Extreme events in excitable systems: a machine learning approach to chaotic dynamics

**Background**
Extreme events, such as earthquakes, tsunamis, rogue waves, power grid failures, stock market crashes and epileptic seizures are ubiquitous in natural, technological and social systems. Such events are characterized by an observable taking values much larger than its usual fluctuation range.

**Problem description**
Prediction of extreme events is crucial both for science and society, yet it remains challenging. Extreme events in networks of coupled chaotic oscillators have been recently connected to excitability, i.e. the ability of a system to produce a large amplitude response to a suitable stimulus. In turn excitability has been linked to the geometrical structure of the underlying chaotic attractor. Systematic methods to visualize and characterize such (high-dimensional) attractors do not exist. Your task will be to apply manifold-learning techniques, borrowed from the field of machine-learning, to this problem.

**Work description**
The project provides a hands-on introduction to both chaotic dynamics and manifold-learning. You will write computer code to model extreme events in systems of chaotic oscillators. You will use (and possibly improve) packages that implement manifold-learning techniques to analyze data from your simulations. You will apply your methods to different model systems of, e.g., neuronal firing or extreme pulse generation in lasers.

**Group size**
3 students.

**Target students**
F, GU-Fysik, TM. Interest in computational methods or applied mathematics/mathematical physics. Programming experience (e.g. Python or Matlab) helpful but not required.

**Literature**
G. Ansmann et al, Extreme events in excitable systems and mechanisms of their generation, http://dx.doi.org/10.1103/PhysRevE.88.052911

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