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Observations of Circularly Polarized Magnetic Fields Associated with Electron Holes

Konrad Steinvall (1,2), Daniel B. Graham (1), Yuri V. Khotyaintsev (1), Andris Vaivads (1), Per-Arne Lindqvist (3), Robert E. Ergun (4), Olivier Le Contel (5), Christopher T. Russell (6), Roy B. Torbert (7), and James L. Burch (8)

(1) Swedish Institute of Space Physics, Uppsala, Sweden (konrad.steinvall@irfu.se), (2) Space and Plasma Physics, Department of Physics and Astronomy, Uppsala University, Uppsala, Sweden, (3) KTH Royal Institute of Technology, Stockholm, Sweden, (4) Laboratory of Atmospheric and Space Physics, University of Colorado, Boulder, USA, (5) Laboratoire de Physique des Plasmas, CNRS/Ecole Polytechnique/Sorbonne Université/Univ. Paris-Sud/Obs. de Paris, Paris, France, (6) Department of Earth and Space Sciences, University of California, Los Angeles, California, USA, (7) University of New Hampshire, Durham, New Hampshire, USA, (8) Southwest Research Institute, San Antonio, Texas, USA

Electron Holes (EHs) are nonlinear positively charged structures frequently observed in space plasmas. They are localized holes in electron phase-space, manifesting themselves as bipolar solitary waves in electric field measurements. By trapping and heating electrons, EHs play an important role in plasma dynamics. Simulations have found EHs Cherenkov-emitting electromagnetic whistler waves in the reconnection region, which in turn was shown to increase the rate of magnetic reconnection. Previous studies have reported magnetic field signatures associated with the EHs and attributed them to the Lorentz transform of the electric field and $\mathbf{E} \times \mathbf{B}$ drifting electrons generating a current and an equivalent magnetic field.

We report observations of fast electromagnetic EHs made in the magnetotail reconnection region by the Magnetospheric Multiscale mission. We apply multi-spacecraft analysis to estimate the properties of the EHs, including the magnetic field generated by the $\mathbf{E} \times \mathbf{B}$ drifting electrons. We find that the EHs have localized, right hand polarized magnetic fields associated with them, inconsistent with the aforementioned source mechanisms. Typically, these fields are either monopolar or bipolar, and are confined within the EHs. In a few cases however, the magnetic field takes on a more whistler wave-like character and up to four wave periods are observed. Additionally, these whistler-like fields extend outside of the EH, forming a tail before quickly disappearing, suggesting strong wave damping. Preliminary results show that the Cherenkov condition is satisfied. We discuss possible generation mechanisms of the magnetic fields associated with EHs.