Non-extensive approach to collisionless magnetic reconnection

Z. Vörös[1], M.P. Leubner[2], E. Yordanova[3]

[1]Institute of Physics, University of Graz, Austria and GGKIMTA Sopron, Hungary

[2]University of Innsbruck, Austria

[3]Swedish Institute of Space Physics, Uppsala, Sweden

Magnetic reconnection and turbulence represent key plasma physical processes in which energy transfer and conversion processes lead to non-adiabatic particle acceleration, heating, energy dissipation and bulk plasma motions. Since these multi-scale dynamical processes pump energy towards kinetic scales faster than the energy-redistribution time scales, particle populations seldom relax to a Maxwell-Boltzmann distribution. In heliospheric plasmas kappa-distributed non-equilibrium particle velocity distribution functions (VDFs) are widely observed, typically exhibiting anisotropies because of the presence of the magnetic field. The possible theoretical justification for kappa-distributed electron and ion VDFs in space plasmas is provided by entropy generalization procedures appearing within the frame of non-extensive systems exhibiting long-range interactions. In an effort to link the in-situ heliospheric particle VDFs with the theoretical (bi-)kappa or Maxwell-Boltzmann distributions, the (an-)isotropic VDFs were fitted by global models describing the entire distribution, or by partial fits, corresponding to the core and the suprathermal halo separately. This contribution is focusing on the thorough examination and non-extensive description of electron and ion VDFs during crossings of the electron diffusion and separatrix regions of magnetic reconnection events observed at the Earths magnetopause from the Magnetospheric Multiscale mission (MMS). We will consider also the negative kappa signs near the reconnection regions which may arise from electric potentials. MMS 3D particle VDFs are available with unprecedented time resolution of 30 ms for electrons and 150 ms for ions. This allows us to study for the first time both the anisotropy effects and the spatial evolution of non-extensive features seen in particle VDFs across magnetic reconnection events. The MMS instrumentation was designed to understand electron scale physics crossing the electron diffusion region mainly at the Earths magnetopause and in the magnetotail . At the same time the data allow us to study turbulence generated structures which can also be associated with reconnection in the magnetosheath region. The non-extensive aspects of magnetic reconnection could help to understand more the kinetic plasma physical concepts, but contribute also to wider understanding of space weather.

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