Characterization of the Earth's Magnetosheath and its Fast Plasma Flows Using Upstream Measurements and Machine Learning

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Abstract

Downstream of the Earth's bow shock, resulting from the interaction of the supersonic solar wind with the geomagnetic field is the Magnetosheath region. This highly disturbed environment contains several transient phenomena (e.g. magnetosheath jets) that further contribute to the plasma turbulence. Most of the properties of the shock and its associated magnetosheath originate from the angle (θ_{Bn}) between the interplanetary magnetic field (IMF) and the bow shock normal vector (n).

Angles less than 45° are associated to the so called "quasi-parallel" shock and these with more than 45° to the "quasi-perpendicular". Closely related is the concept of the ion foreshock. Ion foreshock is the region upstream of the bow shock where wave-particle interactions, defuse ions and ULF wave activity governs the dynamics of the environment. Typically foreshock becomes significant at ~45 degrees and gets intensified closer to the bow shock and when θ_{Bn} becomes smaller.

While shock crossings have been known for a while and theoretical descriptions for idealized cases exist, there is limited work on how specific plasma properties change between the upstream and downstream between the different plasma environments (Q-par/Q-perp shock, Foreshock/no-Foreshock). This is primarily because of the Qpar shock complexity but also due to the unavailability of reliable measurements upstream and downstream of the shock.

In this work, we present the progress done in the modeling, classification and characterization of the different upstream and downstream plasma along with the classification of the localized dynamic pressure enhancements (jets). To accurately characterize the different environments we use a plethora of different spacecraft and datasets. The input of the models consist of solar wind values (OMNIweb), upstream and downstream measurements (Cluster) and magnetosheath data (MMS). These measurements are imported in neural networks that provide the modeling and the final characterization through a variety of classification and regression tasks.