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Solar wind turbulent cascade between ion and electron scales and quasi-parallel whistler waves

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The solar wind is probably the best laboratory to study turbulence in astrophysical plasmas. In addition to the presence of a magnetic field, the differences with neutral fluid isotropic turbulence are: (i) weakness of collisional dissipation and (ii) presence of several characteristic space and time scales. Here we focus on the observational properties of the solar wind magnetic field turbulence around ion and electron characteristic scales. Around ion scales, magnetic spectra are variable and ion instabilities occur as a function of the local plasma parameters. Between ion and electron scales, a small scale turbulent cascade seems to be established, with wave vectors $k_\perp$ mainly perpendicular to the average B field. It is characterised by a well defined power-law spectrum in magnetic and density fluctuations with a spectral index close to -2.8. Approaching electron scales, the fluctuations are no more self-similar: an exponential cut-off is usually observed indicating an onset of dissipation. The small scale inertial range between ion and electron scales and the electron dissipation range can be together described by $\sim k_\perp^{-\alpha} \exp(-k_\perp \ell_d)$, with $\alpha \simeq 8/3$ and the dissipation scale ℓ_d close to the electron Larmor radius $\ell_d \simeq \rho_e$. The nature of this small scale cascade and a possible dissipation mechanism are still under debate. Different spectra are however observed in some regions of the solar wind, with quasi-parallel whistlers between the lower hybrid frequency and about half the electron cyclotron frequency. Such whistler waves may have variable intensity with respect to the background turbulence. Consequently, the total magnetic spectra may present a break, a knee or a more or less intense bump around frequencies at which whistlers propagate. We discuss a possible generation mechanism of quasi-parallel whistler waves in the solar wind.