Electron heating in high Mach number collisionless shocks

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Collisionless shock waves shape the nonthermal emission in a wide range of environments, including modern laboratory experiments and astrophysical outflows. In weakly magnetized plasma flows, self-generated nonlinear electromagnetic plasma processes are inferred to heat and accelerate electrons and ions. Understanding the mechanisms that underpin the energy transfer between plasma species and the downstream temperature ratio between electrons and ions constitutes a fundamental challenge in modeling such blast waves. In this talk, I will outline recent theoretical efforts to model the transport of electrons in Weibel-mediated shocks [1,2]. I will introduce a new theoretical model, supported by kinetic numerical simulations, accounting for electron heating in an ambipolar-type process through the interplay between effective pitch-angle scattering in the microturbulence and the coherent ambipolar field induced by the difference in inertia between species. I will discuss the electron-ion energy partition in the downstream of high Alfvén Mach numbers shocks and implications of this model on electron injection in nonthermal distributions.

[1] A. Vanthieghem, V. Tsiolis, A. Spitkovsky, Y. Todo, K. Sekiguchi, F. Fiuza, submitted (2024)

[2] A. Vanthieghem, L. Gremillet, M. Lemoine, ApJ Lett., 930 L8 (2022)

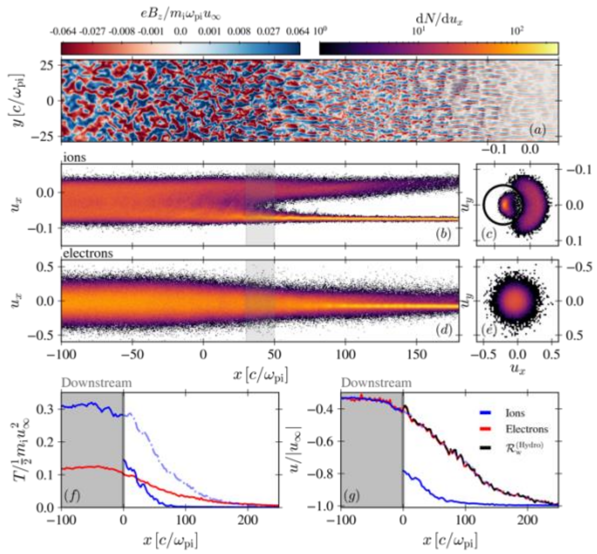

Fig 1: Characteristic structure of a non-relativistic unmagnetized electron-ion collisionless shock wave. The turbulent magnetic field is shown in (a), the $x - u_x$ phase space profile is shown in (b) for the ions, and (d) for the electrons. Insets (c) and (e) show the respective momentum distribution corresponding to the shaded area of panels (b) and (d). The circle in (c) differentiates backstreaming beam and background ions. The temperature profile is shown in (f). The total ion temperature corresponds to the dot-dashed line for comparison. The velocity profile for each species is shown in (g).