Spectral features and energy cascade of plasma turbulence at sub-ion scales

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Thanks to accurate *in situ* solar wind (SW) observations, it is now clearly established that the turbulent magnetic field spectrum follows a Kolmogorov-like scaling $\sim k^{-5/3}$ at MHD scales and steepens below ion scales, where a different power law develops, with a scaling exponent varying between -2 and -4. Recent satellite measurements revealed the presence of a second spectral break at electron scales, where the magnetic field spectrum decreases exponentially. This trend is described by the *exp* model $\sim k^{-8/3}\, exp(-\rho_e\, k)$, where ρ_e is the electron gyroradius. This model was extensively tested on SW data and appears to be a solid feature of the turbulent magnetic field at sub-ion scales [1].

Here we present a study of the spectral properties of the turbulent cascade at sub-ion scales realized by means of a fully kinetic energy conserving particle-in-cell simulation of plasma turbulence. We find that the magnetic field spectrum is accurately described by the *exp* model $k^{-\alpha}\, exp(-\lambda\, k)$ at kinetic scales, with an exponential range starting around $k\,\rho_e \simeq 1$. The same exponential decay is observed for the electron velocity spectrum but not for the ion velocity spectrum, that drops like a steep power law before reaching electron scales. The development of these spectral features is analyzed in terms of the high-pass filtered electromagnetic work $\mathbf{J}\cdot\mathbf{E}$ and pressure-strain interaction $-\mathbf{P}:\nabla\mathbf{u}$ of both electrons and ions. We find that the electrons are the main responsible for the formation of the exponential range and for the dissipation of the magnetic energy that is first converted into electron fluid flow energy and finally into internal energy via the pressure-strain interaction, accounting for the electron heating [2].

References

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