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Simulation strategies for the characterization of realistic radiation-pumped dispersion force-driven nanoscale parametric amplifiers

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Nano-electromechanical systems (NEMS), electrostatically driven at their resonance frequency and parametrically pumped by time-dependent dispersion forces, are theoretically expected to display remarkable gain, sensitivity, resolution, and tunability properties. This author previously discussed employing nanodevices of this novel class as sensors to measure non-gravitational accelerations in such applications as SmallSats, in which spacecraft mass and volume limits are particularly stringent. This author also previously proposed modulating dispersion forces not by varying the interboundary gap width, which adds subsystem mass, complicates device design, and introduces mechanical vibration disturbances, but by back-illuminating a fixed semiconducting surface. Although both such dispersion force approaches have been experimentally demonstrated in the past, no experiment studying dispersion force-driven parametric amplifiers has yet been reported. Furthermore, no simulations of the dynamical behavior of such highly non-linear systems in non-inertial reference frames have appeared in the literature, even in the pump-off state, that is, under static dispersion force conditions. In this paper, we report the first results on such simulations in non-inertial frames, including a comparison between numerical results and a generalized theory of resonance in non-linear one-dimensional (1D) oscillators. In order to enhance the ability of our model to describe the multiphysics nature of our approach and to facilitate future experimentation, dispersion forces with non-ideal materials are introduced for the first time and a block diagram for nanodevice testing with laboratory instrumentation is presented.

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