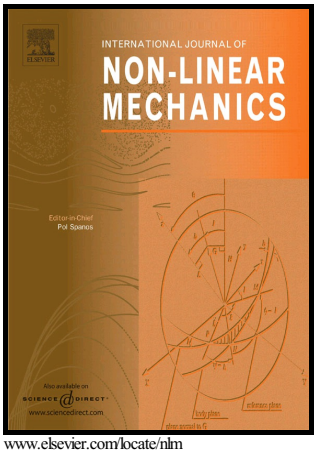

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Application of reconstitution multiple scale asymptotics for a two-to-one internal resonance in Magnetic Resonance Force Microscopy

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Abstract

In this paper we formulate an initial-boundary-value-problem describing the three-dimensional motion of a cantilever in a Magnetic Resonance Force Microscopy setup. The equations of motion are then reduced to a modal dynamical system using a Galerkin ansatz and the respective nonlinear forces are expanded to cubic order. The direct application of the asymptotic multiple scales method to the truncated quadratic modal system near a 2:1 internal resonance revealed conditions for periodic and quasiperiodic energy transfer between the transverse in-plane and out-of-plane modes of the MRFM cantilever. However, several discrepancies are found when comparing the asymptotic results to numerical simulations of the full nonlinear system. Therefore, we employ the reconstitution multiple scales method to a modal system incorporating both quadratic and cubic terms and derive an internal resonance bifurcation structure that includes multiple coexisting in-plane and out-of-plane solutions. This structure is verified and reveals a strong dependency on initial conditions in which orbital instabilities and complex out-of-plane non-stationary motions are found. The latter are investigated via numerical integration of the corresponding slowly-varying evolution equations which reveal that breakdown of quasiperiodic tori is associated with symmetry-breaking and emergence of irregular solutions with a dense spectral content.

Keywords: reconstitution multiple scales, 2:1 internal resonance, magnetic resonance force microscopy, bifurcation structure, quasiperiodic energy transfer.