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New Observations of Solar Wind Interaction with Earth's Bow Shock

George Parks, ensang lee, zhongwei yang, ying liu, suiyan fu, iannis dandouras, henri reme, patrick canu, and melvyn goldstein

UC Berkeley, Space Sciences Laboratory, Berkeley, CA, United States (parks@ssl.berkeley.edu)

The mass, charge and energy dependence of the SW interaction with the bow shock was studied from early days of HEOS-1 and ISEE (Formisano et al, 1970; Peterson et al., 1979). These observations have shown that while thermalization of H+ occurs across the boundary, sometimes the SW He++ ions are found with unchanged energy spectra downstream of the shock inside the magnetosheath and that both SW H+ and He++ beams could be found in the downstream magnetosheath with the same bulk velocities. These studies however used He++ data accumulated over 30 minutes and since the SW dynamics include much faster time variations the results are likely affected by spatial and temporal variations. Moreover, it was not known at that time that the plasma in the neighborhood of the bow shock often include the reflected, gyrating and particles leaking out of the magnetosheath (Skopke et al., 1982; Thomsen et al., 1985) and since these particles occupy different parts of the velocity space, they can significantly affect the SW velocity and temperature computed from first and second velocity moments. To alleviate these problems, a microprocessor-controlled SW plasma experiment was designed and flown on Cluster that selects only particles near the peak energy of the SW distribution, thereby minimizing contamination from the other particles (Rème et al., 2001). We have studied $\sim$110 shock crossings upstream and downstream of the quasi-perpendicular and quasi–parallel bow shock regions and find that in 44 cases the SW beams crossed the shock retaining much of their upstream features. On average the temperature of upstream SW H+ ions was $\sim$4 eV and in the magnetosheath $\sim$4.2 eV, indicating there was little or no heating of the SW going across the bow. The He++ ions have temperatures typically 4 times that of H+ ions in the SW a value consistent with equipartition of energy. Unlike H+ ions, He++ ions very often do not slow down going across the shock. These observations indicate that the SW interaction with the bow shock is much more complicated than existing models predict and they are important constraints for developing new models.