Generating inverted Landau level populations through radiation reaction cooling

P. J. Bilbao & L. O. Silva

GoLP/Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisboa, Portugal

Particles in strong electromagnetic fields dissipate their energy through radiation reaction [1]. The radiation reaction force differs from the Lorentz force as it does not conserve the momentum-space volume. We study the effects of radiation reaction in the total momentum distribution, by including the radiation reaction force term into Vlasov equation. We demonstrate that for an initial Maxwellian plasma, its momentum distribution evolves into a distorded momentum distribution under the presence of a strong magnetic field. The resulting distribution exhibits inverted Landau level population, making it unstable to kinetic plasma instabilities [2]. We were able to confirm our theoretical predictions for both classical and QED radiation reaction descriptions with the help of the particle-in-cell (PIC) code OSIRIS [3] and the OSIRIS-QED module [4, 5]. This finding is of relevance to coherent radiation emission processes, as the production of unstable distributions is key to excite kinetic plasma instabilities, which can lead to coherent radiation emission in astrophysical scenarios permeated by ultra strong magnetic fields such as pulsars.

References

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