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The fluid-coupled motion of micro and nanoscale elastic objects

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We consider two closely spaced elastic objects immersed in a viscous fluid subject to thermal (Brownian) driving and external driving. For Brownian driving the objects exhibit cross-correlations in equilibrium fluctuations in displacement through the long-range effects of fluid motion. For external driving, one object is driven to oscillate while the adjacent object is passive. We model the system as two simple harmonic oscillators whose motion is coupled through the fluid. For external driving we demonstrate the feasibility of shaker-based actuation for nanoscale systems. For Brownian driving the cross-correlations are determined using a thermodynamic approach based upon the fluctuation-dissipation theorem. We perform full numerical simulations of the fluid-solid interactions that include the precise geometries of interest. We then develop analytical expressions using simplified geometries and the unsteady Stokes equations. The analytics are compared with the numerics to develop insight into the fluid-coupled dynamics over a range of experimentally relevant parameters including object separations and frequency based Reynolds numbers.

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