Taylor hypothesis at electron scales and its effects on measured energy spectra onboard spacecraft

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Abstract

The solar wind is a natural laboratory for the study of turbulent plasma. *In-situ* observations from different spacecraft such as STEREO, Wind, ACE or Cluster allow us to investigate turbulence from magnetohydrodynamic (MHD) to kinetic scales (sub-ion and electron scales) of solar wind turbulence. With single spacecraft observations the Taylor frozen-in-flow assumption ($V_\phi << V_{sw}$, V_ϕ is the phase speed of the fluctuations) is usually used to infer spatial (i.e., wavenumber) spectra from the temporal (i.e., frequency) ones measured onboard the spacecraft. While this assumption is generally valid at MHD scales, its validity at electron scales is questionable because of the possible presence of fluctuations having high phase speeds (e.g., whistler or parallel Alfvén waves). In this study we use a simple method to test the validity of Taylor hypothesis in solar wind turbulence at electron scales using the FGM and the STAFF data of the Cluster mission. We show that a significant fraction of the observed spectra violates the Taylor hypothesis. Furthermore, we introduce a toy model to investigate the effects of violating of the Taylor hypothesis on the slopes of the turbulent spectra. From different possible propagation angles and solar wind speeds we show that the slopes vary only slightly in the inertial range, while they vary significantly in the dispersive range. These simulations results can explain the narrow (resp. broader) distribution of the slopes in the inertial (resp. dispersive) range observed in the solar wind.