Heat Transport in Laser-Produced Magnetized Plasmas

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Heat transport in high-energy-density environments is a fundamental process that is strongly influenced by magnetic fields. Indeed, magnetic fields are expected to play a crucial role in Inertial Confinement Fusion (ICF), where they may help achieve optimal ignition conditions by magneto-thermally insulating and confining electrons [1], and in numerous astrophysical systems, where plasma permeated by magnetic fields is ubiquitous. However, laser-driven heating and the subsequent steep temperature gradients inevitably introduce nonlocal transport effects that lead to the preheating of the fuel, a process that significantly degrades fusion yield [2]. Accurately modelling the interplay between thermal transport, magnetic fields, and hydrodynamics remains challenging, further hindered by a critical lack of experimental data.

To address this, an experimental campaign was undertaken at LULI2000 to investigate the impact of magnetic fields on heat transport. High-power lasers heated up gas jets of various compositions and pressures, while a pulsed-power-driven coil generated external magnetic fields up to 20 T [3]. The plasma conditions were characterized using multiple temporally and spatially resolved diagnostics, including Thomson scattering, interferometry, and streaked optical pyrometry (SOP).

Our results provide direct evidence of heat flux inhibition and plasma compression due to the applied magnetic field. Notably, Thomson scattering (TS) spectra reveal a significant temperature increase in magnetized plasmas, and that electrons have a non-Maxwellian distribution function, strongly associated with inverse bremsstrahlung heating and nonlocal transport. This was obtained by extracting the electron distribution function from experimental data using, first, a TS form factor fitting algorithm, and finally neural networks, a novel approach that has never been demonstrated before in this context [4]. Complementary Vlasov-Fokker-Planck numerical simulations were performed to compare with our data.

<u>References</u>

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