# High-speed electron flows and the associated plasma waves in the Earth magnetotail

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**Abstract**

High-speed electron flows (HSEFs) carry intense current, which play a significant role in the energy dissipation and conversion processes in the Earth space. Previous studies have revealed that HSEFs can drive various types of plasma waves and plasma instabilities, affecting the electron-scale dynamics. Until now, the existence, spatial distribution, general properties of the HSEFs, general features of the plasma waves in the HSEFs, and their relationship with the HSEFs are still unknown. Here, we conduct a comprehensive survey of the HSEFs and the associated plasma waves in the Earth magnetotail, utilizing NASA's Magnetospheric Multiscale (MMS) mission observations from 2017 to 2021. A total of 642 HSEFs characterized by electron bulk speeds exceeding 5000 km/s are identified. The main statistical properties of the HSEFs and plasma waves are: (1) HSEFs exhibit a strong dawn-dusk (30%-70%) asymmetry. (2) The HSEFs are widely observed in the plasma sheet (39.6%), plasma sheet boundary (PSBL, 29.0%), and lobe regions (31.4%), respectively. In the plasma sheet, they move arbitrary directions regarding the ambient magnetic field, while in the rest regions, they are mainly field aligned. (3) Only 38.3% and 43.3% of the HSEFs are associated with enhanced parallel and perpendicular electric field fluctuations, respectively. (4) For the parallel electric field fluctuations, 60% of them have their frequencies between 0.1 and 1 electron cyclotron frequency, which may be attributed to electrostatic solitary waves driven by electron two-stream instability. (5) For the perpendicular electric field fluctuations, 76.6% of them have their frequencies concentrated around low hybrid frequency, possibly related to the density depletion at the speed peak of HSEFs. Our study reveals that the HSEFs are closely associated with magnetic reconnection and may directly link the exploring site in the magnetotail and the disturbed ionospheric regions, contributing a deeper understanding of HSEFs in collisionless plasma.

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