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Paradoxical Stabilization of Forced Oscillations by Strong Nonlinear Friction

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Fast tiny vibrations can stabilize a mechanical system. This effect is known in classical mechanics as *induced stability* [1]. A famous example is Kapitza pendulum [2], an inverted pendulum whose statically unstable upper equilibrium position is stabilized by fast small vertical oscillations of the pivot point. P. L. Kapitza had demonstrated that fast small oscillations create an average force which surprisingly drags the pendulum to the upper position. This is a classical example of the ponderomotive force created by a spatially inhomogeneous fast oscillating driving force. It appears in the time-averaging of fast oscillations, which reveals a slow motion corresponding to the spatial scale of the driving force [3].

It is well known that in a weak electromagnetic standing wave, the ponderomotive force repels a charged particle from the maximum of the spatial profile of the electric field. In sufficiently strong electromagnetic field, the particle dynamics becomes dissipative due to the radiation reaction. It leads to a seemingly paradoxical behavior: electrons tend to concentrate near the electric filed maxima [4]. We explain this phenomenon [5], using a simplified model formulated in the style of the classical textbook [3].

We show that in a dissipative dynamic system driven by an oscillating force, a strong nonlinear highly oscillatory friction force can create a quasi-steady tug, which is always directed opposite to the ponderomotive force induced due to a spatial inhomogeneity of oscillations. When the friction-induced tug exceeds the ponderomotive force, the friction stabilizes the system oscillations near the maxima of the oscillation spatial amplitude of the driving force.

The proposed model represents a new type of *dynamic stabilization*. It differs from the Kapitza pendulum effect, because in our case the stabilization factor is a nonlinear growth of the friction with the driving force, which creates a tug counteracting and exceeding the ponderomotive force. It also gives an important rival to the effects of dissipation-induced instabilities [6]. We believe that our model is essential for all fields of science which incorporate in their basis the concepts and mathematical apparatus of classical mechanics.

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