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Magnetosheath jets: coupling shocks, reconnection, and particle acceleration

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Quasi-parallel shocks generate a multitude of transient structures in their surroundings, both upstream and downstream. Some of the most prominent phenomena are magnetosheath jets - localized enhancements of dynamic pressure with typical scales of about 1 Earth radius (10s of ion inertial lengths). Here we present new advances in understanding the role jets play in linking fundamental particle energization processes.

Key characteristics of nonlinear structures such as the jets are their scale sizes and shapes. While it is possible to investigate the jet scale sizes and shapes with multi-point spacecraft observations, many assumptions underlie such a (statistical) analysis. The 2D nature of previous simulations, on the other hand, may have limited the magnetosheath and jet flow patterns, therefore affecting their structure. Here we present new global 3D hybrid-Particle-in-Cell simulations, and compare the results of clustering analysis and virtual spacecraft analysis.

Large jets impact the dayside magnetopause many times per hour. Could such impacts trigger local magnetopause reconnection? We present THEMIS observations indicating that a jet impact compressed an originally thick, high magnetic shear magnetopause until it was thin enough for reconnection to occur. Magnetosheath jets could therefore act as a driver for bursty reconnection.

Jets with high enough speed could also affect particle acceleration by driving localized secondary shocks within the magnetosheath. We search a THEMIS database of about 3000 jet events for supermagnetosonic jets associated with sharp increases in magnetic field strength and density, and a large velocity deflection. We find that about 12% of the jet events have a shock-like structure ahead of them. These events also have a higher probability to be associated with local higher energy ions and electrons. We conclude that secondary shocks driven by magnetosheath jets can energize particles, which has implications for the downstream plasma heating and bow shock acceleration.