Collisionless Shock Waves and Wave-Particle Interactions

Wilson III, Lynn B., lynn.b.wilsoniii@gmail.com, NASA Goddard Space Flight Center, Greenbelt, MD, USA.

Collisionless shock waves are a topic of great interest in multiple fields of study from lab plasmas to astrophysics. Shock waves are arise when a nonlinearly steepening wave manages to form a stable discontinuity through the irreversible transformation of the free energy, or energy dissipation, available in the change in bulk flow kinetic energy across the shock to some other form (e.g., heat). In a regular fluid (e.g., Earth's atmosphere), shock initiation can occur because binary particle collisions provide sufficient energy dissipation to balance nonlinear wave steepening. Ever since the prediction of collisionless shocks nearly 60 years ago, the debate surrounding possible energy dissipation mechanisms has been a subject of great debate. The energy dissipation mechanisms proposed are: (1) quasi-static field effects [e.g., cross-shock potential]; (2) particle reflection; (3) dispersive radiation; and (4) wave-particle interactions. However, recent results show that the first three mechanisms are all part of pathways that ultimately end with this "black box" mechanism I refer to as "wave-particle interactions." Therefore, in this talk I will focus on wave-particle interactions and present recent results showing that they are capable to regulating the macroscopic structure of collisionless shock waves.