Geophysical Research Abstracts
Vol. 18, EGU2016-1806, 2016
EGU General Assembly 2016

Three-dimensional turbulence structure in space and astrophysical plasmas

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Plasma turbulence appears in the solar wind and around the Earth bow shock, and serves as an ideal natural laboratory for studying turbulence structure, mechanisms of energy cascade and dissipation, and particle energization. Understanding dissipation mechanisms and particle energization is relevant to astrophysical applications such as accretion disks, interstellar medium, and supernova explosions. Our knowledge on turbulence structure and dissipation mechanisms has been advanced so much through the past decade thanks to multi-point measurements in space. Using the Cluster measurements in the solar wind, the three-dimensional filamentary structure of solar wind turbulence has experimentally been revealed from magnetohydrodynamic scales (at about 1,000 to 10,000 km) down to ion kinetic scales (at about 100 km). The filamentation process has also been confirmed by hybrid simulations of ion-kinetic turbulence. Based on a review of filamentation process, wave modes, spectral anisotropy models from the Cluster observations and the hybrid simulations, observational scenarios for understanding particle energization process for the THOR mission concept (Turbulence Heating Observer) are discussed.