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On the Scharkovskiy's periodicity for differential equations governing dynamics of flexible shells

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Abstract

In this work complex vibrations of flexible elastic shells subjected to transversal and sign changeable local loads in the frame of non-linear classical theory are studied. A transition from partial to ordinary differential equations is carried out using the higher order Bubnov-Galerkin approach. Numerical analysis is performed applying theoretical background of nonlinear dynamics and qualitative theory of differential equations.

Investigating vibrations of a cylindrical shell with $k_y = 112.5$ and $\lambda = 3$ subjected to transversal sign changeable load $q = q_0 \sin(\omega_p t)$ applied to zone width $\varphi_0 = 6$, among chaotic zones also periodic windows belonging to the so called Sharkovskiy's series are found. Time histories (signals) in the shell centre, phase portraits, power spectra, and Poincare maps, as well as the modal characteristics $w(w_{yy})$ for the orbits mentioned in the Sharkovskiy's theorem are reported.

The following Sharkovskiy's series is shown $3;\ 5;\ 2^2 \cdot 5;\ 9$. It should be emphasized that the so called Sharkovskiy's series is not followed from each other, but they should be separated from the parameters $\{q_0, \omega_0\}$ space. The following scenarios are detected: In the case of period tripling a partition to three equal parts of the signal is observed; for period 5 we deal with 5 equal parts, and so on. In Poincare maps one observes $3;\ 5;\ 2^2 \cdot 5;\ 9$ points. In a phase portrait period doubling is observed too. The mentioned orbits are situated in the windows of regularity occurred in chaotic zones and their structure is the same in the whole studied manifold.

Investigating complex vibrations of cylindrical panels subject to a longitudinal sign changeable two parameters excitation of the form $p_x = p_0 \sin(\omega_p t)$ and $p_y = \alpha \cdot p_x$ for $k_y = 24$ and $\alpha = 3$, besides of chaotic zones also periodic orbits being members of the Sharkovskiy series are detected, i.e. the Sharkovskiy series $3;\ 2 \cdot 3;\ 5; 2 \cdot 5;\ 7; 2 \cdot 7;\ 11;\ 13$ are shown.

[1] Li T.Y., Yorke I.A., Period three implies chaos, Am. Math. Monthly. 1975. Vol. 82, 985 – 992.
[2] Sharkovskiy, A. N., Existence of cycles of a continuous transformation of a straight line into itself. Ukrainian Mathematical Journal, 1964, Vol. 26, No 1, 6 –71.