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The Fluid Coupled Dynamics of Small Oscillating Elastic Objects

MARK PAUL, Virginia Tech — There is broad interest in the correlated motion of small elastic objects in a viscous fluid. In many cases, the coupled motion of an array of objects provides more information, and improved resolution, when compared with what is learned from the motion of a single object alone. The physical implications and subtleties of the fluid dynamics caused by oscillating objects for a range of applications will be discussed. The theoretical and numerical ideas needed for the quantitative description of these systems will be presented for external harmonic excitation and for dynamics driven by Brownian motion. An analytical approach for the correlated motion of two elastic objects in fluid will be presented. Each oscillating object is replaced with a two-dimensional cylinder of finite mass that is attached to a spring. The fluid motion is governed by the unsteady Stokes equations. Using linear response theory and the fluctuation-dissipation theorem, analytical expressions will be developed for the motion of the two fluid-coupled cylinders. A comparison of the analytical results with full finite element numerical simulations yields excellent agreement. These ideas can be extended to include different geometries, large arrays, and objects that are tethered together.

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