Mathematical Physics

Stability properties of periodically driven overdamped pendula and their implications to physics of semiconductor superlattices and Josephson junctions

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We consider the first order differential equation with a sinusoidal nonlinearity and periodic time dependence, that is, the periodically driven overdamped pendulum. The problem is studied in the case that the explicit time-dependence has symmetries common to pure ac-driven systems. The only bifurcation that exists in the system is a degenerate pitchfork bifurcation, which describes an exchange of stability between two symmetric nonlinear modes. Using a type of Prufer transform to a pair of linear differential equations, we derive an approximate condition of the bifurcation. This approximation is in very good agreement with our numerical data. In particular, it works well in the limit of large drive amplitudes and low external frequencies. We demonstrate the usefulness of the theory applying it to the models of pure ac-driven semiconductor superlattices and Josephson junctions. We show how the knowledge of bifurcations in the overdamped pendulum model can be utilized to describe effects of rectification and amplification of electric fields in these microstructures.

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