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Tentative topic of the invited talk

Flows in bubbles and drops induced by ultrasound

Abstract of the invited talk

Cavitation microstreaming is the steady, non-oscillatory flow induced by a bubble oscillating in an acoustic field. The shear stresses generated by an oscillating bubble can cause cell wall rupture without affecting the cytoplasm. We focus on two configurations: of the bubble, sessile- and pendent-type configurations. Bubbles of constant volume were placed in the cuboidal chamber, and the effect of the height of the chamber and the frequency of excitation was studied. The Energy Minimization Method was used to verify the shape of the stationary bubble. PIVlab in Matlab was used to determine the velocity field obtained from Micro-Particle Image Velocimetry (μ-PIV). We investigate the effect of confinement with rigid boundaries on flow fields seen in cavitation microstreaming. A flow regime map in the parameter space of chamber height and driving frequency for both sessile and pendent-type bubbles is presented. These maps would help experimentalists identify suitable patterns in lab-on-chip devices for sonoporation, cell lysis, and micro-mixing applications. A key finding of this study is that there are two different physics that govern the flow field depending on the frequency of the acoustic excitation. Specifically, the streaming patterns are dominated by vibration-induced flow at low frequencies. On the other hand, acoustic pressure-induced interface deformation is dominant when the resonant frequency of the transducer coincides with that of the bubble. Acoustofluidics also offers contactless manipulation, high versatility, and good biocompatibility. Microfluidic paper-based analytical devices (μPAD) have key advantages like multiplexing, rapid response, and portability. The present study is a first step which combines acoustics with μPADs to develop Acoustic-μPADs (A-μPADs). We focus on the fundamental aspects of acoustic field-driven flow in a sessile drop placed on a paper substrate. Young's modulus and acoustic impedance were used to sort and select suitable paper. A simple, two-step fabrication process was used to impart hydrophobicity to paper, which eliminates liquid imbibition. A temporal variation of contact angle (with and without acoustics) was used to set the experiment duration. We investigate the effect of frequency and amplitude of excitation on the drop. The velocity field in the drop was obtained from Micro-Particle Image Velocimetry (μ-PIV). Faraday waves and atomization were captured using high-speed imaging (8000 fps). A key finding of this study is that the system exhibits three different phenomena, internal streaming, Faraday waves, and atomization on a single device. These are captured in a flow regime map in the parameter space of dimensionless frequency

and amplitude. These maps can be used as a guide for applications such as mixing (streaming), patterning (Faraday waves), and mist generation (atomization).