Natural time and the interconnection between the complexity of seismicity and nonextensive statistical mechanics

by

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Novel dynamical features hidden behind time series in complex systems can emerge upon analyzing them in a time domain, termed natural time, that has been introduced recently (P. Varotsos, N. Sarlis and E. Skordas, *Practica of Athens Academy* **76**, 294, 2001; *Phys. Rev. E* **66**, 011902, 2002). This analysis enables the study of the dynamical evolution of a complex system and identifies when the system enters the critical stage. Relevant examples have been published in a large variety of fields including biology, earth sciences and physics. As a first example, we mention the analysis of the electrocardiograms which may herald a cardiac arrest (*Phys. Rev. E* **70**, 011106, 2004; ibid **71**, 011110, 2005). Second, natural time analysis enables the distinction between the precursory electric signals, termed Seismic Electric Signals (SES) and similar looking electrical noise emitted from manmade sources. Third, the analysis of seismicity subsequent to the SES detection allows the determination of the occurrence time of the impending strong earthquake(s) within a narrow range around a few days at the most (*Phys. Rev. E* **72**, 041103, 2005; *ibid* **73**, 031114, 2006). Fourth, the data of avalanches of the penetration of magnetic flux into thin films of type II superconductors as well as those of a three dimensional pile of rice getting progressively closer to the critical state conform to the features suggested, on the basis of natural time, to describe critical dynamics (*Phys. Rev. B* **73**, 054504, 2006). Fifth, the analysis in natural time can distinguish the two "origins" of self-similarity, i.e., the process' memory and the process' increments "infinite" variance (arXiv:cond-mat/0604575). Beyond a presentation of the aforementioned examples, we review the key role of natural time to reveal a deep interconnection between the complexity of seismicity and nonextensive statistics (Tsallis statistics or *q*-statistics)