Numerical investigation of non-homogeneous ECR plasma opacities assuming an external black-body radiation

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Laboratory plasma may become an attractive environment for making innovative research activities impacting Astrophysics and Nuclear Physics in the context of the Multi-messenger Astronomy. In this scenario, the PANDORA project [1] aims at investigating nuclear β-decays under plasma conditions resembling astrophysical scenarios, following theoretical predictions [2] and allows to better address the study of s-process nucleosynthesis. In addition, the project aims at measuring, for the first time, plasma opacities which are relevant for addressing the opacity input, arising from freshly synthesized r-process elements in post-merging plasma ejecta, relevant for the Kilonovae signal interpretation [3]. In this paper, we numerically estimated the electron densities and temperatures of the non-homogeneous laboratory Electron Cyclotron Resonance (ECR) plasma in non Local Thermodynamical Equilibrium conditions through a Particle-In-Cell (PIC) code [4]. Moreover, by means of the population kinetics code FLYCHK [5], we also simulated the optical properties of an Ar plasma using the PIC simulation results together with an input black-body radiation, to establish and characterize the opacities, along 1-D line of sight. Finally, we studied the behaviour of the outcoming intensity as impacted by the opacity arising from both radiation-perturbed and not optically thin plasma, according to the population levels distribution of the excited Ar atoms. Results presented can offer benchmarks about plasma induced radiation field distortion, useful for supporting laboratory spectral characterizations.

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