Electron Heating by Parallel Electric Fields in Magnetotail Reconnection

L. Richard[1], Yu. V. Khotyaintsev[1], C. Norgren[1], K. Steinvall[2], D. B. Graham[1], J. Egedal[3], A. Vaivads[4,5], R. Nakamura[6]

[1] Swedish Institute of Space Physics, Uppsala 751 21, Sweden
[2] Department of Physics, Chalmers University of Technology, Göteborg 412 96, Sweden
[3] Department of Physics, University of Wisconsin-Madison, Madison, Wisconsin 53706, USA
[4] Division of Space and Plasma Physics, KTH Royal Institute of Technology, Stockholm 100 44, Sweden
[5] Ventspils University of Applied Sciences, Ventspils 3601, Latvia
[6] Space Research Institute, Austrian Academy of Sciences, Graz 8042, Austria

Magnetic reconnection is a ubiquitous collisionless plasma process that converts electromagnetic energy to heating and accelerating ions and electrons. Understanding how charged particles are heated during magnetic reconnection is essential for explaining the energy release in the Universe's most powerful energy sources and magnetized plasma devices such as tokamaks. In particular, large-scale magnetic field-aligned electric fields, a characteristic feature of magnetic reconnection, are thought to play an important role in electron heating. However, the exact role, nature, and importance of such parallel electric fields in electron heating remains debated.

We use data from the Magnetospheric Multiscale (MMS) mission to study electron heating by parallel electric fields during magnetic reconnection in the Earth's magnetotail. We show that the parallel electric fields scale with the inflow Alfvén and thermal speeds to maintain macroscopic quasi-neutrality in the plasma. In addition, we find that the work done by the parallel electric fields on the electrons can reach up to ten times the electrons' initial temperature. Our results demonstrate that parallel electric fields play a major role in electron heating and the ion-to-electron energy partition during magnetic reconnection.