# Chaotic behaviour of seismic mechanisms: observation and models

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## Abstract

Today, it is impractical work modelling the dynamics of failure, given the high complexity of the systems involved. As soon, it is important to identify models, as simples as possible, with qualitatively similar to the failures. The first model introducing is it the mechanical block-spring model, given by Burrigde-Knopoff [1].

In this work the subject was treated by experimental means. For that purpose it was developed and designed a mechanical system similar it that used in the numerical modulations, the so called earthquake machine (shown in Figure 1). We have equipped the springs of the machine with a set of force sensors connected to a data acquisition system (DAQ), linked in turn to a computer. The data recorded in the mechanical prototype consists of temporal series of tensions measured by the sensors that correspond to the sequence of tension accumulation and drop taking place in the springs.

Data processing followed two distinct methodologies. The first treated the data according to the techniques used in seismology with field measurements. In the second methodology, we tried to use the series recorded in the context of chaos theories to investigate the behaviour of prototype.

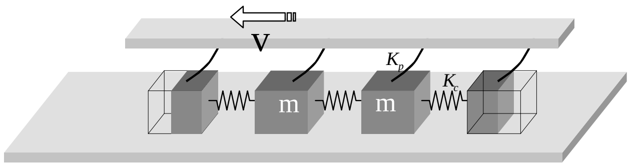


Figure 1 – Earthquake machine

A approach to the sitck-slip problems like ones discussed above is to consider the phenomena as linear dynamical system depending on a slowly nonlinear variation of parameters that are not easily detectable in a relatively short time series period, these parameters can detect using the signal processing tools and chaos theory. The model is described by a nonlinear differential equation given as:

$$\frac{d^2x}{dt^2} + p(x)\frac{dx}{dt} + x = F(t) \qquad (1)$$

Where *p(x)* is nonlinear damping which depend on the velocity. In fact this in an usual model of an earthquake and as well known it consist of a mass M sliding over the a surface with a solid friction. The movement occur when the module of the force F is great enough to overcome the friction's forces. In our model the force F is a saw-toughs function of time t. At each period of F the characteristic movement is very slow and the movement of the mass M seems to be forced by F but suddenly it can occur a slip.

The function *p(x)* can be expressed as hyperbolic function of the velocity [2]. The procedure to extract relevant physical information on the dynamical system from observed data (in our case simulated ones) is the following:

1. Signal separation of noise: using spectral analysis;
2. Phase space reconstruction: based on embedding theory, so we must calculate the embedding lag and the embedding dimension;
3. Signal classification: comparing with invariants of the attractor as the estimated fractal dimension or the Lyapunov exponents.

## References

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