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Closing (plenary) lecture

STOCHASTIC DYNAMICS OF ENGINEERING SYSTEMS

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Abstract

The objective of the lecture is to expose the main features of stochastic dynamics with a special emphasis on its methodological beauty and applicatory power.

Stochastic dynamics is a relatively new but greatly advanced field of science comprising the models and methods for investigation of real dynamical systems (of diverse physical nature) subjected to parametric and/or external random excitations. It includes, for instance, the analysis of control systems in the presence of random noises, stochastic vehicle dynamics, stochastic structural dynamics studying the response to earthquake, wind, sea waves, etc. In addition, today the methods of stochastic dynamics are widely used in many other fields including population dynamics, groundwater (pollution) transport, meteorological processes as well as economic and financial systems.

The genesis of stochastic dynamics is connected with problems of physics. Although the probabilistic/statistical thinking is present in physics already in the 19-th century (e.g. the Maxwell distribution of velocities of a gas molecules, Boltzmann entropy and his H-theorem), the first years of the 20-th century brought a systematic formulation of statistical mechanics (Gibbs – 1903) and the models of the phenomenon of the Brownian motion (Einstein – Smoluchowski, 1905/06, Langevin, 1909). These results can be regarded to be the roots of contemporary stochastic dynamics of a wide class of real systems. The lecture is inspired by this one-hundred anniversary and, therefore, starts from short comments on these great origins.

The basic content of the lecture is devoted to contemporary stochastic dynamics of physical/engineering systems and consists of six short parts.

In the 1-st part the general mathematical model of stochastic dynamics is shown in the form of a system of stochastic differential equations. The basic theorem concerning this system and relation to the Fokker-Planck Kolmogorov equation is presented. The 2-nd part expounds the models of engineering stochastic vibratory systems and explains how they can be embedded in the general mathematical model of stochastic Itô system. In order to make the model applicable for practical situations, the real random excitations (loads) have to be appropriately described; so, the 3-rd part shows how such excitations as sea wave load and the earthquake action can be characterized. The 4-th part is about characterization of the response by the effective solution methods. The basic existing methods are sketched with some additional emphasis on the method of maximum informational entropy. Hawing characterized the random response of a system the problem of basic engineering importance concerns failures of stochastic dynamical systems and the reliability assessment. In part 5-th of the lecture some light is shed on the characterization of safe performance of stochastic systems.

The last part of the lecture is concerned with the question: are any phenomena or effects generated by random noises/excitations which affect the most internal, “microscopic” dynamics of the systems? There are a number of qualitative effects which are called the “noise-induced transitions”. Such phenomena as: stabilization and destabilization by random noise, noise-induced bifurcations, “regularization” of chaotic dynamics by random noise, the Korteweg de Vrics waves in randomly varying medium are shortly discussed.

The lecture ends with closing remarks on the future of stochastic dynamics and stochastic/probabilistic methods – in general.