High-speed jets and related phenomena in Earth's bow shock and magnetosheath

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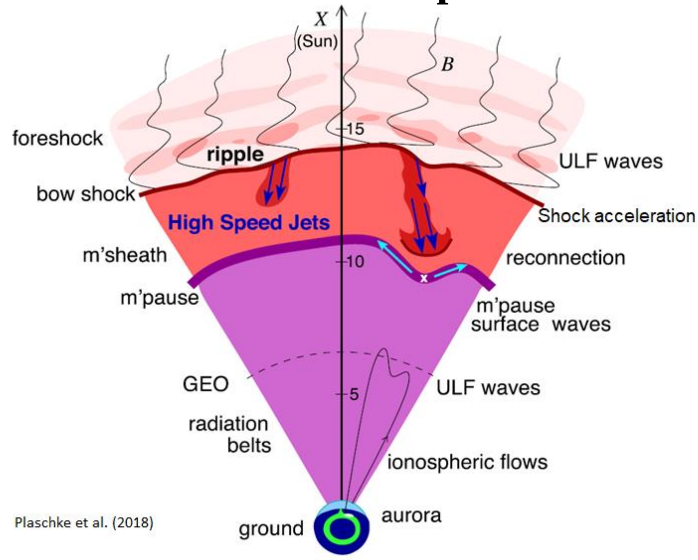

Magnetosheath high-speed jets are dynamic pressure enhancements downstream of Earth's bow shock. Their formation has been associated to several mechanisms including solar transient phenomena and the dynamical evolution of the bow shock. Their importance to plasma and space science lies in their connection to numerous effects. After their formation at the bow shock, jets interact with the background population of the magnetosheath, exciting different waves and accelerating particles. As they approach the magnetosphere they can penetrate the magnetopause, drive surface waves or cause magnetopause reconnection. Their effect to the inner geospace environment can be seen in substorm manifestation and ground magnetometer observation.

In this presentation, an overview of the recent advanced in understanding and modeling magnetosheath jets is presented. We focus on a series of recent articles on the formation, evolution and statistical properties of jets. Most of the work is done using NASA's Magnetosphere Multiscale (MMS) mission, while other tetrahedron missions like Cluster and THEMIS and upstream solar wind monitors (e.g., ACE and Wind) are also used. For our analysis we also apply advanced machine learning techniques such as neural networks and computers simulations. These techniques combined with observations and multi-spacecraft data analysis, provide a more detailed picture on the dynamics of transient phenomena such as magnetosheath jets.

We initially show the importance of finding different classes of jets based on the shock orientation and interplanetary magnetic field (IMF) and provided an open-access database of magnetosheath jets using MMS. By doing so we highlight the necessity to correctly identify and classify the phenomena under investigation in order to provide meaningful statistical results. After this dataset is validated and used in multiple works, we focus on the formation and evolution of jets close to the Earth's bow shock. We show direct in-situ evidence that shock reformation and the evolution of upstream waves are sufficient to generate downstream high-speed jets. Sequentially, by evaluating the properties of jets on a kinetic level, we demonstrate that jets exhibit complex velocity distribution functions (VDFs) throughout their life. Deriving partial plasma moments to isolate the jet from the background population, we reveal the limitations of studying these phenomena from a single-fluid prospective and how the derived plasma moments relate to upstream solar wind. Next, we discuss how their interaction with the magnetosheath background may have a lot of effects, contributing to the excitations of waves and energy transfer. Finally, we discuss how modern data analytics techniques and the plethora of observations can be used for future work.