# CAPILLARY SWITCHES: SCIENCE AND APPLICATIONS

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# ABSTRACT

Capillary switches, formed by two droplets connected via a conduit, are explained. The experimental realization of capillary switches is done by overfilling a milimeter-sized circular orifice with water. As the volume of the protruding liquid increases, the equilibrium state undergoes a pitchfork bifurcation. Several mechanisms that can 'toggle' between stable states which are nearly dissipation-free are demonstrated. The gas-liquid interfaces that form the switch provide a restoring force when the system is perturbed from its equilibrium position, making it a natural oscillator. The frequency response of the oscillatory driven system was studied and several resonant frequencies were found for a range of volumes.

Application of the capillary switch as an adaptive lens is demonstrated. Surface tension is made to change on one capillary surface relative to the other by means of an electric voltage that works in conjunction with a redox surfactant. The change in curvature of the capillary surfaces induces a change in focal length in a process that is shown to be reversible. Focal length values are between 0.5 mm and infinity depending on the volume, and electrochemical activation can change the focal length of the liquid lens by 50% or more. Using pressure activation, the oscillatory behavior of the system is used to produce a fast scanning liquid lens by driving it near resonance while avoiding highly-deformed interfaces. Time response of less than 1 ms is achieved and scanning focal plane distances between 5 mm and infinity are obtained.

Application of the capillary switch as a droplet manipulator is examined. The system is used to detach droplets from solid surfaces, which is generally difficult to accomplish energy efficiently. The capillary switch is able to pull packets of liquid formed at a circular source and then is able to deposit them onto another location. The grabbing process utilizes the pinch-off of a liquid bridge to detach and pull off the packet of liquid from the solid surface. This technique shows great promise in manipulating small volumes of liquid, as a millimeter-sized device is able to handle nano-liter sized droplets.