The Effect of Variable Solar Wind Conditions on the Bow Shock Structure and its Ability to Generate Energetic Ions

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Turbulent fluctuations in the magnetic field and in the bulk plasma parameters of the solar wind have important effects on the propagation and evolution of energetic particles throughout the heliosphere and on the coupling of the solar wind to the Earth's magnetosphere. At the shock the solar wind kinetic energy is converted into downstream plasma heating, ion reflection and acceleration. Changes in upstream plasma conditions can result in changes in the dynamics of the shock, its structure, and the suprathermal ion population it generates. These upstream variations can be due to transients, interplanetary shocks, and other discontinuities. They can also result from nonlinear interactions, causing an intermittent energy dissipation and leading to possible currents sheet structures. A number of these events can be found in observations from STEREO (for interplanetary traveling shocks) and CLUSTER/MMS (for the Earth's bow shock) in the magnetosheath.

We performed 3D-hybrid simulations to study the effects of spatially confined disturbances, such as density enhancements, depletions, and current layers/sheets and studied the shock dynamics, and the energetic particle release at various distances from the bow shock. The results of these simulations are then discussed in terms of multi-spacecraft observations in the magnetosheath at various scales. The results show that shock reformation is highly impacted by density depressions/enhancements and so is the generation of waves and suprathermal ions. Also, upstream solar wind variations can alter the shock properties considerably at the various virtual spacecraft in the simulations.