Ion-Acoustic Waves and the Proton-Alpha Streaming Instability at Collisionless Shocks

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Abstract

Ion-acoustic waves are routinely observed at collisionless shocks and could be an important source of resistivity. The source of instability and the effects of the waves are not fully understood. We show, using Magnetospheric Multiscale (MMS) mission observations and numerical modeling, that across low Mach number shocks a large relative drift between protons and alpha particles develops, which can be unstable to the proton-alpha streaming instability. Linear analysis and a numerical simulation show that the resulting waves agree with the observed wave properties. The generated ion-acoustic waves are predicted to become nonlinear and form ion holes, maintained by trapped protons and alphas. The instability reduces the relative drift between protons and alphas, and heats the ions, thus providing a source of resistivity at shocks.

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