

PHYSICAL MATH SEMINAR

Circulation and Transport in Hele-Shaw Flows



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ABSTRACT:

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 re-create 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 to the governing equations 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.

TUESDAY, FEBRUARY 4, 2025

2:30 PM – 3:30 PM

Building 2, Room 449