Dependence of the collisionless shock jump conditions on downstream parameters

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Shock acceleration is considered as a cause of high-energy cosmic rays. It is important to understand the structure of collisionless shocks and the behavior of plasma.
In this study, in order to understand the large scale structure of collisionless shocks in detail, we compare between in-situ observations of the Earth’ s bow shock and the MHD shock theory with temperature anisotropy taken into account [Kalimabadi et al., 1995]. We use data obtained from a particle detector, FPI (Fast Plasma Instrument) on board the MMS spacecraft to determine upstream and downstream physical quantities in de Hoffmann Teller Frame which is one of the shock rest frames. The shock normal is estimated with the Minimum Variance Analysis. Downstream parameters are also determined theoretically from the MHD shock jump conditions, using upstream parameters and the shock normal estimated from the MMS observations. We use observed temperature anisotropies for both cases. We then use the Alfvén Mach number for comparison.
We analyzed data for five bow shock crossings in October 2017. For all events, the difference in downstream Aflvén Mach number between observations and theory is larger than observational errors. We discuss the importance of downstream temperature anisotropy in the shock jump conditions. We also investigate the relative significance of possibly effective downstream parameters: heat flux due to shock-accelerated particles and energetic particles escaping from the magnetosphere, and magnetic field pressure originating from downstream turbulence.

Keywords: collisionless shock, shock jump conditions, in-situ observations, Bow Shock

