Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Compliant membranes exhibit enhanced drag due to membrane fluctuations. ASIMANSHU DAS, Center for Fluid Mechanics, School of Engineering, Brown University, VARGHESE MATHAI, Center for Fluid Mechanics, School of Engineering, Brown University and Department of Physics, University of Massachusetts, Amherst, KENNETH BREUER, Center for Fluid Mechanics, School of Engineering, Brown University — We study the kinematics and dynamics of a highly compliant membrane disk placed head-on in a uniform flow. With increasing flow velocity, the membrane disks deform nonlinearly into increasingly parachute-like profiles. The experiments were carried out in a closed-loop low-speed wind tunnel with Reynolds number in the range of \$10ˆ4 -10ˆ5. Remarkably, these aerodynamically sustained membrane disks show a higher flow resistance (drag) than similarly shaped rigid concave bodies. We model the steady structural response of the membranes using a nonlinear aeroelastic model. The predictions of the model agree well with the mean deformations of the membrane disks for the full range of experimental parameters studied. Through a simultaneous quantification of the unsteady membrane kinematics and forces, we detect the onset of large amplitude membrane fluctuations, match with the observed drag modulation and have their origins in the resonance between the flow structures and the membrane's natural frequency. A drum model with anisotropic spring-stiffness is proposed, which quantitatively captures the observed resonant response. Further, PIV experiments are being conducted to yield deeper insights into the steady and transient fluid-structure interactions.

Asimanshu Das
Brown University

Date submitted: 03 Aug 2020 Electronic form version 1.4