Understanding turbulent dissipation and particle energization in Earth's magnetosheath: Results from the MMS magnetosheath campaign

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Abstract

Earth's magnetosheath is at the interface between Earth's magnetosphere and the solar wind. It is a very dynamic environment, characterized by strong turbulence, significant plasma heating and particle acceleration. Tracing the pathways of energy transfer in this region is a crucial piece the interaction between Earth and the interplanetary medium. The MMS spacecraft provide us with multi-point, high-resolution particle and fields measurements, that are necessary to resolve the kinetic physics that control the turbulent energy dissipation and particle energization. However, the scarcity of burst-resolution data obtained in the magnetosheath limited our ability to gain a comprehensive understanding of its dynamics. To address this, a dedicated campaign was carried out by the MMS mission with the goal of collecting an unbiased set of burst-resolution samples throughout the entire magnetosheath. This dataset was obtained for several consecutive orbits during the 2023 and 2024 dayside phases of the mission, covering a wide range of conditions during a very active part of the solar cycle. These observations allow us to examine how the local turbulence and plasma energization are impacted by the variable upstream conditions, the

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bow-shock configuration, and the spatial evolution of the turbulent plasma across the region. We examine the evolution of the local turbulence and the associated dissipation across the magnetosheath and the effect of varying upstream solar wind parameters in this process. We analyze the properties of the intermittent structures that form in the turbulence at ion and sub-ion scales, and the role of magnetic reconnection observed within such structures. We also discuss the role of wave-particle interactions, plasma instabilities, and the generation of non-maxwellian features in particle distribution functions, providing valuable insights into the kinetic processes that mediate collisionless heating and particle acceleration.