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Observations of Flux Ropes Associated With Magnetic Reconnection in the Earth's Magnetosphere

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Magnetic reconnection is a fundamental physical process that enables the rapid transfer of magnetic energy into plasma kinetic and thermal energy in the laboratory, astrophysical and space plasma. Flux ropes have been suggested to play important role in controlling the micro-scale physics of magnetic reconnection and electron acceleration. In this presentation, we will show the observations of flux ropes associated with magnetic reconnection in the magnetotail based on the Cluster and MMS multi-spacecraft data. Firstly, two consecutive magnetic flux ropes, separated by less than 30 s ($\Delta t < 30$ s), are observed within one magnetic reconnection diffusion region without strong guide field. In spite of the small but non-trivial global scale negative guide field ($-By$), there exists a directional change of the core fields of two flux ropes, i.e. $-By$ for the first one, and $+By$ for the second one. This is inconsistent with any theory and simulations. Therefore, we suggest that the core field of flux ropes is formed by compression of the local preexisting By. Secondary, we will present *in-situ* observations of a small scale flux rope locally formed at the separatrix region of magnetic reconnection without large guide field. We suggest that this flux rope is locally generated at the separatrix region due to the tearing instability within the separatrix current layer. Thirdly, an ion-scale flux rope, embedded in a high-speed electron flow (possibly an electron vortex), is investigated in the magnetotail using observations from the MMS spacecraft. Intense electric field and current and abundant waves are observed in the exterior and interior regions of the flux rope. Electron demagnetization occurs in some sub-regions of the flux rope. It is surprising that strong dissipation ($\boldsymbol{J}\cdot\boldsymbol{E}'$ up to 2000 pW/m^3) occurs in the center of the flux rope without signatures of secondary reconnection or coalescence of two flux ropes, implying that flux rope may provide another important channel for energy dissipation in space plasmas. These features indicate that the observed flux rope is still highly dynamical, and hosts multi-scale coupling processes, even though the flux rope has a very large scale and is far away from the reconnection site.

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