STOCHASTIC SIMULATION OF NEURONAL SPIKE TRAINS AND DISLOCATIONS IN CRYSTALS

K.K. Sabelfeld
Институт вычислительной математики и математической геофизики СО РАН
sabelfeld.karl@yahoo.de

Abstract

In this talk I present a simulation method for the analysis of neuronal spike trains considered as stationary stochastic random processes with a given power spectrum. In rapidly growing classes of neurophysiological experiments, the train of impulses ("spikes") produced by a nerve cell is a subject of statistical treatment involving the time intervals between spikes.

A neuronal spike train is the sequence of nerve impulses, or action potentials, produced by a neuron, typically observed over a long period of time. The analysis of spike trains has been of increasing interest to neurophysiologists in recent years, stimulated by wide availability of automatic data-processing equipment. Mathematically, the neuronal spike train can be considered as a random point process defined as a generalized stochastic process. As a simple example, widely used in practice, we mention a renewal process defined as a sum of delta-impulses happened at random times having a Poisson distribution. In a generalized renewal process the random time intervals between two spikes may be arbitrarily distributed but arranges in a Markovian structure.

We evaluate explicitly the correlation function of this type of spike trains. Much more difficult is the inverse problem: we are given a correlation function B(t) of the spike train, construct a renewal process having the desired correlations B(t). We construct a stochastic algorithm which solves this problem for the renewal processes as well as for other point processes, both for stationary and nonstationary random processes. Interesting applications of the spike trains are in the analysis of dislocations in crystals, e.g., see [1]. To calculate the x-ray diffraction peaks on dislocations, we have to simulate spatial spike trains distributed along an edge of a crystal, so there is a full analogy with the neuronal spike trains. We discuss in this talk other applications of the spike trains.

References

[1] Vladimir M. Kaganer and Karl K. Sabelfeld. X-ray diffraction peaks from correlated dislocations: Monte Carlo study of the dislocation screening. Acta Crystallographica, A66, 2010, 703-716.