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Electron acceleration and plasma frequency waves at the bow shock and electron foreshock

Daniel Graham (1), Yuri Khotyaintsev (1), Andris Vaivads (1), Mats Andre (1), Per-Arne Lindqvist (2), Barbara Giles (3), Christopher Russell (4), James Burch (5), Robert Ergun (6), and Roy Torbert (7)

(1) Swedish Institute of Space Physics, Uppsala, Sweden (dgraham@irfu.se), (2) Space and Plasma Physics, School of Electrical Engineering, KTH Royal Institute of Technology, Stockholm, Sweden., (3) NASA Goddard Space Flight Center, Greenbelt, MD, USA., (4) Department of Earth and Space Sciences, University of California, Los Angeles, CA, USA., (5) Southwest Research Institute, San Antonio, TX, USA., (6) Laboratory of Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA. , (7) Space Science Center, University of New Hampshire, Durham, NH, USA.

At Earth's quasi-perpendicular bow shock electrons can be accelerated to high velocities to form electron beams. These electrons can excite Langmuir and beam-mode waves in the electron foreshock region. These waves can then be converted to radio waves via linear or nonlinear processes. Previous results have shown that quasi-perpendicular shocks can have complicated structures, such as ripples at MHD and ion kinetic scales. These structures can potentially modify electron acceleration and formation of electron beams in the electron foreshock.
We investigate electron acceleration and the formation of beams at Earth's quasi perpendicular bow shock using the Magnetospheric Multiscale (MMS) mission, and the properties of the Langmuir and beam-mode waves excited in the electron foreshock region using the three-dimensional electric field. Preliminary results show that the electron beams just upstream of the bow shock are often intermittent, suggestive of a highly dynamic bow shock. Statistical results of the electric fields show that distinct spectral peaks near the plasma frequency are often observed, suggestive of simultaneous observation of beam-mode and Langmuir waves or nonlinear electrostatic decay. In addition, the electric fields often have large perpendicular components suggestive of low wavenumber Z-mode-like waves, which indicates that linear mode conversion may be a viable source of radio waves.