Acoustic Streaming Enhancement in Sharp-edged Microchannels and baroclinic streaming at low frequency

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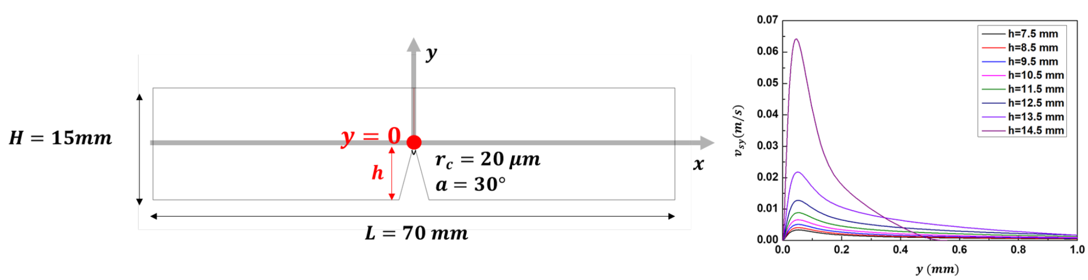
Acoustic streaming denotes the stationary flows generated by a mechanical or acoustic forcing on a fluid, originating either from bulk dissipation by viscosity or by the Reynolds stress near solid boundaries. In this later case, the flow significantly depends on the geometry. As an example, intense streaming could be generated near sharp-edge structures [1] at audible frequencies, as low as 10 Hz [2], with the practical advantage to use broadband, large amplitude vibration generators. Recent studies showed that temperature or density gradients would impact the streaming flow patterns at moderate or relatively high frequency (of the order of MHz [3]) or kHz [4]). This so-called *baroclinic streaming* originates from a coupling between density and compressibility gradients and the inhomogeneities of acoustic velocity v_a and pressure p_a. Hence, high enough frequency is likely to be required, in order that the wavelength λ be smaller than the channel size L. Our study shows that by prescribing a narrow enough constriction near a sharp edge, v_a shows strong variations in the constriction, so that not only the streaming v_s gets strongly enhanced, but also a baroclinic streaming appears under a temperature gradient ∇T. Specifically, we conducted numerical simulations using COMSOL to investigate the impact of different sharp-edge height h on the streaming flow under a longitudinal forcing at f=300 Hz. Figure 1 presents the channel geometry and results of $v_s(y)$ for various $(H-h)$, H being the channel size in the y direction. Our simulations also reveal that a transverse ∇T significantly modifies the v_s profile and the whole streaming pattern, an effect which can be attributed to baroclinic streaming. These results extend the applicability of temperature-controlled streaming and provides a support for the design of low-frequency sharp-edge streaming applications in mili- or microfluidics, with the purpose of mass and heat transfer enhancement.



(*a*) (*b*)

Figure 1. (a) Schematic diagram of the computational domain ; (b) Streaming velocity profile for different sharp-edge heights at f=300 Hz (v_a=0.005 m/s).

Références

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