Abstract Submitted
for the MAR17 Meeting of
The American Physical Society

Flow-stabilized levitation in a magnetic stirrer.[1] KYLE BALDWIN, DAVID FAIRHURST, JEAN-BAPTISTE DE FOUCHIER, PATRICK ATKINSON, THOMAS DARWENT, Nottingham Trent University, RICHARD HILL, MICHAEL SWIFT, University of Nottingham — Magnetic stirrers are a useful tool for preparing solutions as the mixing vessel can be completely sealed, with no physical contact between the drive magnet and stir-bar. However, colloquially, stir-bars are known as "fleas" due to the onset of jumping at high speeds, which halts mixing. Here, we investigate the transition from spinning to jumping and discover an intriguing additional state, where the flea is levitated several centimeters while moving in a superposition of rotation and oscillation. This is of interest as Earnshaw's theorem states that there is no arrangement of static permanent magnets that be levitated stably. Current mag-lev technology side-steps this via secondary effects (*e.g.* diamagnetic repulsion or superconductive flux-line pinning), none of which can account for the flea's stability. We map the equations of motion onto a driven damped-pendulum system, universally characterize the onset of jumping, and successfully predict the oscillating flea's behavior. We further find that the stability is maintained by the flea's oscillation, which, at intermediate Reynolds numbers (Re ≈ 10), pumps fluid out from the ends of the flea, creating a streaming flow that centers it. If, however, Re is too low/too high, the respective flows are reciprocal/reversed, which both destabilize the levitation. This levitation technique demonstrates increasing Re can reverse the streaming flows relevant to propulsion, and could be cheaply implemented to study a variety of fluid and biological systems.

[1]We acknowledge support from NTU and the Erasmus student programme.

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Date submitted: 06 Jan 2017 Electronic form version 1.4