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High-speed electron flows in the Earth magnetotail

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High-speed electron flows play a significant role in the energy dissipation and conversion processes within the terrestrial magnetosphere, particularly in regions associated with magnetic reconnection, such as the vicinity of electron diffusion regions (EDRs)[1,2] and separatrix layers[3]. NASA's Magnetospheric Multiscale (MMS) mission was specifically designed to reveal electron-scale kinetic processes occurring in Earth's magnetosphere. Statistical studies have demonstrated that the importance of the fast electron flows in the kinetic processes and dynamic structures.[4]

However, due to the extremely low-density feature of magnetotail, the high energy particles and solar ultra-violet emission can regularly cause severe contaminations to the MMS FPI ion and electron measurements. In this study, we compute the partial moments of ions and electrons from the three-dimensional velocity distribution function and conduct a comprehensive survey of high-speed electron flows in the terrestrial magnetotail, utilizing MMS observations spanning from 2017 to 2021. Our analysis identifies a total of 642 events characterized by electron bulk speeds exceeding 5,000 km/s. Notably, these events exhibit a clear dawn-dusk asymmetry, with 73% of them occurring in the dusk magnetotail. Along the magnetotail's normal direction, we find that 37.7%, 21.8%, and 40.5% of the events are located in the plasma sheet, plasma sheet boundary layer, and lobe region, respectively. The occurrence rate of these events peaks when the magnetic field strength is approximately 19 nT. High-speed electrons predominantly move along magnetic field lines in the plasma sheet boundary layer and lobe region, while in the plasma sheet, they traverse along arbitrary directions with respect to the magnetic field. Our study contributes to a deeper understanding of the complex electron dynamics under various plasma and magnetic field conditions within Earth's magnetotail.

References

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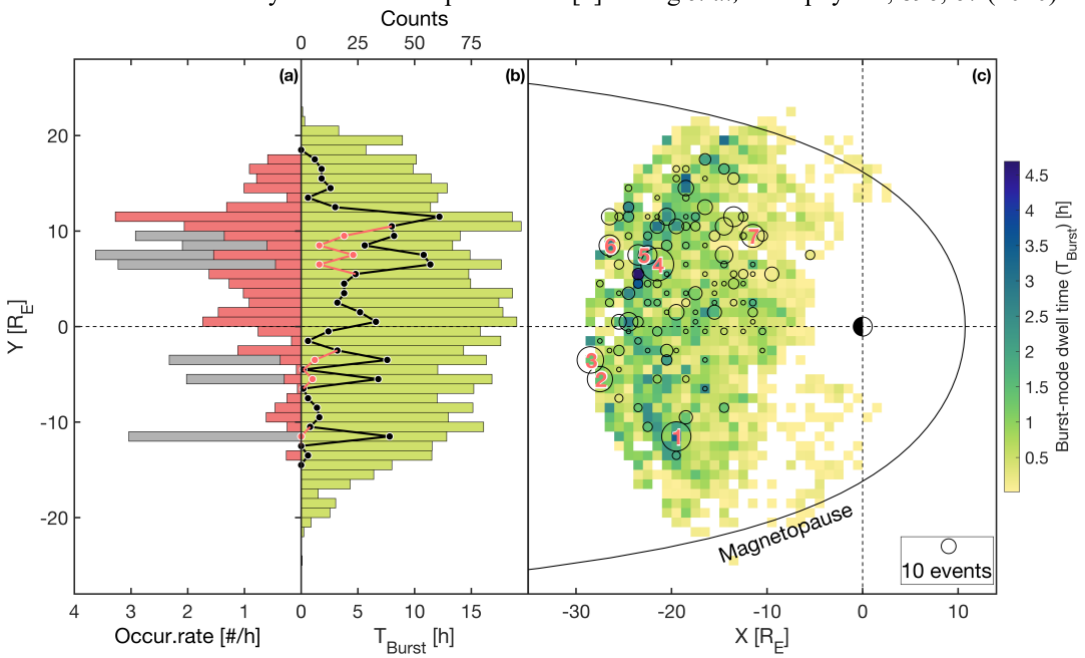

Figure1. Dawn-dusk asymmetry of the HSEF events. (a) Histogram of HSEF occurrence rate along the Y direction. (b) HSEF event counts and histogram of MMS burst-mode dwell time T_{Burst}. (c) HSEF event counts and 2D histogram of T_{Burst} in the GSE X-Y plane. The black curve shows the nominal magnetopause position and the circle area represent event counts. The numbers (1-7) highlight continuous events (>20) within one-orbit observations. The black/red histogram in (a) and line in (b) represent the results of the total events and without those continuous events.