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Low-frequency dynamics of systems with modulated high-frequency stochastic excitation

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Abstract

A mechanical system under the action of low-frequency forces and parametric high-frequency excitation is considered. The excitation is assumed to be random and to have a broadband spectrum with non-correlated phases of oscillations with different frequencies. Within the framework of the concept of vibrational mechanics, a general formula is obtained for the vibrational force, that is, for an additional low-frequency force in the equation of slow motion, which gives on average the same effect as the high-frequency excitation. A formula is derived also for the amplitude of an equivalent single-frequency excitation leading to the same vibrational force as a specified random excitation. The analysis of this formula shows that there are possibly five different scenarios for the generation of a vibrational force in dependence on the variables of the random excitation entering into the modulation (coordinate, velocity, velocity and coordinate, velocity and slow time, as well as any modulation combined with a nonlinear dependence of the slow force on velocity).

Using the example of a stochastic analogue of the Stephenson-Kapitza pendulum, the proposed method is validated by comparing its results with a direct averaging of the numerical solutions of the corresponding stochastic equation over the ensemble of representations. As another example of an application, a linear oscillator in a turbulent flow is considered.

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