A Simple Physical Model of Earthquakes Based on Friction-Induced Oscillations

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Abstract

This paper examines one of the classical approaches to the physical modeling of earthquakes, namely the Burridge–Knopoff spring-block model. The physical interpretation, structure, underlying principles, and numerical simulations of the model are presented. Numerical experiments were carried out in MATLAB and include graphical representations of the obtained results.

Particular attention is devoted to incorporating random forces (noise) into the governing equations and investigating their relationship to earthquake dynamics. In addition, the paper discusses self-oscillations and their physical nature, demonstrating friction-induced self-oscillatory behavior. It should be noted that this work is based on the studies of numerous researchers and scientists, as well as on the equations and results they have established.

Finally, the obtained results are presented graphically and analyzed. The numerical experiments demonstrate that combining the Burridge–Knopoff model with the Van der Pol equation produces periodic motion. Furthermore, when a random force (noise) is introduced into the system, the resulting behavior provides a simple yet physically meaningful representation of the pre-seismic dynamics associated with earthquakes.

The obtained results confirm that relatively simple mechanical systems can be effectively employed for the qualitative analysis of seismic processes and the investigation of nonlinear dynamical systems.

Therefore, the proposed model may be regarded as a simplified yet physically meaningful description of earthquake dynamics, combining the stick-slip mechanism, nonlinear oscillatory processes, and the influence of random forces.

Keywords: seismology, earthquake, modeling, physical interpretation, self-oscillation.