

Kinetic study of relativistic collisionless shocks

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LANL, T-5

ABSTRACT: Collisionless shocks are ubiquitous in astrophysical plasmas. A number of long-standing problems in astrophysics – from understanding the magnetic field generation in gamma-ray bursts and pulsar wind nebulae to the acceleration of the highest energy cosmic rays – hinge on a more complete understanding of relativistic collisionless shocks. These shocks also play an important role in space physics. However, the formation processes for these shocks are not fully understood, especially in the extreme relativistic regime. It is proposed that magnetic field is generated through Weibel instability at the streaming interface between plasma flows, and leads to shock formation and subsequent non-thermal particle acceleration. This widely held idea have been recently tested in ab-initio kinetic simulations by several groups. We further develop an improved kinetic modeling capability to explore the physical mechanism at work for the counter-streaming, initially unmagnetized, relativistic plasma flows. We will compare our findings for various flow Lorentz factors and mass ratios, such as shock formation time and speed, to existing results.