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Electron heating at Saturn's bow shock

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Collisionless shock waves are a widespread phenomenon in both solar system and astrophysical contexts. The nature of energy dissipation and particle acceleration at such shocks is of particular interest, especially at high Mach numbers. We use data taken by the Cassini spacecraft to investigate electron heating at Saturn's bow shock, one of the strongest collisionless shocks encountered by spacecraft to date. Measurements of the upstream solar wind ion parameters are scarce due to spacecraft pointing constraints and the absence of an upstream monitor. To address this we use solar wind speed predictions from the Michigan Solar Wind Model. An analysis of a set of 94 Cassini crossings of Saturn's bow shock reveals a positive correlation between the electron temperature increase across the shock and the kinetic energy of an incident proton, where electron heating accounts for between $\sim$3% and $\sim$7% of this incident ram energy. This percentage decreases with increasing Alfvén Mach number, a trend that we confirm continues into the hitherto poorly explored high Mach number regime, up to an Alfvén Mach number of $\sim$150. This work reveals that further studies of the Saturnian bow shock will bridge the gap between the more modest Mach numbers encountered in near-Earth space and more exotic astrophysical regimes where shock processes play central roles, potentially shedding light on the nature of particle acceleration at collisionless shocks.