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Title: Nonlinear Dynamics and Orbital Instabilities in Magnetic Resonance Force Microscopy

Magnetic resonance force microscopy (MRFM) is an imaging technique that enables acquisition of three-dimensional magnetic images at nanometer scales which has been adapted for detection of the magnetic spin of a single electron. This technique is based on combining the technologies of magnetic resonance imaging (MRI) with atomic force microscopy (AFM), and is implemented mechanically using a vibrating sensor to directly detect a modulated spin gradient force between sample spins and a ferromagnetic particle attached to the tip of an AFM microcantilever. While MRFM systems are receiving a growing amount of interest, to date, a comprehensive theoretical treatment is still lacking. Existing models are based on simplistic lumped-mass reductions that include linear estimates of cantilever stiffness and damping complemented by a nonlinear approximation of the magnetic force. We thus formulate a nonlinear initial-boundary-value problem (IBVP) combining the micro-cantilever motion and the magnetic moments of the spin. We reduce the IBVP to a modal dynamical system and investigate its orbital stability via multiple-scale asymptotics augmented by numerical integration which reveal both local bifurcations and existence of lengthy chaotic-like transients in low damping operation conditions.

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