Drag Forces and Unsteady Wakes Behind a Poro-Elastic Membrane Disk

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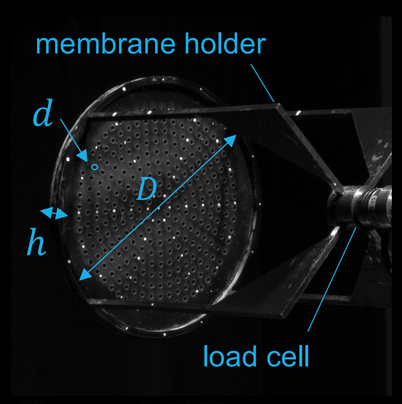
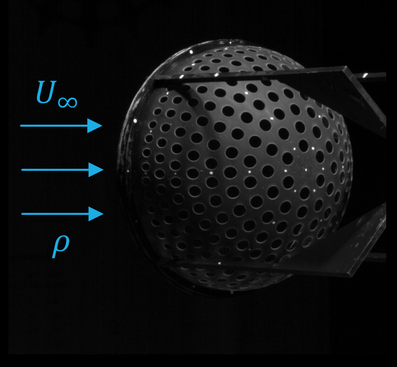
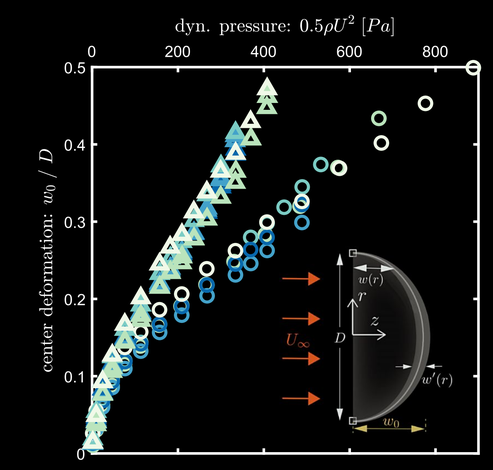
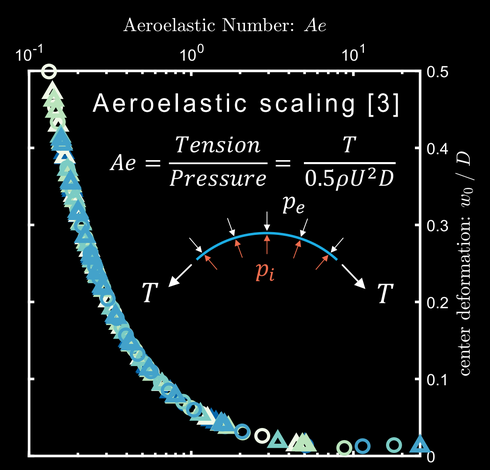
In nature, flexibility and porosity aids structures like leaves and seeds in adapting to strong winds [1,2]. Our experiments demonstrate that while flexible, non-porous disks experience increased drag with higher deformation [3], adding porosity reduces both average drag and fluctuations. Poro-elasticity in a compliant membrane mimics natural mechanisms observed in e.g. dandelion seeds and bird feathers, stabilizing the turbulent wakes, suppressing vortex shedding, and dampening vibrations.

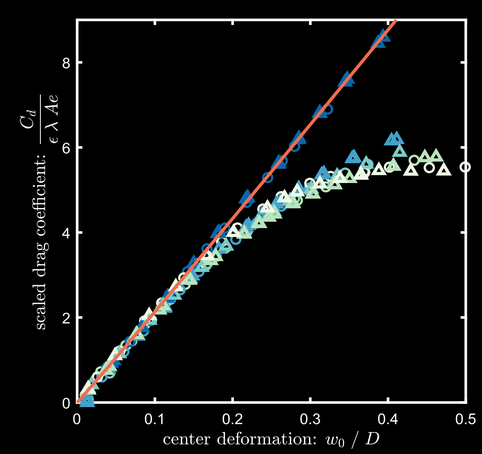


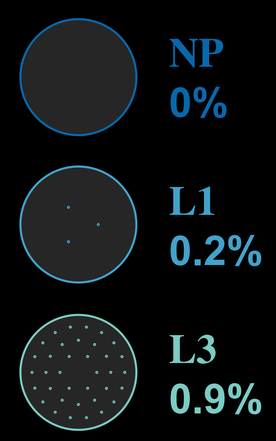


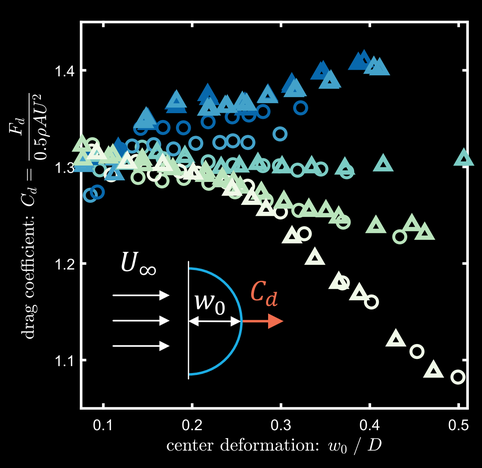
Porous, flexible membranes made from a hyper-elastic polymer

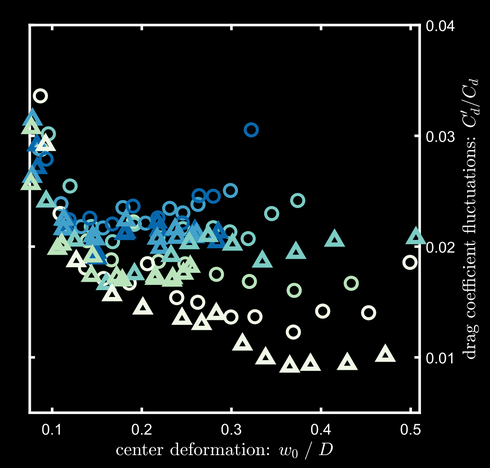


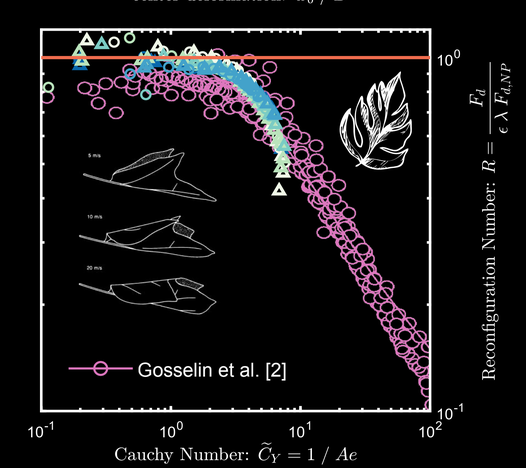




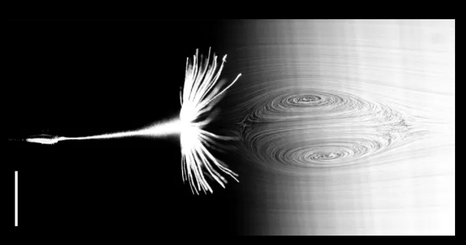


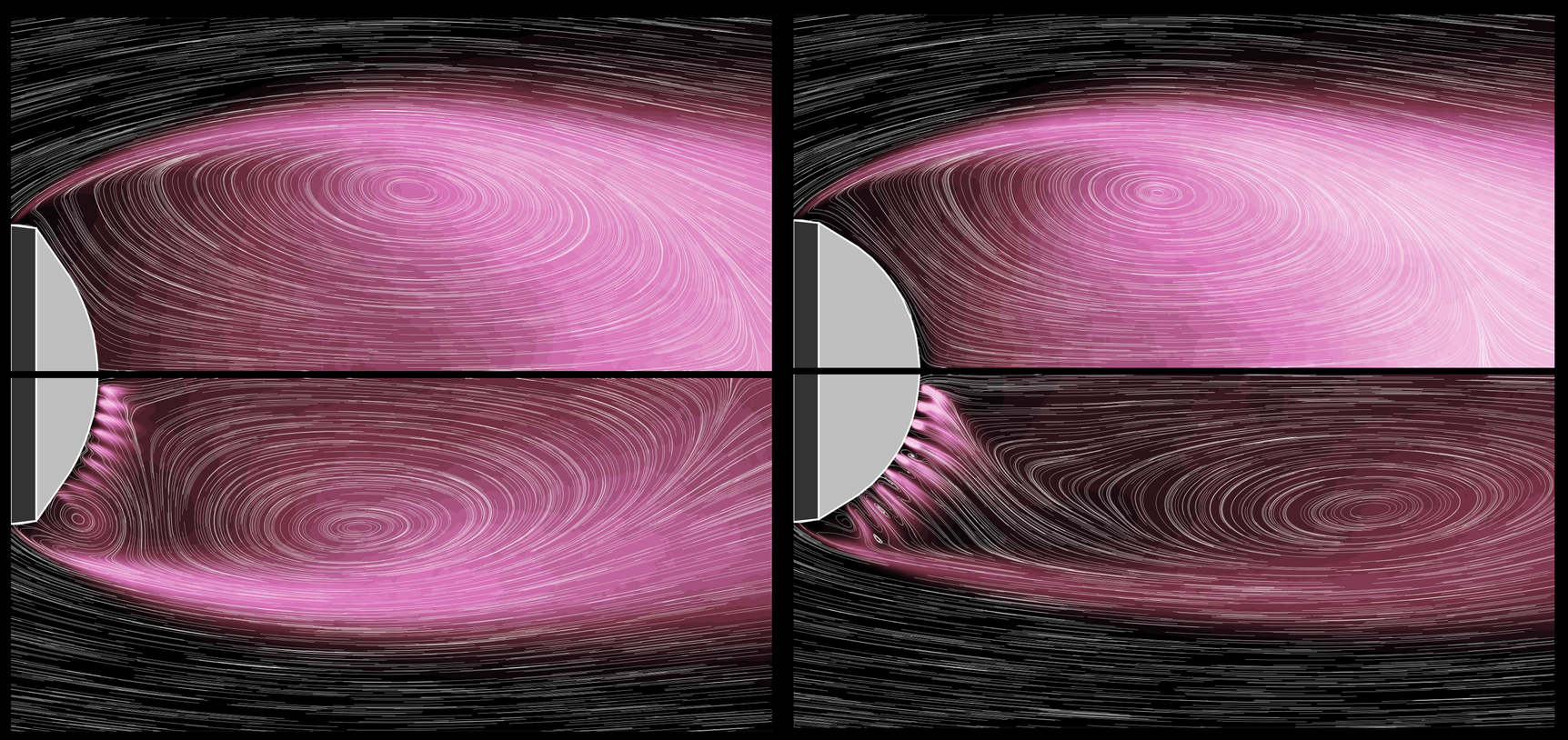






Porosity leads to weaker, stretched vortices similar to the wakes of Dandelion seed [1]





[1] Cummins, Cathal, Madeleine Seale, Alice Macente, Daniele Certini, Enrico Mastropaolo, Ignazio Maria Viola, and Naomi Nakayama. A. Separated Vortex Ring Underlies the Flight of the Dandelion. Nature, 562, no. 7727: 414–18, 2018.
[2] Gosselin, Frédérick, Emmanuel De Langre, and Bruno A. Machado-Almeida. "Drag Reduction of Flexible Plates by Reconfiguration." Journal of Fluid Mechanics 650 (May 10, 2010): 319–41.
[3] Mathai, Varghese, Asimanshu Das, Dante L. Naylor, and Kenneth S. Breuer. Shape-Morphing Dynamics of Soft Compliant Membranes for Drag and Turbulence Modulation. Physical Review Letters, 131, no. 11: 114003, 2023.

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