Incompressible and compressible energy cascade rates in the inner heliosphere

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Compressible turbulence has been a subject of active research within the space physics community for the last three decades and is actually believed to be essential for understanding the physics of the solar wind (for instance the heating of the fast wind), of the interstellar medium (in cold molecular clouds) and other astrophysical and space phenomena. In this talk I will give an overview of the different studies that we have done regarding the compressible and incompressible cascade rates in the interplanetary space. Firstly, using the exact law of compressible isothermal magnetohydrodynamic (MHD) turbulence [Banerjee & Galtier, PRE, 2013], we give an estimation of the compressible energy cascade rate (|εC|) in the Earth's magnetosheath using THEMIS and CLUSTER spacecraft data and show that it is at least three orders of magnitude larger than its value in the solar wind. Moreover, we show the role of the density fluctuations in increasing the spatial anisotropy in the Earth's magnetosheath [Hadid et al., PRL, 2018]. Secondly, using the exact law of compressible Hall MHD turbulence [Andrés & Sahraoui, PRE, 2017] we give a complete estimation of |εC | at the MHD and the sub-ion scales in the Earth's magnetosheath using MMS data [Andrés et al., PRL, 2019]. Finally we show the radial evolution of the turbulent cascade rate from the Sun (~0.2 A.U.) up to Mars (~1.5 A.U.), using Parker Solar Probe and Maven data [Andrés et al. 2022].