Programme national hautes énergies

ID de Contribution: **64**

Type: **Non spécifié**

Microturbulence in unmagnetized relativistic collisionless shock waves

jeudi 16 septembre 2021 09:55 (20 minutes)

Microturbulence produced by plasma instabilities plays an important role in the dynamics and dissipation mechanisms of relativistic astrophysical collisionless shocks, such as those associated with gamma-ray bursts and blazar environments. We present the tenets of an analytical model that describes the dynamics of the precursor of relativistic unmagnetized collisionless shock waves in electron-positron and electron-ion plasmas. The model is compared with results from particle-in-cell simulations and shown to accurately capture the deceleration and heating of the background plasma species. We further address the dynamics of relativistic radiation mediated shock waves that dictate the early emission in numerous transient sources such as supernovae and binary neutron star mergers. In the relativistic regime, a high pair multiplicity inside the shock transition leads to a lepton-baryon velocity separation, prone to plasma instabilities. We present a theoretical and numerical analysis of the hierarchy of plasma instabilities growing in an electron-ion plasma loaded with pairs and subject to a radiation force. Based on this analysis, we extend the analytical model introduced in the first part to demonstrate nonadiabatic compression in a Joule-like heating process by the joined contributions of the decelerating turbulence, radiation force, and electrostatic field. These results show that this analytical framework can be useful in describing how the microturbulence impact the dynamics and energy partition of a large class of relativistic shock waves.

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Classification de Session: Shocks & Cosmic rays: Theory & Simulations