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The influence of asymmetric electrodes on the non-planar dynamics of a parametrically excited nonlinear microbeam

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Abstract: Electrodynamically excited nano- and micro-mechanical resonators consist of configurations and structural elements which make use of one of their resonance frequencies. Their applications include atomic force microscopy, mass sensing etc. Majority of theoretical studies in literature assume that electrodes and beams are symmetrically spaced for both single and multi-element arrays. Thus in this work we study the influence of an imperfect configuration with asymmetric gaps between the electrodes and investigate the bifurcation structure resulting from spatio-temporal effects of the asymmetrical gap configuration on a non-planar, nonlinear micro-beam-string response. An initial-boundary value problem describing the three dimensional motion of a parametrically excited nonlinear microbeam in an asymmetric dual gap configuration is investigated asymptotically and numerically to study the influence of imperfections on its spatio-temporal dynamics. The analytical and numerical investigation of the non-planar dynamics reveals coexisting period doubled and quasiperiodic solutions corresponding to saddle-node and secondary Hopf instabilities in the slowly varying evaluation equations. The results are also compared with measurements from an experiment with asymmetric electrode gaps demonstrating that a planar model with parametric excitation cannot predict the documented bias in the observed frequency response of a nonlinear microbeam with an imperfect electrode configuration.

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