Non-extensive statistical analysis of magnetic field during the March 2012 ICME event using a multi-spacecraft approach

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In this study we present some new and significant results concerning the dynamics of interplanetary coronal mass ejections (ICMEs) observed in the near Earth at L1 solar wind environment, as well as its effect in Earths magnetosphere. The results are referred to Tsallis non-extensive statistics and in particular to the estimation of Tsallis q-triplet, (qstat, qsen, qrel) of magnetic field time series of the ICME observed at the Earth resulting from the solar eruptive activity on March 7, 2012 at the Sun. For this, we used a multi-spacecraft approach based on data experiments from ACE, CLUSTER 4, THEMIS-E and THEMIS-C spacecraft. For the data analysis different time periods were considered, sorted as quiet, shock and aftershock, while different space domains such as the Interplanetary space (near Earth at L1 and upstream of the Earths bowshock), the Earths magnetosheath and magnetotail, were also taken into account. Our results reveal significant differences in statistical and dynamical features, indicating important variations of the magnetic field dynamics both in time and space domains during the shock event, in terms of rate of entropy production, relaxation dynamics and non-equilibrium meta-stable stationary states.

So far, Tsallis non-extensive statistical theory and Tsallis extension of the Boltzmann-Gibbs entropy principle to the q-entropy entropy principle (Tsallis, 1988, 2009) reveal strong universality character concerning non-equilibrium dynamics (Pavlos et al. 2012a,b, 2014a,b; Karakatsanis et al. 2013). Tsallis q-entropy principle can explain the emergence of a series of new and significant physical characteristics in distributed systems as well as in space plasmas. Such characteristics are: non-Gaussian statistics and anomalous diffusion processes, strange and fractional dynamics, multifractal, percolating and intermittent turbulence structures, multiscale and long spatio-temporal correlations, fractional acceleration and Non-Equilibrium Stationary States (NESS) or non-equilibrium self-organization process and non-equilibrium phase transition and topological phase transition processes according to Zelenyi and Milovanov (2004). In this direction, our results reveal clearly strong self-organization and development of macroscopic ordering of plasma system related to strengthen of non-extensivity, multifractality and intermittency everywhere in the space plasmas region during the CME event.

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