Inhomogeneity and dynamical complexity in space plasmas

G. Consolini

INAF-Istituto di Astrofisica e Planetologia Spaziali, Roma, Italy

Space plasmas and their evolution are generally described as fluid media coupled with self-consistent magnetic fields in the framework of magneto-hydrodynamics (MHD). However, the MHD description is a mean field description whose variables are generally analytically smooth functions of position and time. This regularity of the MHD description is not able to take into account of the inherent inhomogeneity and stochastic nature of actual plasma media. Indeed, real magnetized space plasmas are turbulent and non-equilibrium matter media that display dynamical complexity, scale-invariance and non-Gaussian probability distribution functions of several physical quantities. The inherent irregularity of actual space plasma media can be due to the formation of macroscopic/mesoscopic multiscale magnetic field and plasma coherent structures, whose evolution is at the basis of the dynamical complexity of the entire plasma medium.

Examples of space plasmas environments characterized by such a complex dynamical features are heliospheric and magnetospheric space plasmas [Bruno and Carbone, 2016; Consolini and Chang, 2001]. In these space regions there is indeed a wide evidence of the formation of stochastic coherent structures [see e.g. Bruno et al., 2001] and of how the evolution of such coherent structures can explain the observed coherent coarse-grained dissipation [Chang et al., 2003].

Here, after a brief review of the complex dynamical features of some space plasma media, the role that extreme event statistics, multiscale structures and inhomogeneity might play in the emergence of non-Gaussian probability distribution functions in such matter media, is discussed. In particular, following the statistical approach by Lavenda [1995] on the thermodynamics of composite systems, we attempt a description of the irregular nature of space plasmas and of the non-Gaussian features of fluctuations of several quantities. Some examples of the application of such approach to heliospheric and magnetospheric plasma environments will be also presented and discussed.

[l] R. Bruno, V. Carbone, Lect. Notes in Phys. **928**, (2016).

[2] G. Consolini, T. Chang, Space Sci. Rev. **95**, 309 (2001).

[3] R. Bruno, et al., Planetary Space Sci. **49**, 1201 (2001).

[4] B.H. Lavenda, Thermodynamics of extremes **Albion Pub.**, (1995).