Superstatistical Properties of Ionization Rates of Li^+

SAMIA DILMI[1*], Fadhila KHALFAOUI[2]

[1]University of El Oued, Fa. Exact Sciences, Lab in Operator Theory and PDE, 39000, W. El-Oued, Algeria,
[2]University of El Oued, Fa. Exact Sciences, Lab in Operator Theory and PDE, 39000, W. El-Oued, Algeria
*Corresponding Author

ABSTRACT

Electron-impact ionization (EII) can also have a significant effect on the charge state distribution for plasmas with a non-thermal electron energy distribution. We demonstrate the connection between the Maxwellian distributions and the Beck-Cohen superstatistics and the influence of superstatistics on nonthermal and suprathermic distributions on the calculation of ionization rates for Li^+.

INTRODUCTION

The electron impact ionization (EII) is a cause of generated collisional plasma. In the ionization state can be limited by ionization rates [1]. Where we depend on the Maxwellian distributions and the Beck-Cohen Superstatistics, Then we study the influence of superstatistics on nonthermal and suprathermic distributions by calculation of ionization rates for Li^+.

THEORETICAL ASPECT

Cohen and Beck introduced superstatistics [2] (in 2003), which are shown in nonequilibrium and stable states. Where they are described by effective Boltzmann factor $B(E)$ as:

$$B(E) = \int_0^\infty f(\beta) e^{-\beta E} d\beta$$

where: $f(E)$ is probability distribution, E is an energy.
Then it becomes into general form as [3]:

$$B(E) = e^{-\beta_0 E}(1 + \frac{1}{2}(q-1)\beta_0^2 E^2 + g(q)\beta_0^3 E^3 \ldots)$$

where the factor g(q) refers to:

$$g(q) \begin{cases} =0 & \text{(Uniform and 2-level)} \\ =-\frac{1}{3}(q-1)^2 & \text{(Gamma)} \\ =-\frac{1}{3}(q^3-3q+2) & \text{(log-normal)} \\ =-\frac{1}{3}\frac{(q-1)(5q-6)}{3-q} & \text{(F-distribution)} \end{cases}$$

In the case of direct ionization, the coefficient of the ionization rates is given by:

$$\tau = \int v\sigma(E)F(E)dE, \qquad (cm^3 s^{-1})$$

Where M and $v = \sqrt{\frac{2E}{M}}$ are mass and velocity of electron, $\sigma(E)$ is the cross section and it was calculated by the Flexible Atomic Code (FAC) [4] and $F(E)$ is a Maxwellian distribution function.
In our work, we replace $F(E)$ with effective Boltzmann factor $B(E)$ to using superstatistics.

DOI: 10.21467/abstracts.122 ISBN: 978-81-954993-3-5

So, the formula of the coefficient of the ionization rates becomes:

$$\tau = \int v\sigma(E)e^{-\beta_0 E}\left(1 + \frac{1}{2}(q-1)\beta_0^2 E^2 + g(q)\beta_0^3 E^3\right)dE$$

RESULTS AND DISCUSSION

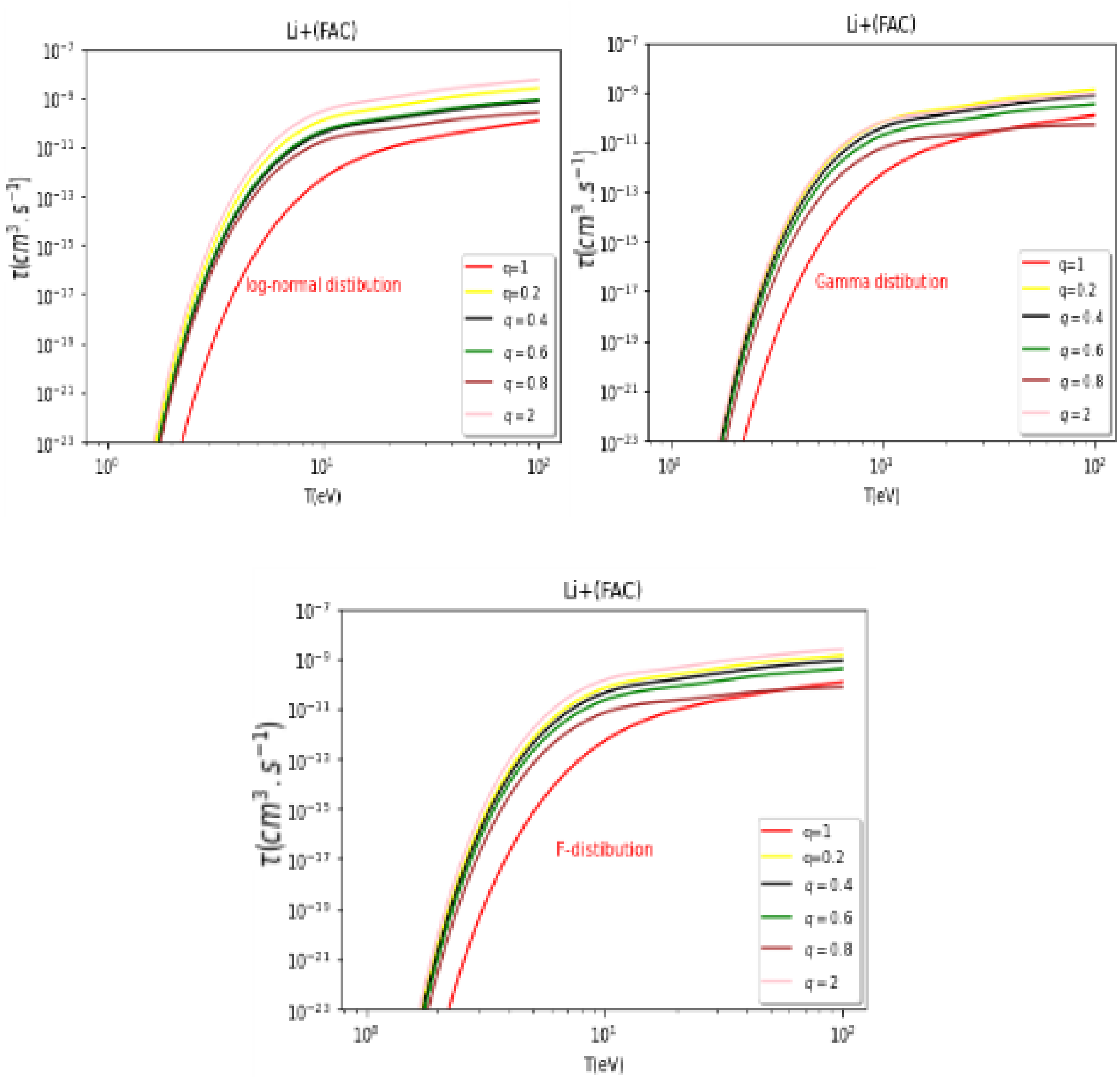

Figure 1: Coefficients of the ionization rates of Li^+: obtained using different forms of distribution functions and of various values from q.

The ionization rates are obtained using the various $g(q)$ functions of superstatistic. It is noted that the superstatistics approach in the calculation of the rates for Li ions, there is nice coordination between the curves of the three functions especially for the low values of q.

CONCLUSION

We can remark the connection between the Maxwellian distributions and the Beck-Cohen superstatistics where we have shown the relation between the superstatistics approach as well as the low values of q less than 1 on the calculation of ionization rates of Li^+.

ISBN: 978-81-954993-3-5
DOI: 10.21467/abstracts.122

REFERENCES

1. Sergio Davis, Jalaj Jain, Diego Gonz´alez, Gonzalo Guti´errez, Implications Superstatistics for steady-state plasmas, IOP Conf. Series: Journal of Physics: Conf. 1043 , 012011, (2018).
2. C. Beck and E.G.D. Cohen, Physica 322A, 267 (2003).
3. A. Boumali , F. Serdouk, S. Dilmi, J.Phys.A: Statistical Mechanics and its Applications (2020).
4. S. Dilmi, AM. Boumali, Ukr. J. Phys. Vol. 66, No. 8, (2021)

ISBN: 978-81-954993-3-5

DOI: 10.21467/abstracts.122