Recent advances on statistical physics of earthquakes by combining natural time analysis and Tsallis non-additive entropy

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Several advances in the study of earthquakes have been recently achieved [1] by means of natural time analysis introduced in 2001 [2] as well as by Tsallis non-additive entropy [3] in the frame of which kappa distributions arise [4]. Applications are presented for various seismic prone areas, including major earthquakes that occurred in Japan and Mexico. Examples treated are: First, before the Tohoku earthquake of magnitude (M) 9.0 that occurred on 11 March 2011 in Japan, the Tsallis entropic index q exhibits a precursory increase along with the fact that the Lifshitz–Slyozov–Wagner (LSW) theory for phase transitions is applicable. Moreover, upon analyzing the Japanese seismic data in natural time, we find a similar behavior for a precursory change of seismicity and in particular by the fluctuations of the entropy change ΔS of seismicity under time reversal [5]. In addition, the M7.3 foreshock at 11:45 LT on 9 March 2011 of the Tohoku earthquake, leads to a scaling behavior with a characteristic exponent 1/3 that conforms to the LSW theory for phase transitions [6]. Second, upon analyzing the seismicity during the 6-year period 2012–2017 in natural time in the Chiapas region in Mexico, where the M8.2 earthquake occurred on 7 September 2017 (Mexico's largest earthquake in more than a century), we find [7] that almost three months before the M8.2 earthquake, i.e., on 14 June 2017, the complexity measure Λ associated with the fluctuations of the entropy change ΔS under time reversal shows an abrupt increase. On the same date, ΔS has been previously found [8] to exhibit a minimum accompanied by a simultaneous increase of the Tsallis entropic index q.

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