.321	0.813E-01	0.300E-01	0.666E-02	0.347E-01	0.586E-02
7185.8 Å	10000.	0.257	0.591E-01	0.371E-01	0.979E-02	0.397E-01	0.854E-02
C=0.32E+20	30000.	0.222	0.395E-01	0.453E-01	0.139E-01	0.464E-01	0.116E-01
	50000.	0.223	0.329E-01	0.477E-01	0.160E-01	0.482E-01	0.130E-01
	100000.	0.225	0.249E-01	0.499E-01	0.179E-01	0.490E-01	0.151E-01
	200000.	0.220	0.213E-01	0.515E-01	0.207E-01	0.503E-01	0.170E-01
N II 3d^{3}P^o-4p^{3}P	5000.	0.304	0.817E-01	0.292E-01	0.669E-02	0.336E-01	0.585E-02
6972.8 Å	10000.	0.242	0.597E-01	0.359E-01	0.980E-02	0.384E-01	0.852E-02
C=0.32E+20	30000.	0.209	0.400E-01	0.435E-01	0.138E-01	0.450E-01	0.115E-01
	50000.	0.209	0.332E-01	0.459E-01	0.157E-01	0.463E-01	0.130E-01
	100000.	0.212	0.252E-01	0.489E-01	0.182E-01	0.475E-01	0.152E-01
	200000.	0.208	0.214E-01	0.506E-01	0.207E-01	0.493E-01	0.165E-01
N II 3d^{3}P^o-4p^{3}S	5000.	0.294	0.869E-01	0.288E-01	0.830E-02	0.328E-01	0.713E-02
6824.0 Å	10000.	0.234	0.628E-01	0.354E-01	0.121E-01	0.377E-01	0.103E-01
C=0.29E+20	30000.	0.208	0.426E-01	0.436E-01	0.166E-01	0.445E-01	0.139E-01
	50000.	0.210	0.343E-01	0.461E-01	0.190E-01	0.456E-01	0.157E-01
	100000.	0.214	0.277E-01	0.487E-01	0.217E-01	0.479E-01	0.180E-01
	200000.	0.209	0.227E-01	0.522E-01	0.253E-01	0.494E-01	0.205E-01

been taken from Moore (1993) and Kramida et al. (2021). Table 1 contains the results, for W and d, for 45 N II multiplets broadened by electron-, proton-, and ionized helium impacts for electron density 10^{16} cm^{-3} and temperatures 5 000 K, 10 000 K, 30 000 K, 50 000 K, 100 000 K, and 200 000 K. We point out that the wavelengths are calculated by using the atomic energy levels, meaning that they are not always identical to wavelengths in the NIST databases (Kramida et al. 2021). Table 1 also provides the quantity C (Dimitrijević and Sahal-Bréchot 1984a), which, when divided by the corresponding width (W), yields the maximal perturber density for which the line may be considered isolated. For all lines and plasma conditions (N and T) in Table 1, we checked the validity of the impact approximation by calculating the value of $N\,V$, where V is the collision volume and N the perturber density. For all values in Table 1 inequality $N\,V < 0.1$ holds which means that the impact approximation is valid. In Griem (1974), the error of the semiclassical perturbation method was estimated to be within 20 per cent for simple spectra. For the shift however, the accuracy is within the error bars of the width. But, as a difference from the width, where all contributions are positive, in the case of the shift they may be positive or negative. If, due to mutual cancellations of positive and negative contributions, shift is much smaller than the width,

Table 2: Comparison of the obtained results for FWHM (W_{SCP}[Å]) and shift (d_{SCP}[Å]) with the results of Griem (1974) (W_G[Å], d_G[Å]). The results are for electron density 10^{16} cm^{-3} and temperature 10 000 K.

TRANSITION	λ[Å]	W_{SCP}[Å]	d_{SCP}[Å]	W_G[Å]	d_G[Å]	W_{SCP}/W_G	d_{SCP}/d_G
N II $2p^2\ ^1D$-$3s^1P^o$	747.0 Å	0.707E-03	0.323E-03	0.902E-03	0.445E-03	0.78	0.73
N II $2p^2\ ^3P$-$^3d^3P^o$	529.7 Å	0.450E-03	0.169E-03	0.564E-03	0.231E-03	0.80	0.73
N II $3s^3P^o$-$3p^3D$	5680.9 Å	0.754E-01	-0.274E-02	0.760E-01	-0.319E-01	0.99	0.09
N II $3p^3D$-$3d^3F^o$	5005.9 Å	0.683E-01	-0.850E-03	0.530E-01	-0.354E-02	1.29	0.24
N II $3p^3S$-$3d^3P^o$	5002.2 Å	0.591E-01	0.804E-02	0.570E-01	-0.187E-01	1.04	-0.43
N II $3p^3P$-$3d^3D^o$	5940.2 Å	0.913E-01	-0.397E-02	0.772E-01	-0.744E-02	1.18	0.53
N II $3d^3F^o$-$4p^3D$	6169.8 Å	0.204	0.486E-01	0.218	0.872E-01	0.94	0.56
N II $3d^3D^o$-$4p^3P$	6347.6 Å	0.206	0.543E-01	0.212	0.108E-01	0.97	5.03
N II $3d^3P^o$-$4p^3D$	7185.8 Å	0.257	0.591E-01	0.294	0.117	0.87	0.51
N II $3d^3P^o$-$4p^3P$	6972.8 Å	0.242	0.597E-01	0.252	0.125	0.96	0.48
N II $3d^3P^o$-$4p^3S$	6824.0 Å	0.234	0.628E-01	0.244	0.125	0.96	0.50

error bars (determined according to the value of width), may be quite large.

In the Table 2, our results for FWHM and shift are compared, when possible, with the semiclassical results of Griem (1974). One can see that the results for Stark widths are in a good agreement. The averaged ratio of our results (W_{SCP}) and those of Griem (1974) (W_G) is 0.98. In the case of the shifts, a big disagreement exist in some cases.

Lets examine closer one of the cases with largest difference, the multiplet $3d^3D^o$-$4p^3P$ 6347.6 Å, where this ratio is 5.03. In this case, we have additional results and for the transition $3d^3P^o$-$4p^3P$ 6972.8 Å, belonging to the same supermultiplet and, even more the upper energy level $4p^3P$ is the same for both transitions. According to the investigation of similarities of Stark line shifts (Wiese and Konjevic 1992): “Stark shifts should be similar for lines within multiplets and, to a lesser degree, within supermultiplets”. Our shifts for 6347.6 Å and 6972.8 Å are 0.0543 Å and 0.0597 Å respectively, which is in accordance with this conclusion, while the results of Griem (1974) are 0.0108 Å and 0.125 Å and the difference is more than ten times larger.

We can see in Table 2, that the shift is always smaller than the width and that the best agreement is when the difference between the shift and the corresponding width is smaller (see the ratio for the first two lines). Namely, while in the case of the width all contributions are positive, for shifts they can be positive and negative, which allows for mutual cancellations of positive and negative contributions. If the shift is much smaller than width, the accuracy of the obtained results is smaller.

4. CONCLUSIONS

The Stark widths (FWHM) and shifts, the parameters which determine the Lorentzian profile of a spectral line, were calculated for 45 multiplets of N II, by using the impact semiclassical perturbation theory (Sahal-Bréchot 1969a,b, Sahal-Bréchot, Dimitrijević, & Ben Nessib 2014). The results have been obtained for broadening by collisions of a singly charged nitrogen ion (N II) with electrons, protons and singly charged helium ions. Such results are of interest for different problems in stellar physics, such as modelling of stellar atmospheres, analysis and synthesis of the N II lines in stellar spectra, the nitrogen abundance determination, opacity, radiative transfer and radiative acceleration calculations, etc. The obtained results are also of interest for investigation, modelling and diagnostics of a laboratory plasma, laser produced plasma, and for proton-boron fusion research, since in some experimental devices, the boron nitride (BN) targets are used, so that data on nitrogen ions in various stages of ionization are of interest for diagnostic purposes and for optimization, modeling and investigation of created plasma in various stages of its development and towards the edge. The obtained data on Stark broadening of N II spectral lines will also be implemented in the STARK-B database (http://stark-b.obspm.fr/ - Sahal-Bréchot et al. (2015)), a part of Virtual Atomic and Molecular Data Center (VAMDC) (http://www.vamdc.org/ - Dubernet et al. (2010, 2016), Albert et al. (2020)).

Acknowledgements – This article is based upon the work from COST Action CA21128-PROBONO “PROton BOron Nuclear fusion: from energy production to medical applicatiOns”, supported by COST (European Cooperation in Science and Technology.Thanks also to Technical University of Sofia for the provided help. Sylvie Sahal-Bréchot acknowledges the French Research Laboratory LUX (Paris Observatory and the CNRS UMR 8112) and the “Programme National de Physique Stellaire” (PNPS) of CNRS/INSU, CEA and CNES, France for their support.

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ШТАРКОВО ШИРЕЊЕ СПЕКТРАЛНИХ ЛИНИЈА N II

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УДК 523.316.2 : 535.5 : 539.144 : 539.16 : 546.17
Оригинални научни рад

Штаркови параметри ширења, ширине и помаци, израчунати су за сударе са електронима, протонима и јонима хелијума, за спектралне линије унутар 45 N II мултиплета, при чему је коришћена семикласична метода пертурбације. Добијени резултати су упоређени са другим теоријским прорачунима. Они су од интереса за интерпретацију, анализу и синтезу звезданих спектара и за моделирање, дијагностику и истраживање звездане плазме.