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Stochastic Dynamics of Paleo-climatic Time Series

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Simple models of the earth's energy balance are instrumental for interpreting some qualitative aspects of the dynamics of paleo-climatic data. In the 1980s this led to the investigation of periodically forced dynamical systems of the reaction-diffusion type with small Gaussian noise, and a rough explanation of glacial cycles by Gaussian meta-stability. A spectral analysis of Greenland ice time series performed at the end of the 1990s representing average temperatures during the last ice age suggest an $\alpha-$stable noise component with an $\alpha \sim 1.75$.

In terms of statistics of stochastic processes, this leads to a model selection problem. For instance, if the time series is modeled as a dynamical system perturbed by α-stable noise, one needs an efficient testing method for the best fitting α. We develop a statistical testing method based on the p-variation of the solution trajectories of SDE with Lévy noise.

Generalizing the solution of the model selection problem, we are led to a class of reaction-diffusion equation with additive α-stable Lévy noise, a stochastic perturbation of the Chafee-Infante equation. We study exit and transition between meta-stable states of their solutions. Due to the heavy-tail nature of an α-stable noise component, the results differ strongly from the well known case of purely Gaussian perturbations.