Recent progress in compressible plasma turbulence: theory and *in-situ* observations in the near-Earth space

S. Banerjee[1], L.Z. Hadid[2], S. Galtier[3], S.Y. Huang[4], F. Sahraoui[3]

[1] *Department of Physics, Indian Institute of Technology, Kanpur, India*

[2] *Swedish Institute of Space Physics, Uppsala, Sweden*

[3] *Laboratoire de Physique des Plasmas, Ecole Polytechnique, Univ. Paris-Sud, France*

[4] *School of Electronic Information, Wuhan University, Wuhan, China*

In situ measurements show that the solar wind temperature T exhibits a decrease with the heliocentric distance R in R^{-a}, with a<1 and 0.3AU < R < 50AU, which is significantly slower than an adiabatic cooling in $R^{-4/3}$. What is the source of heating? During the last decade, several studies have been devoted to this question by assuming that the main source of local heating is turbulence. The main idea is that the turbulent cascade provides a natural channel to transport the energy furnished by the Sun at the largest scales, down to the sub-ion scales where it is dissipated by some kinetic effects. No need to know precisely the kinetic mechanisms because we have to our disposal an inertial range at the MHD scales where exact statistical laws of turbulence can be used to extract the heating rate which identifies to the rate of energy transfer. To better understand this problem, the exact laws of turbulence have been generalized to compressible fluids. The new universal law for compressible isothermal MHD turbulence has been used as a model to evaluate the local heating in the fast and slow solar winds. Based on data collected by ESA's Cluster and NASA's THEMIS missions, the analysis reveals that the heating rates found are much greater than the values obtained previously when incompressible MHD was used. This new result gives a convincing explanation for the law T(R) reported above. Recently – and for the first time – this question of the local heating has been investigated for the Earth's magnetosheath which is highly compressible. The measures reveal that the heating rate is much greater (by a factor 100) than the one found in the compressible solar wind. New empirical power-laws are evidenced and relate the heating rate to the turbulent Mach number. These new findings have potential applications in distant astrophysical plasmas that are not accessible to *in situ* measurements.