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Identifying 3-D Vortex using Magnetospheric Multiscale mission

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Identifying vortices is the key to understanding the turbulence in plasma shear layers. Though no precise mathematical definition of a vortex is accepted universally, several vortex identification methods using Galilean invariance are proposed by researchers. By using the MMS (Magnetospheric multiscale) satellite ion velocity data, we linearly interpolate the velocity data and obtain its rate of distortion tensor, and linearly approximate the velocity field. In order to identify 3-D vortex using MMS, we use the vortex identification criteria that satisfies Galilean invariance as follows: (i) the first criterion is Q-criterion that defines vortices as regions in which the vorticity energy prevails over other energies; (ii) the second criterion is the $\lambda 2$-criterion that is related to the minus eigenvalue of the Hessian matrix of the pressure terms; and (iii) the third criterion called the geometrical line-type method requires the existence of Galilean-invariant vortex core inside the satellite tetrahedral regions. Using these method, we identify vortices in a Kelvin-Helmholtz event on 8 September 2015 by the MMS mission. The results show that 23 vortices are observed where 13 vortices are right rotations and 10 are left rotation.