The electron cyclotron maser instability in laser ionised plasmas

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The electron cyclotron maser (ECM) is one of the prominent mechanisms that may explain the origin of part of the coherent radiation in astrophysical plasmas. The ECM instability has a kinetic nature, requiring specific electron distribution functions for the interaction of the plasma electrons with an external magnetic field to lead to an unstable feedback loop that causes the amplification of the cyclotron radiation.

One of the main critiques for the ECM as the mechanism for coherent emission is the required distribution functions that would not naturally occur. Recent results [1] have shown that these distribution functions may, in fact, be much more prominent than originally thought; indeed, ring-shaped momentum distributions may be a global attractor of the Vlasov-Maxwell dynamics when accounting for radiation reaction. This renews the interest in this mechanism; therefore, it is timely to have configurations available in the laboratory to study the ECM.

We propose using gases ionised by circularly polarised lasers (cf. [2]) as an experimental platform to probe the ECM in the laboratory. Because of the canonical momentum conservation, the resulting plasma will have the laser polarisation imprinted in its momentum space [3], generating ring momentum distribution functions suited for ECM growth. This configuration is flexible, as using of other gases and laser parameters can lead to different resulting distribution functions. We use particle-in-cell simulations and theory to demonstrate that the setup can probe the ECM in the laboratory with current state-of-the-art laser and magnetic field technology.

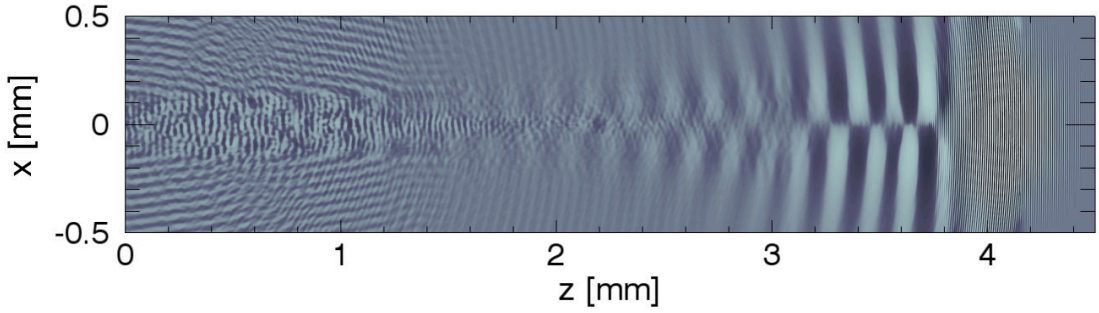

Figure 1: Laser propagating to the right and ECM radiation emitted by the plasma in the left.

References

[1] P. Bilbao and L.O. Silva, arXiv:2212.12271
[2] C. Zhang *et al.*, Sci. Adv. 2019; **5**: eaax 4545
[3] P. Gibbon, Short Pulse Plaser Interactions with Matter (2005)