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Power Anisotropy, Dispersion Signature and Diffusion Region in the 3D Wavenumber Domain of Space Plasma Turbulence

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We explore the multi-faceted important features of turbulence (e.g., anisotropy, dispersion, diffusion) in the three-dimensional (3D) wavenumber domain (k, k_{perp1}, k_{perp2}), by employing the k-filtering technique to the high-quality measurements of fields and plasmas from multi-spacecraft constellation (i.e., MMS). We compute the 3D power spectral densities (PSDs) of magnetic and electric fluctuations (marked as PSD(δB(k)) and PSD(δE'‹v_i›(k))), both of which show prominent spectral anisotropy in the sub-ion range. We calculate the ratio between PSD(δE'‹v_i›(k)) and PSD(δB(k)), the distribution of which is related with nonlinear dispersion relation. We also compute the ratio between electric spectra in different frames of ion flow, that is PSD(δE'local v_i)/PSD(δE'‹v_i›), to demonstrate the turbulence ion diffusion region (T- IDR) in the wavenumber space. The T-IDR has an anisotropy and a preferential direction of wavevectors, which is generally consistent with the plasma wave theory prediction based on the dominance of kinetic Alfvén wave (KAW). This work manifests the worth of the k-filtering technique in diagnosing turbulence comprehensively, especially when the electric field is involved.