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The structure of parallel electric fields in collisionless plasmas: ionosphere and magnetospheric observations

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It was long believed that electric fields parallel to the background magnetic field could not exist in a collisionless plasma. Ionospheric rocket observations of accelerated electrons in the Earth's aurora provided the first indirect evidence for the occurrence of a quasi-static parallel potential drop. The S3-3 satellite obtained the first direct measurements of the parallel electric field, including observations of solitary waves, double layers and oblique double layers. Data from the FAST and Polar satellites dramatically enhanced understanding of the structure of parallel electric fields in both the upward and downward field-aligned current regions in the auroral zone and their role in acceleration of electrons and ions to high energies. Parallel electric fields are also observed higher altitudes in the magnetosphere in association with narrow boundaries and with reconnection at the magnetopause and magnetotail. I will review satellite observations and recent simulations with a focus on the occurrence of large potential drops in small-scale size nonlinear structures and summarize our current understanding of parallel electric fields in the Earth's magnetosphere and implications for particle acceleration and dissipation processes in other astrophysical plasma systems.