Contribution ID: **43** Type: **Poster**

Interplay Between Multi-scale CR-driven Plasma Instabilities

Collisionless shocks are ubiquitous in astrophysical environments and can now be reproduced in the laboratory using high-power lasers. These shocks play a crucial role in accelerating energetic particles, such as cosmic rays (CR), via a Fermi-type mechanism that relies on turbulent magnetic fields, amplified by various plasma instabilities, to confine the particles near the shock front. Using kinetic numerical simulations, supported by analytical descriptions, we investigate the interplay between multiscale CR-driven plasma instabilities and their role in shaping the turbulent magnetic fields. We present and discuss the nonlinear coupling between these different instabilities captured by large-scale Particle-In-Cell simulations using the code SMILEI. This research aims to provide a deeper understanding of the interplay between plasma instabilities and particle acceleration in various astrophysical environments, as well as of laser-generated collisionless shock experiments.

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Session Classification: Poster session