Identifying Vortex Core and Extremum Lines using four Satellites based on Field Topology

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Identifying vortices are the key to understanding the turbulence in plasma shear layers. Here, the term ‘vortex’ **or** ‘vortex core’ is associated with a region of Galilean invariance [*Jeong and Hussain*, 1995]. Unfortunately, no single precise definition of a vortex is currently universally accepted, despite the fact that many space plasma authors claim that many observations have detected “vortices” (**as** Kelvin-Helmholtz vortices at/around the magnetopause). By using the four satellite velocity data, and Taylor series, we expand the velocity data around the satellites, calculate its first order tensor, and linearly approximate the field. We can identify the vortex structures by using various vortex identification criteria as follows: (i) The first criterion is Q-criterion that defines vortices as regions in which the vorticity energy prevails other energies; (ii) the second criterion is the lambda2-criterion that is related to the minus of the Hessian matrix of the pressure related term; and (iii) the third criterion requires the existence of vortex-core-lines that is the Galilean invariance inside the four satellite tetrahedral region. Using these methods, we can identify and analyze more precisely the 3D vortex using tetrahedral satellite configuration. In the field topology theory, the extremum lines (X-lines) that are other manifolds corresponds to different eigenvalues also can be identified using the same method.

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