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Global Characteristics of Cold Protons Around Midnight in the Magnetotail: MMS/HPCA observations

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We investigate plasma transport to and plasma heating in the plasma sheet in the noon-midnight meridian, characterizing protons with temperature colder than the core plasma sheet protons (<700 eV). We extract the density and temperature of the cold protons from velocity distribution functions measured by the HPCA (Hot Plasma Composition Analyzer) instrument on board the MMS (Magnetospheric Multiscale) spacecraft in the radial distance (r) of 6 – 25 Re, performing two-component Maxwellian fits. We selected time intervals with no fast flow (>70 km/s) observed, to examine the characteristics of magnetotail plasma not directly affected by magnetic reconnection and associated phenomena. In the region of r >~ 10 Re, the two-component populations are identified more frequently near the plasma sheet boundary than the central plasma sheet. The cold component density peaks near the boundary, in contrast to the hot components which display high density near the central plasma sheet. These characteristics suggest that cold protons are convected from the lobe and then efficiently heated and mixed with the plasma sheet hot plasma near the lobe-plasma sheet boundary. The statistical features of the extracted cold components indicate that, in the tailward regions (r >~ 20 Re), temperature increases with decreasing vertical distance from the plasma sheet (represented by plasma β) in a similar trend to the hot components. In the near-Earth plasma sheet (r <~ 15 Re), cold proton temperature is lower at higher-β regions; the density decreases as increasing r. These features suggest that cold protons in the near-Earth plasma sheet are of ionospheric origin, transported to the plasma sheet in the closed magnetic field configuration.

Reference:
Keika, K., Asami, R., Hoshino, M., & Fuselier, S. A. (2022). Global characteristics of cold protons around midnight in the magnetotail: Implication for efficient heating and origin. Journal of Geophysical Research: Space Physics, 127, e2021JA029576. https://doi. org/10.1029/2021JA029576