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Nonlinear Interaction of the Solar Wind with Earth's Bow Shock

George Parks (1), Zhongwei Yang (2), Ying Liu (2), Ensang Lee (3), Naiguo Lin (1), Suiyan Fu (4), Jinbin Cao (5), Patrick Canu (6), Iannis Dandouras (7), Henri Reme (7), and Melvyn Goldstein (8)

(1) UC Berkeley, Space Sciences Laboratory, Berkeley, United States (parks@ssl.berkeley.edu), (2) NSSC, CAS, Beining, China, (3) Kyunghee University, Suwon, Korea , (4) Peking University, Beijing, China , (5) Beihang University, Beijing, China , (6) Ecole Polytechnique, Paris, France , (7) University of Toulouse, Toulouse, France, (8) NASA, GSFC, Greenbelt, MD

The bow shock is the best-known collisionless shocks in nature. We have known from early on that the solar wind (SW) interaction with the bow shock produces gyrating and reflected particles. Some of these particles travel back into the upstream region, perturb the oncoming SW, and excite a host of nonlinear structures including hot flow anomalies, foreshock cavities and density holes. We have examined these nonlinear structures using data from 2003 when the four Cluster satellites were in a string-of-pearl configuration. We find that the nonlinear structures are evolving as they are convected with the solar wind toward Earth producing many shock-like features similar to those at the bow shock. Full 1D PIC simulation has reproduced many of the features, but the simulation requirements are different from observations. For example, the simulation shows that directly transmitted SW occurs only when the Mach number is small (sub-critical shocks). However, observations show that SW particles can penetrate the bow shock even in super-critical perpendicular shocks. This talk will discuss the new observations and simulation results with emphasis on understanding the SW dissipation mechanisms across the bow shock.