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Streaming driven by sessile microbubbles: Explaining flow patterns and frequency response BHARGAV RALLABANDI, CHENG WANG[1], LIN GUO, SASCHA HILGENFELDT, Department of Mechanical Science and Engineering, University of Illinois at Urbana-Champaign — Ultrasound excitation of bubbles drives powerful steady streaming flows which have found widespread applications in microfluidics, where bubbles are typically of semicircular cross section and attached to walls of the device (sessile). While bubble-driven streaming in bulk fluid is well understood, this practically relevant case presents additional complexity introduced by the wall and contact lines. We develop an asymptotic theory that takes into account the presence of the wall as well as the oscillation dynamics of the bubble, providing a complete description of the streaming flow as a function only of the driving frequency, the bubble size, and the physical properties of the fluid. We show that the coupling between different bubble oscillation modes sustains the experimentally observed streaming flow vortex pattern over a broad range of frequencies, greatly exceeding the widths of individual mode resonances. Above a threshold frequency, we predict, and observe in experiment, reversal of the flow direction. Our analytical theory can be used to guide the design of microfluidic devices, both in situations where robust flow patterns insensitive to parameter changes are desired (e.g. lab-on-a-chip sorters), and in cases where intentional modulation of the flow field appearance is key (e.g. efficient mixers).

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