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Energetic Electrons as Evidence for a Temporary Bow Shock at Ceres

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The Gamma Ray and Neutron Detector (GRaND) of the Dawn spacecraft observed bursts of energetic particles in its exterior scintillators during Survey orbit when Dawn was at a distance of ~10 Ceres radii from the planet. Despite the onset of the bursts being coincident with a solar proton event, the particles do not come from the solar direction. Instead, they are observed when Ceres is within the field of view of the detectors, indicating the electrons are streaming away from the planet. The electrons are found to be highly energetic with energies between 20-100 keV and last ~20 minutes each burst. Over a period of 10 days, they repeatedly occur in specific locations in the Ceres Solar Orbital coordinate system suggesting their source is controlled by the solar wind interaction with the body. Here we hypothesize that the solar proton event caused enhanced sputtering at the surface creating a temporary bow shock via mass loading as the sputtered atoms were ionized and picked up by the solar wind. Energetic electrons would then be detected as bursts as Dawn transected the electron foreshock. This could explain the temporal behavior, flux, and energy of the electrons. We use a single fluid magnetohydrodynamic model to test the transient atmospheric density and bow shock size that would be needed to replicate the geometry of the electrons.