Turbulence in the solar wind, spectra from Voyager 2 data

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A description of the spectrum of the solar wind has not been fully established, in particular in the outermost part of the helioshpere where, beyond the termination shock, the solar wind interacts with the interstellar medium. This work shows the solar wind spectra deduced from the data recorded by the Voyager 2 mission, which allows us to resolve the velocity and particle density fluctuations between 10^-5 and 4x10^-3 Hz, i.e. in the MHD inertial range of solar wind. We used two data sets: 1979 data, acquired when Voyager was at about 5 astronomical units from the sun, and 2007-2013 data when it crossed the termination shock and enters the heliosheat. These data are incomplete time series, more lacunous as the craft moves away from the sun (45% missing data in 1979, 97% in 2012). We have estimated the spectra by extracting almost complete subsets and filling small gaps, up to three consecutive missing data, with polynomial interpolation. Then, a global DFT for irregularly spaced data is also used. The 1979 data show a nice power law fit. The exponents, -1.63, -1.57 and -1,52 for the radial, equatorial and polar velocity components respectively, show the presence of anisotropy, but are suggestive of a Kolmogorov-like inertial range. Preceded by a small bump in the equatorial and polar components only, there is a gradual steepening of the spectrum above 3x10^-4 Hz, which resembles the behaviour of plasma turbulence at the transition between MHD and kinetic ranges [Koval-Szabo 2013, Richardson et al,1995]. The 2007-2013 data, too sparse, have been preprocessed by a low rank matrix completion reconstruction technique [Pillai et al,2012]. These preliminary results have been analyzed by introducing the sequence of gaps observed in the Voyager data to velocity datasets extracted from direct numerical simulations of incompressible Navier-Stokes turbulence as well as synthetic turbulence and by comparing the relevant spectra.