Snap-induced flow in a closed channel

Oz Oshri*[1], Kirill Goncharuk[1], and Yuri Feldman[1]

[1]Ben-Gurion University of the Negev – Israel

Abstract

Snap-through is a buckling instability that allows slender objects, including those in plants and biological systems, to generate rapid motion that would be impossible if they were to use their internal forces exclusively. In microfluidic devices, such as micro-mechanical switches and pumps, this phenomenon has practical applications for manipulating fluids at small scales. The onset of this elastic instability often drives the surrounding fluid into motion – a process known as snap-induced flow. To analyze the complex dynamics resulting from the interaction between the sheet and the fluid, we develop a prototypical model of a thin sheet that is compressed between the two sides of a closed channel filled with an inviscid fluid. At first, the sheet bends towards the upstream direction and the system is at rest. However, once the pressure difference in the channel exceeds a critical value, the sheet snaps to the opposite side and drives the fluid dynamics. We formulate an analytical model that combines the elasticity of thin sheets with the hydrodynamics of inviscid fluids to explore how external pressure differences, material properties, and geometric factors influence the system's behavior. To analyze the early stages of the evolution, we perform a linear stability analysis and obtain the growth rate and the critical pressure difference for the onset of the instability. A weakly nonlinear analysis suggests that the system can exhibit a pressure spike in the vicinity of the inverted configuration.

*Speaker