## Soft, Fluid, Living Matter (SoFLivMat) Coffee Hour
**(April 24th, 2025, 2:30-3:30 pm, Mason room 107)**

### Circulation and Transport in Hele-Shaw Flows

Kyle McKee, MIT

Viscously-dominated flow between two closely spaced plates is described by two-dimensional potential flow according to the standard Hele-Shaw approximation. When driven exclusively by pressure, the class of realizable potential flows is highly restricted: only flows with exactly zero circulation are possible. For example, the Hele-Shaw experiments presented in Van Dyke's famous Album of Fluid Motion clearly illustrate this zero-circulation restriction. In the present work, we demonstrate how the Hele-Shaw cell can be used to capture flows with circulation - by using a conducting fluid and applying a constant magnetic field normal to the plates. We describe the physical picture and experimentally recreate canonical Hele-Shaw flows from Album of Fluid Motion now with arbitrary amounts of circulation induced by electromagnetic effects. The experimental flows are well described by our accompanying theoretical model. In the second part of this talk, I will segue into a related investigation of transport (advection-diffusion) in multiply-connected potential flows. By constructing a suitable conformal mapping, which is computed using recently developed methods (the AAA algorithm), we simplify the governing equations. We then formulate a boundary-integral solution in the mapped domain, where the exact Green's function is known. Distinct scalings for the rate of transport (Nusselt number) under various boundary conditions are revealed.

**Bio:**
Kyle McKee is a Ph.D. candidate in Mathematics at MIT, originally from Yellowknife, Canada. He is currently supported by a MathWorks Fellowship and an NSERC Postgraduate Scholarship (PGSD). His research focuses on fluid dynamics and, more broadly, Physical Applied Mathematics, integrating theoretical analysis with experimental investigations. Kyle's recent work has been published in Journal of Fluid Mechanics, Physical Review Fluids, and the ASME Journal of Heat and Mass Transfer. He was a Chateaubriand Fellow at ESPCI in Paris in 2024 and was recently named a Geophysical Fluid Dynamics Fellow, a position he will take up this summer at the Woods Hole Oceanographic Institution.

(https://pahlavan.yale.edu/soflivmat-coffee-hour)