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Evolution of Fourier spectra through interplanetary shocks

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Well established nearly isothermic solar wind expansion requires an additional heating. A dissipation of large scale variations of the solar wind kinetic energy into the thermal energy via turbulence cascades is thought to be an important source of this heating, although the exact mechanism is yet to be found. For this reason, the turbulence in the solar wind is a subject of extensive theoretical and experimental studies on different time scales ranging from years to minutes. The frequency spectrum of magnetic field fluctuations can be divided into several domains differing by spectral indices — the lowest frequencies are controlled by the solar activity, MHD activity shapes the spectrum at higher (up to 0.1 Hz) frequencies, whereas the ion and electron kinetic effects dominate at the high frequency end of the spectra.

Interplanetary shocks of various origins are a part of solar wind turbulence naturally occurring in the solar wind and the BMSW instrument onboard the Spektr-R spacecraft has detected tens of them in course of the 2011–2013 years. Based on its high-time resolution of the ion flux, density and velocity measurements reaching 31 ms, we study an evolution of the frequency spectra on MHD and kinetic scales across fast forward low Mach number shocks.

We have found that the power of downstream fluctuations rises by an order of magnitude in a broad range of frequencies independently of its upstream value but the slope of the spectrum on the kinetic scale ($\approx$3–8 Hz) has been found to be statistically steeper downstream than upstream of the shock. The time needed to a full relaxation to the pre-shock spectral shape is as long as several hours. A combination of the ion flux power spectra obtained by BMSW with fast magnetic field observations of other spacecraft enhances our understanding of dissipation mechanisms.