Stark–Zeeman spectra of Rydberg atoms and ions in plasma

Letunov A Yu[1,2,@] **and Lisitsa V S**[2,3]

[1] Federal State Unitary Enterprise "Russian Federal Nuclear Center—Academician Zababakhin All-Russian Research Institute of Technical Physics", Vasilieva 13, Snezhinsk, Chelyabinsk Region 456770, Russia
[2] National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe Shosse 31, Moscow 115409, Russia
[3] National Research Center "Kurchatov Institute", Kurchatov Square 1, Moscow 123182, Russia

[@] letunovayu@vniitf.ru

A simplified method of the spectral line shapes calculations for the hydrogen atoms (hydrogen-like ions) in plasma with an external magnetic field is presented. This approach is based on the semiclassical approximation for the transition probabilities [1]. Even though this method has been developed for large values of the principal quantum numbers, it perfectly works for the first Balmer lines. For instance, the error for the H_α line ($3 \to 2$) does not exceed 10%. The calculation rate within the presented approach growth like $n\bar{n}$, where n and $\bar{n}$ are the principle quantum numbers of the upper and lower states correspondingly. At the same time, in the framework of the accurate quantum consideration the calculation rate growth like $n^4\bar{n}^5$. For example, for the $4 \to 3$ transition (the P_α line) the semiclassical calculation is 5184 times faster than the accurate calculation. Thus, the presented method is applicable for large amounts of calculations which is necessary for the plasma diagnostics. The obtained results are in agreements with the experimental data and the molecular dynamics calculations. This method might be especially useful for the laser induced quenching method [2] where the $4 \to 3$ and $5 \to 4$ transitions are used for the divertor plasma diagnostics.

[1] Letunov A Yu and Lisitsa V S 2020 *J. Exp. Theor. Phys.* **131** 696–706

[2] Gorbunov A, Mukhin E, Munoz Burgos J M, Krivoruchko D, Vukolov K, Kurskiev G and Tolstyakov S 2022 *Plasma Phys. Controlled Fusion* **64** 115004