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# Object Transport by Confined Active Fluids


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## ABSTRACT:


Active fluids, and more generally active matter, are out of equilibrium systems emblematic of biological materials, such as a cell interior or a developing multicellular organism. Chemical energy is locally converted into work that can guide their evolution through internal stresses in ways that lead to instabilities and generally rich phenomenology. Means to organize such systems to perform life-like tasks is particularly interesting for understanding biology and designing similar systems. We introduce an established continuum model for active suspensions based on common biological components, motivated by either diffused swimmers or kinesin-linked microtubule, and then use simulations to show how such a system transports objects within a closed container. This is a step toward identifying how such systems might be designed to perform particular tasks. A circular object within a circular container provides the simplest case to expose mechanisms. For a diffuse suspension of swimmers, adjusting the activity strength shows regimes in which the object is repelled from the wall in a chaotic flow, attracted to it, and transported along it at a fixed distance from it. There are also conditions for which the transport of the object can lead to stabilization of the suspension and cessation of all flow. In this same geometry, a dense stericly aligning suspension shows unexpected fixed-point and limit-cycle solutions. These solutions typically appear after periods of chaotic flow that is characterized by the creation and annihilation of defects in the fluid nematic order. These behaviors are analyzed and explained and cast as building-block phenomena that are likely to be important in more complex geometries. The simulations are generalized to more complex geometries to demonstrate this.


## BIOGRAPHY:

Jonathan Freund is the Donald Biggar Willett Professor and Head of Aerospace Engineering at the University of Illinois Urbana-Champaign. He is a Fellow of the American Physical Society, and a winner of the 2008 Frenkiel Prize from its Division of Fluid Dynamics and has served in division leadership in several capacities. He is on the editorial board of Annual Review of Fluid Mechanics. Computational science has been central to his research across and beyond fluid mechanics, which has included simulations of turbulent jet noise and its control, the dynamics of molecularly thin liquid films, nanostructure formation by ion-bombardment of semiconductor materials, bubble dynamics in confinement, and the dynamics of red blood cells flowing in the narrow confines of the microcirculation. He is the PI and co-director of the Center for Exascale-enabled Scramjet Design (CEESD).