GFD 2019: Dissolving shapes

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Structures in the natural world are often formed by a rich interplay between fluid flow and the evolving shape of a dissolving or eroding solid [1]. When an object dissolves or erodes in a flow, it tends towards a self-similar terminal shape that can be predicted from similarity solutions to the Prandtl boundary layer equations and free-streamline theory [2, 3]. These dynamics create a beautiful back-and-forth interplay between the evolving free interface of the solid boundary and the fluid mechanics.

For the case of a dissolving object, dissolution sets up density differences between the solute-laden fluid and the ambient fluid, resulting in buoyancy-driven flow. Depending on the stability of the buoyancy-driven flow, the shape of an object can change or remain the same with time [4]. This project will conduct mathematical and experimental analysis of the evolution of a dissolving object surrounded by a stable buoyancy-driven flow. The methods will involve a combination of mathematical analysis and laboratory experimentation. Experiments will consist of dissolving 3D candy shapes (cylinders and cones of varying angles) in a tank of water and examining the evolving shape of the upper surface. Concurrently, a mathematical model based on coupling the evolution of the surface shape with a boundary-layer theory for the buoyancy-driven flow can be developed and analysed using analytical, asymptotic and numerical approaches.

- **A video of some dissolving candy.**

- More information about **Megan Davies Wykes**.

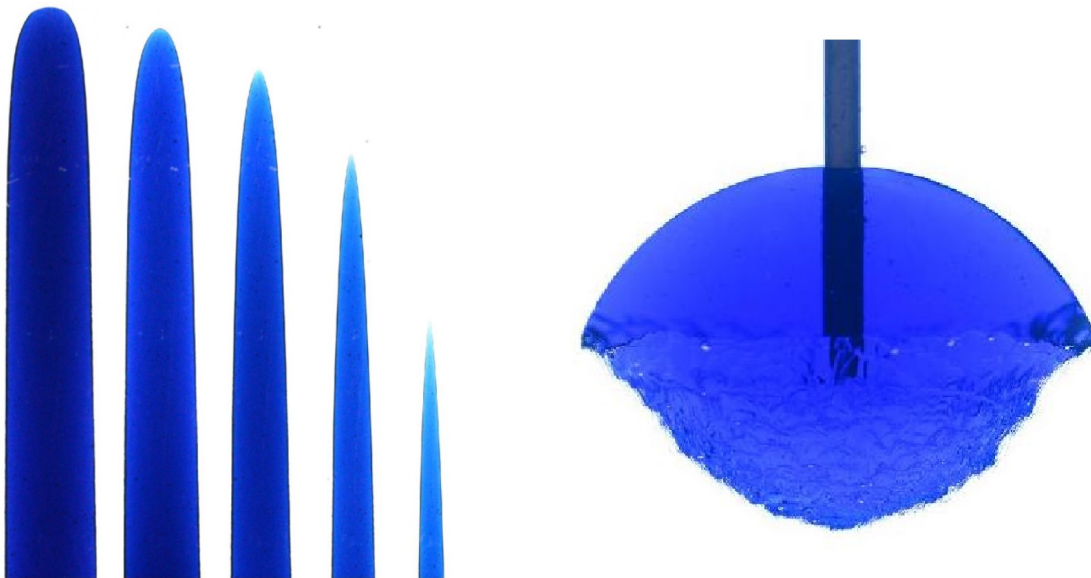- More information about **Sam Pegler**.

Figure 1: A partially dissolved candy stick (left) and sphere (right).

References

[1] Leif Ristroph. Sculpting with flow. *Journal of Fluid Mechanics*, 838:1–4, March 2018.

[2] Matthew N. J. Moore, Leif Ristroph, Stephen Childress, Jun Zhang, and Michael J. Shelley. Self-similar evolution of a body eroding in a fluid flow. *Physics of Fluids*, 25(11):116602, November 2013.

[3] Jinzi Mac Huang, M. Nicholas J. Moore, and Leif Ristroph. Shape dynamics and scaling laws for a body dissolving in fluid flow. *Journal of Fluid Mechanics*, 765, February 2015.

[4] Megan S. Davies Wykes, Jinzi Mac Huang, George A. Hajjar, and Leif Ristroph. Self-sculpting of a dissolvable body due to gravitational convection. *Physical Review Fluids*, 3(4), April 2018.