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O4.208 Anisotropic heating and magnetic field generation due to Raman scattering in laser-plasma interactions

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The interaction of intense electromagnetic waves with plasmas is a rich research topic. Magnetic fields play a crucial role in this context and there are several processes that can lead to the generation and amplification of these fields. Recent experiments, for instance, demonstrated the generation large-scale magnetic fields [1] due to hot electron currents in underdense plasmas, and determined the turbulent [2] dynamics of intense magnetic fields in laser-solid interactions.
In this work we explore a novel mechanism to drive the Weibel instability in laser-plasma interactions using theory and full scale particle-in.cell simulations in two- and three-dimensions with the code OSIRIS [3]. We show that intense laser pulses interacting with sub-quarter-critical density plasmas can lead to anisotropic heating, if stimulated Raman scattering (SRS) grows. Electron heating, due to wavebreaking of the SRS excited plasma waves, will be preferential in the propagation direction of the excited plasma waves, creating a temperature anisotropy behind the laser. The direction of the scattered waves has a dependence on the plasma temperature, as Landau damping can prevent small wavelength waves to grow. We find a good agreement between the observed magnetic field growth rate and characteristics with theoretical predictions of the Weibel instability due to temperature anisotropy.
We also argue that this setup can be used to investigate the long-time evolution of the Weibel instability in laboratory, as the evolution of the Weibel generated magnetic fields can be related to the time delay of the laser passage for the region. This is of great relevance to understand the structure of collisionless shocks in astrophysical objects, in particular, gamma-ray bursts [4, 5].

References

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