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Acoustics driven forces for manipulating small particles

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(Hosted by: Oriel Shoshani)

Abstract:

Particles much smaller than the acoustic wavelength are subjected to forces arising from two nonlinear phenomena, acoustic radiation pressure and acoustic streaming which is a localized mean flow. The scattering of acoustic waves from a particle results in radiation forces and the acoustic streaming affects the drag force. For particle acoustic levitation, acoustic radiation forces are used to counteract gravity and manipulate the particle position in space, while the drag force is usually ignored. To propel particles and microrobots, acoustic streaming is harnessed to generate thrust, and the acoustic radiation force is often neglected.

We discuss these forces via two case studies. The first deals with a novel approach for manipulating acoustically levitated particles via parametric excitation (PE), which is achieved by a periodic change in the system's energy-storing parameters (i.e., inertia or stiffness). We discuss how PE can be used to manipulate the particle’s position, without changing the acoustic trap’s position. An ultrasonic levitator was used to generate a complex acoustic field, whose structure was numerically estimated, then by employing Gor’kov’s theory, the radiation forces were analytically approximated. To introduce PE experimentally, the levitator's vibration spectrum was modulated by integrating a phase-locked loop and signal processing realized in real-time via a fast, digital signal processor. Realization of principal parametric resonance allows to 1) oscillate a specific particle, 2) oscillate a particle in a chosen direction in space, 3) eject a particle from an acoustic trap.

The second case study deals with the modal analysis of a fluid-structure interaction (FSI) problem, an entrapped gas microbubble in a fluid domain. The bubble can have an arbitrary shape and multiple gas-fluid interfaces. The modal FSI problem is solved analytically, then using numerical simulations the acoustic streaming and thrust are computed.

Bio:

Amit Dolev is a postdoctoral associate at the MicroBioRobotic Systems Laboratory at École Polytechnique Fédérale de Lausanne headed by Prof. Sakar. He received his B.Sc. in Mechanical Engineering at Technion – Israel Institute of Technology and Ph.D. at the Dynamics Laboratory headed by Prof. Izhak Bucher at the Technion-IIT during a direct doctoral track. Currently, he works on the utilization of acoustics for powering microscale technologies. He pursues a broad range of research interests including nonlinear dynamics, fluid-structure interactions, vibrations, signal processing, acoustics, and control.

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