Super-magnetosonic Downstream Jet Formation as a Direct Consequence of Shock Reformation

S. Raptis[1], T. Karlsson[1], A. Vaivads[1], C. Pollock[2], F. Plaschke[3], A. Johlander[4,5], H. Trollvik[1], P-A. Lindqvist[1]

[1]*Space and Plasma Physics, School of Electrical Engineering and Computer Science, KTH Royal Institute of Technology, Sweden*
[2]*Denali Scientific, Fairbanks, AK, 99709, USA*
[3]*Space Research Institute, Austrian Academy of Sciences, Graz, Austria*
[4]*Department of Physics, University of Helsinki, Finland*
[5]*Swedish institute of Space Physics, Uppsala, Sweden*

Abstract

Downstream magnetosheath jets are transient and localized dynamic pressure enhancements found behind the Earth's bow shock. Their velocities can reach solar wind levels while their density is typically higher than both the magnetosheath and the solar wind local value. Jets have been associated with several magnetospheric phenomena, including the excitation of surface eigenmodes at the magnetopause, magnetic reconnection and particle acceleration. Their exact origin is still under debate while some of the proposed mechanisms involve the interaction of solar wind with the local inclination of the bow shock (ripples), hot flow anomalies, and solar wind discontinuities.

By using the Magnetospheric Multiscale (MMS) mission and utilizing its "string-of-pearl" configuration, we show the first *in-situ* observations of a super-magnetosonic jet generated downstream of the quasi-parallel bow shock as a direct result of upstream wave evolution and an ongoing reformation cycle. The downstream jet is generated directly from the dynamical evolution of the shock and the emergence of a spatially de-attached solitary magnetic structure which acts as the local bow shock front. This effectively creates a reformation cycle at the Earth's bow shock allowing solar wind particles to be transferred downstream without interacting strongly with the bow shock. Furthermore, we observed the initial shock front corresponding to a Short Large Amplitude Magnetic Structures (SLAMS) evolving in time and finally dissolving into becoming a density enhanced region in the magnetosheath ("embedded plasmoid").

The proposed mechanism describes jet generation as a direct result of the dynamical evolution of the bow shock. This is fundamentally different compared to other proposed mechanisms that require the presence of external factors (e.g. discontinuities) or specific geometric configurations (e.g. ripples) to take place to explain jet generation. These results are not only relevant to Earth but also to planetary and astrophysical plasmas where collisionless shocks are ubiquitous.