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Nonlinear responses and stability analysis of viscoelastic nanoplate resting on elastic matrix under 3:1 internal resonances

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Abstract

The nonlinear responses and stability of double-layered nanoplate embedded in the elastic medium are investigated in the presence of 3:1 internal resonance. By the nonlocal theory, the method of multiple scales is employed to obtain the analytical nonlinear frequency-response relations. Two different external primary resonance conditions, i.e. the first and the second modes being directly excited, are considered. The influences of the small scale effect and viscous damping on the nonlinear vibration are explored in details. From the results, the frequency-response curves for the two primary resonance cases present complete different characteristics. It should be noted that the response curves are closed loops for the resonance of the second mode, which implies the steady-state response just exists in a finite frequency range. The regions of multi-values appear for both cases and the stability of the response is determined. When the first mode is directly excited, the impact of the viscidity of nanoplate and small scale effect on the frequency range of unstable response is rather significant. Furthermore, when the second mode is directly excited, a novel phenomenon, i.e. the frequency range for the closed loops of response diminished enormously as the increase of the viscidity of nanoplate, can be observed. Response curves of the second mode as $\Omega \approx \omega_{20}$, $\omega_{20} \approx 3\omega_{10}$ with different viscous damping parameters (μ = 2nm).

Graphical Abstract

The effect of the viscidity of the nanoplate on the nonlinear response for the case that the second mode is directly excited is illustrated in the following figure. From the results, it is rather novel that the frequency range for the steady-state response is diminished tremendously with the increase of the viscous damping.