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From Quarks to Cosmos

Very Significant Revision Required for Electron Densities in White Dwarfs Deduced from Widths of Hydrogen Spectral Lines

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In strongly magnetized plasmas of DA white dwarfs, where the magnetic field B could be ~ (10^2 – 10^5) Tesla, electrons move along strongly helical trajectories. The allowance for helical trajectories of plasma electrons dramatically changes the Stark width of hydrogen spectral lines compared to all previous calculations. We show analytically that without allowance for this effect, the **electron densities** deduced from all previous observations of hydrogen lines in DA white dwarfs can be ***erroneous by up to one order of magnitude***. Thus, a **very significant revision of electron densities** deduced ***from all observations*** of hydrogen lines in DA white dwarfs, is required.

- While calculating the Stark broadening of hydrogen lines in plasmas, both the old, standard theory [1, 2] and the more recent generalized theory [3, 4] assumed that perturbing electrons in plasmas move in rectilinear paths.
- However, in strongly magnetized plasmas of DA white dwarfs, where the magnetic field B ~ (10^2 – 10^5) Tesla, the perturbing electrons in plasmas move along **strongly helical trajectories**.
- In our papers [5-7], which we follow in this talk, it was shown by *analytical* calculations that the allowance for helical trajectories of perturbing electrons **very dramatically** affects the width of hydrogen lines emitted by DA white dwarfs.

[1] P. Kepple and H.R. Griem, Phys. Rev. **173** (1968) 317.

[2] H.R. Griem, *Spectral Line Broadening by Plasmas* (Academic, New York) 1974.

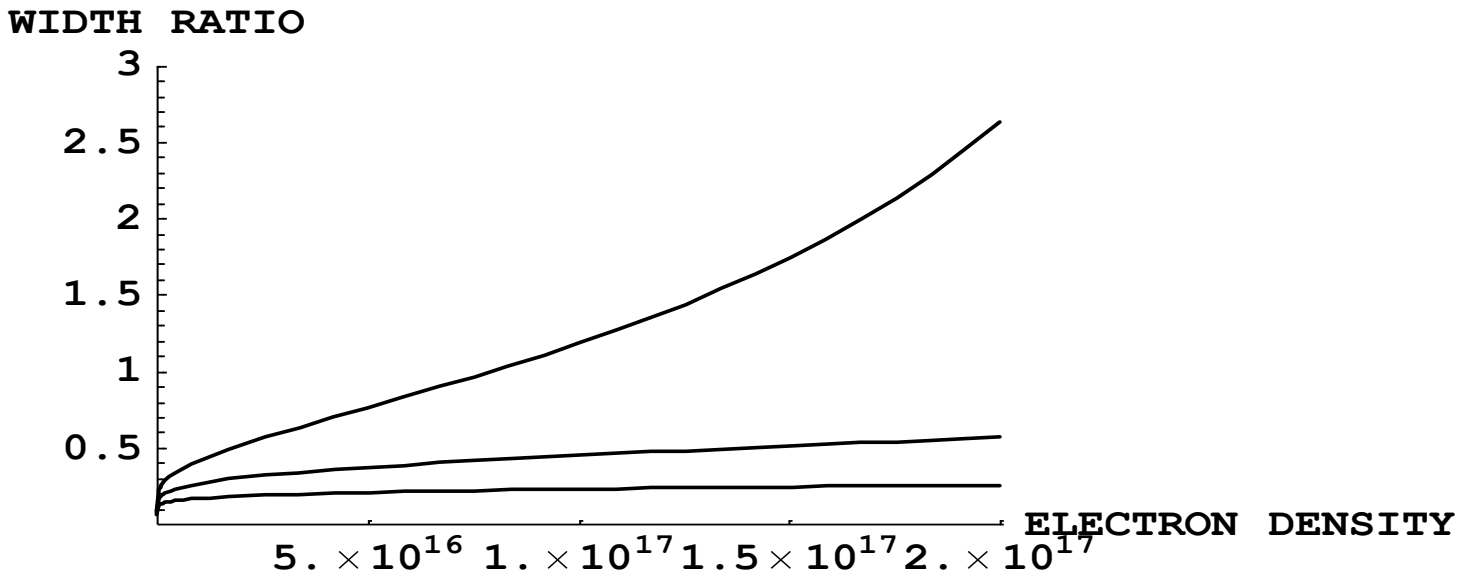
[3] Ya. Ispolatov and E. Oks, J. Quant. Spectr. Rad. Transfer **51** (1994) 129.

[4] E. Oks, *Diagnostics of Laboratory and Astrophysical Plasmas Using Spectral Lines of One-, Two-, and Three-Electron Systems* (World Scientific, New Jersey) 2017.

[5] E. Oks, J. Quant. Spectrosc. Rad. Transfer **171** (2016) 15.

[6] E. Oks, Intern. Review of Atomic and Molecular Phys. **8** (2017) 61.

[7] E. Oks, Atoms **6** (2018) 50.



- This figure shows the **ratio of the Stark widths**, calculated with and without the allowance for helical trajectories, versus the electron density (in cm^{-3}) for the *Balmer-alpha* line (the *lower* curve), the *Balmer-beta* line (the *middle* curve), and the *Balmer-delta* line (*upper* curve).
- It is seen that for the Balmer-alpha and -beta lines, the neglect of helical trajectories leads to the ***overestimation*** *of the Stark width by up to* ***one order of magnitude*** and thus to the ***underestimation*** *of the* ***electron density*** *by up to* ***one order of magnitude.***
- For Balmer-delta and higher lines the neglect of helical trajectories leads to the ***underestimation*** *of the Stark width* ***by several times*** and thus to the ***overrestimation of the electron density*** ***by several times****.*
- Thus, a **very significant revision of electron densities** deduced ***from ALL observations*** of hydrogen lines in DA white dwarfs, is required.