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Stokes flows for non-closed, internal boundaries

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Calculations for the streaming flow around deformable surfaces are of broad interest in physiology and engineering. Electroporation, as a specific example, is an experimental technique that creates a pore in a cell membrane and enables the transmission of once impermeant molecules in and out of the cell. In order to make progress in modeling such phenomena, it is necessary to solve for the flow field around surfaces that themselves have a boundary. The prototypical setup is for a spherical cap—a hollow sphere with a single, circular hole—immersed in a viscous fluid, and here a complete analytical solution has been obtained [1]. Computational frameworks [2] using boundary element and finite element methods are now able capture the dynamics of open and axisymmetric elastic membranes, interacting with ambient Stokes flow.

References

[1] Ryham: On the viscous flows of leak-out and spherical cap natation. Journal of Fluid Mechanics, 836 (2018), 502–531.

[2] Zhou, Young, Mori: Modeling and Simulation of Open Membranes in Stokes Flow with Mixed-Dimensional Coupling. Multiscale Modeling & Simulation, 24:2 (2026), 474–500.