Analyzing Earth's Bow Shock Compression Ratio With Magnetohydrodynamic Limits

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The project was the study of Earth’s bow shock compression ratio. The bow shock is a collisionless shock that occurs when supersonic plasma interacts with planetary objects. The role of bow shocks is to dissipate the incoming solar wind radiation; thus protecting humans from deadly energized plasma. With collisionless shocks, an upstream plasma flow exists before the shock and a downstream plasma flow occurs across the shock which results in an abrupt increase in density, temperature, pressure, and a decrease in velocity. Bow shocks follow magnetohydrodynamics(MHD). Equations derived from MHD are made to predict the compression ratio by its Mach number and adiabatic index. This equation restricts the downstream density to never be more than 4 times greater than the upstream density. The project explores the possibility that collisionless shocks may not follow the MHD. The Magnetospheric Multiscale(MMS) NASA’s four space probes orbiting Earth were utilized to gather data shortly before and after the bow shock. A significant number of ratios were above the restriction of the equation with statistical significance; i.e. the ratio of downstream density to upstream density was greater than 4. The conclusion supports the possibility that collisionless shocks may not follow MHD behavior. The reasoning may be our limited understanding of plasma physics however, many factors must be tested to verify such deviation. This possibility is important in the astrophysical, heliospheric, and magnetospheric understanding of our universe as these shocks are very abundant in space.

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