The truth of chaotic oscillations of flexible rectangular nanoplates under transverse alternating load

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This paper is a generalization of the results obtained in [1]. Variational and differential equations as well as boundary and initial conditions are obtained from Hamilton's principle. The following hypotheses are used as the basis for the theory: the body is isotropic and elastic, the von Kármán geometric nonlinearity is adopted, the size dependence is taken into account according to the modified couple stress theory [2] [3].

As noted by Lozi [4], in most scientific papers, the truth of chaotic oscillations is not reliable, since the error of calculations is often taken for chaotic oscillations due to the fact that the studied structures are treated as systems with a small number of degrees of freedom. This work aims to avoid this error. For this purpose, the obtained nonlinear partial differential equations are reduced to the Cauchy problem by two fundamentally different methods: the Faedo-Galerkin method in higher approximations and the finite difference method. The Cauchy problem is also solved by several methods such as Runge-Kutta and Newmark methods. The obtained signals are cleared of internal noise with the use of the principal component analysis. To analyze the signals, various nonlinear dynamics methods are used, including time histories, phase portraits, Fourier power spectra, wavelet spectra, autocorrelation functions, Lyapunov exponents, etc. Signs of Lyapunov exponents are analyzed by Kantz's [5], Rosenstein's [6], and Wolf's [7] methods as well as the method of neural networks proposed in the reference [8].

The maps of nature of the oscillations are obtained for different numbers of members of the expansion of solutions in the Faedo-Galerkin method and different numbers of intervals of the integration region in the finite difference method for different values of the size-dependent parameter. The Feigenbaum scenario of transition from harmonic to chaotic oscillations is detected and the Feigenbaum constant is obtained. It has been proven that taking the size-dependent parameter into account changes vibrations from chaotic to periodic.

References

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