Master 2 internship proposition

A thermally activated slider-block model to simulate earthquakes interactions

Earthquakes and faults are often considered as a paradigm of “crackling noise”, i.e. slowly driven complex systems that respond through intermittent events [1] characterized by scale-free statistics such as a power law distribution of seismic moments, space/time correlations expressed e.g. by a slow decaying rate of aftershocks associated to scale free (sub)diffusion. Understanding the physical origin of these scaling laws is also obviously of primary importance in terms of natural hazards forecasting.
Slider-blocks model, incorporating (only) simple static friction and elastic interactions, have been proposed for a long time to simulate fault mechanics and earthquakes[2]. The seminal 1D models were later extended to 2D using cellular automata with a simplified (short-range) version of elastic stress redistribution[3]. If these models are able to simulate intermittent events, power-law distributed in slip sizes, they do not incorporate a timescale, so are unable to simulate aftershocks and the associated space and time clustering. More recently, deterministic rheologies (e.g. viscous-elastic [4] or rate-and-state [5]) of the blocks were introduced to simulate these complex space/time properties.
The goal of this project will be to introduce timescales at a more fundamental level by allowing the thermal activation of the slip of individual blocks, in order to explore the coupled effects of thermal activation and elastic stress redistribution on earthquakes self-organization. This is also a means to introduce temperature effects on earthquake triggering. In addition, the effect of the nature of the elastic redistribution kernel (short-range vs (more realistic) long-range) will be explored as well. The model results will be compared to seismic catalogs and data.

This work requires a strong background in (non-equilibrium) statistical physics, some skills in programming (preferentially Matlab, and/or Python or C++), and a taste for the study of natural systems.

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This Master thesis could be potentially extended to a (funded) PhD, within the framework of an ANR project. This PhD will also analyze experimental data coming from different (existing) laboratory fault models, and compare them to real earthquakes and model results.

Refs.:

[1] J. P. Sethna, K. A. Dahmen, and C. R. Myers, Nature **410**, 242 (2001).
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[3] Z. Olami, H. J. S. Feder, and K. Christensen, Phys. Rev. Lett. **68**, 1244 (1992).
[4] E. Jagla and A. Kolton, Journal of Geophysical Research: Solid Earth **115** (2010).
[5] T. W. de Geus and M. Wyart, Phys. Rev. E **106**, 065001 (2022).