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Is the evolution towards global failure irreversible after the appearance of distinguishing features in the preseismic EM time series?

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Two fundamental questions unanswered yet that scientists in this field ought to address are as follows. Is the evolution towards global failure irreversible after the appearance of distinguishing features in the preseismic electromagnetic (EM) time series? We view earthquakes (EQ's) as large-scale fracture phenomena in the Earth's heterogeneous crust. Our main observational tool is the monitoring of the microfractures, which occur in the focal area before the final break-up, by recording their kHz-MHz EM emissions, with the MHz radiation appearing earlier than the kHz. Our model of the focal area consists of a backbone of strong and almost homogeneous large asperities that sustains the system and a strongly heterogeneous medium that surrounds the family of strong asperities. We distinguish two characteristic epochs in the evolution of precursory EM activity and identify them with the equivalent critical stages in the EQ preparation process. First, the initial MHz part of the preseismic EM emission, which has antipersistent behavior, is triggered by microfractures in the highly disordered system that surrounds the essentially homogeneous ''backbone asperities" within the focal area and could be described in analogy with a thermal continuous phase transition. However, the analysis reveals that the system is gradually driven out of equilibrium. Considerations of the ''symmetry-breaking" and ''intermittent dynamics of critical fluctuations" method [1] estimate the time beyond which the process generating the preseismic EM emission could continue only as a nonequilibrium instability. Second, the abrupt emergence of strong kHz EM emission in the tail of the precursory radiation, showing strong persistent behavior, is thought to be due to the fracture of the high strength ''backbones." The associated phase of the EQ nucleation

is a nonequilibrium process without any footprint of an equilibrium thermal phase transition. The family of asperities sustains the system. Physically, the appearance of persistent properties may indicate that the process acquires a self-regulating character and to a great degree the property of irreversibility, one of the important components of predictive capability. Arguments by means of cumulative Benioff type EM energy release as well as Levy-flights statistics support the aforementioned two stage model of the EQ nucleation process.

[1] Y. Contoyiannis, P. Kapiris and K. Eftaxias, A Monitoring of a Pre-Seismic Phase from its Electromagnetic Precursors, Physical Review E, 71, 066123, 2005.

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