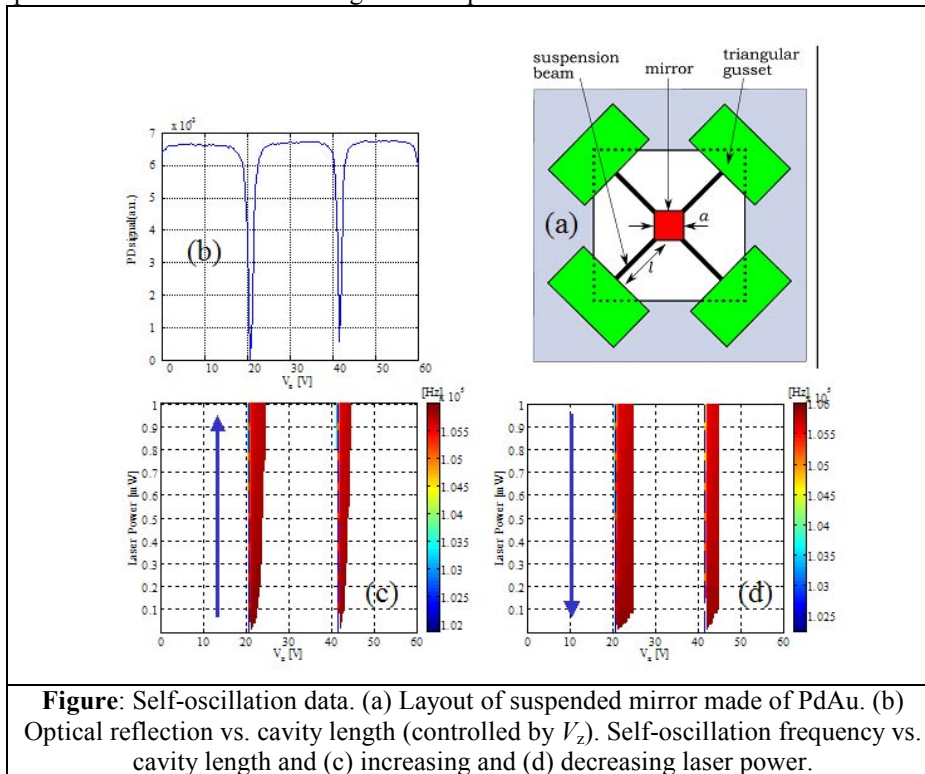


Optically Induced Self Oscillations in Mechanical Resonators

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We study a novel configuration for displacement detection of mechanical resonators consisting of an optical fiber, fiber Bragg grating (FBG) and a microlens. In this configuration an optical cavity is formed between the mechanical resonator under study and the FBG. The microlens at the tip of the fiber allows focusing the optical spot impinging on the mechanical vibrating element. Such a cavity configuration allows significant improvement in displacement detection sensitivity. We study a variety of mechanical resonators made using different materials and having different geometries. The observed response, both linear and nonlinear, of the system to external forcing excitation exhibits strong dependence on optical power and on cavity length. Moreover, above some threshold value of optical power (which depends on cavity length) we observe optically induce self-oscillations (see figure). Similar effects have been previously observed in other configurations of optomechanical cavities [1-8]. However, we find that the underlying mechanism responsible for the instability (as well as for all other optomechanical effects) in our system is unique. The two dominantly contributing coupling mechanisms between the mechanical resonator and the optical field are found to be (a) a non-retarded force acting on the mechanical element due to radiation pressure and (b) parametric modulation of the mechanical resonance frequency due to a retarded process of heating. Theoretical modeling of these coupling mechanisms yields a set of coupled equations of motion for the entire optomechanical system. We find approximated analytical solutions for both, forced and self oscillations, which are valid provided that the amplitude of oscillations is sufficiently small. Moreover, numerical solutions are obtained for the more general case. This relatively simple model is capable of reproducing many of the experimental results, mainly those that were obtained with relatively low optical power. On the other hand, accounting for the experimental results in the region where optomechanical effects are stronger will require further work.



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