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Energy Partitioning of Ions and Electrons for Parallel Shock Waves

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When the supersonic plasma flow interacts with the shock front, the flow is decelerated, and the bulk flow energy can be converted to plasma heating. In essence, the magnitude of ion heating is considerably more substantial in comparison to electron heating. This is primarily attributable to the fact that the bulk flow energy of ions is consistently greater than that of electrons, as indicated by the mass ratio. The total heating of collisionless shock waves can be estimated using the Rankine-Hugoniot jump conditions. The individual temperatures of ions and electrons in downstream are determined by the shock dynamics and the energy transfer processes in plasmas. Such processes include wave-particle interactions, plasma instabilities, and plasma turbulence. In the context of high Mach number shocks, the shock front exhibits characteristics that are neither laminar nor stationary. This phenomenon occurs when the Mach number exceeds the critical Mach number.

Numerous numerical simulations of shock waves have been conducted, leading to significant advancements in our comprehension of non-stationary shock dynamics. In recent discourse, the subject of energy partitioning among ions and electrons has been explored, particularly with regard to the ion-electron temperature ratio in supernova remnants and the solar wind. This exploration has involved the integration of computer-simulated shocks and observational data, fostering a comprehensive understanding of the subject. However, the current state of knowledge regarding energy partitioning is such that a comprehensive understanding remains elusive. This is primarily due to the fact that energy partitioning is a function of numerous variables, including Mach number, shock angle, and the ion and electron plasma beta, among others.

In this presentation, we will examine a parallel shock wave by employing a two-dimensional particle-in-cell simulation. We will also engage in a discussion of various plasma heating processes that are conducive to understanding the energy partitioning between ions and electrons. Specifically, the focus is on the generation of large-amplitude Alfven waves, which are excited by reflected particles from the shock front, and the heating processes that are induced by parametric decay and modulational instabilities, as well as by magnetic reconnection in the current sheet, which is induced by the train of large-amplitude Alfven waves.