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MMS observations of coherent structures in the turbulent magnetosheath plasma

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Thanks to the unprecedented high time resolution data of the MMS mission, we identified two types of coherent structures in the turbulent magnetosheath plasma.

The first one is ion-scale magnetic island/flux rope. The magnetic island is characterized by bipolar variation of magnetic fields with magnetic field compression, strong core field, density depletion and strong currents dominated by the parallel component to the local magnetic field. Distinct particle behaviors and wave activities inside and at the edges of the magnetic island are observed: parallel electron beam accompanied with electrostatic solitary waves and strong electromagnetic lower hybrid drift waves inside the magnetic island; bidirectional electron beams, whistler waves, weak electromagnetic lower hybrid drift waves and strong broadband electrostatic noise at the edges of the magnetic island. Our observations demonstrate that highly dynamical, strong wave activities and electron-scale physics occur within ion-scale magnetic islands in the magnetosheath turbulent plasma.

The second one is electron vortex magnetic hole. The magnetic hole is characterized by a magnetic depression, a density peak, a total electron temperature increase (with a parallel temperature decrease but a perpendicular temperature increase), and strong currents carried by the electrons. The current has a dip in the core region of the magnetic hole and a peak in the outer region of the magnetic hole. There is an enhancement in the perpendicular electron fluxes at 90° pitch angles inside the magnetic hole, implying that the electrons are trapped within it. The variations of the electron velocity components Vem and Ven suggest that an electron vortex is formed by trapping electrons inside the magnetic hole in the circular cross-section. These observations demonstrate the existence of a new type of coherent structures behaving as an electron vortex magnetic hole in turbulent space plasmas as predicted by recent kinetic simulations.