PHYSICAL MATH SEMINAR

Acoustic manipulation with the acoustic radiation force: from acoustical tweezers to acoustic quantum analogues

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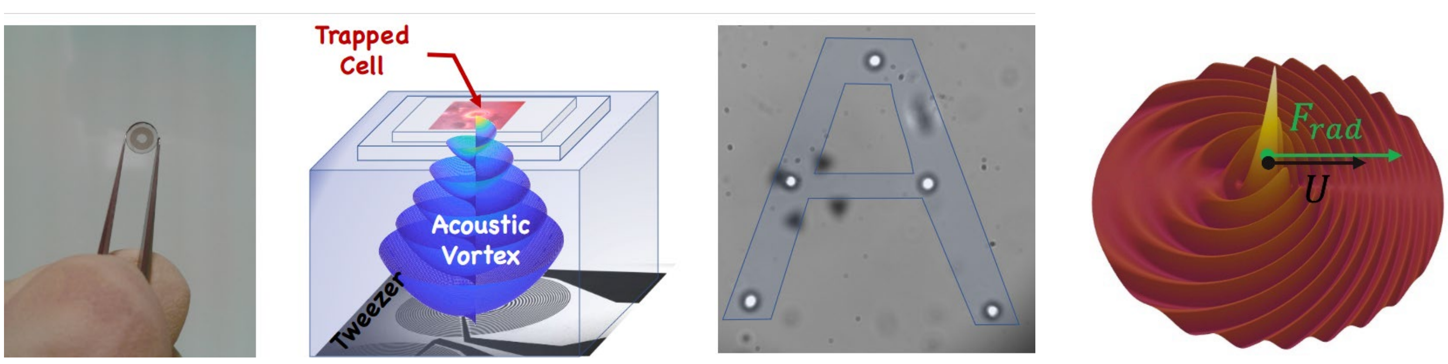

Left: Figure illustrating the principle of acoustical tweezers based on active holograms and acoustical vortices [3, 4} Right: Illustration of the propulsivee self-radiation force exerted on a dipolar source [5,6].

ABSTRACT:

When an acoustic wave interacts with a particle possessing different acoustic properties compared to its surrounding medium, nonlinear effects give rise to a net average force known as the acoustic radiation force. This force enables the remote contactless manipulation of objects using acoustic waves i.e., the development of acoustical tweezers (ATs). While early experiments on particle manipulation with sound date back to the early 19th century, the three-dimensional manipulation with a single beam, akin to the pioneering work of Nobel laureate A. Ashkin in optics [1], has only been achieved recently. Indeed, it requires the use of specific focused beams with pressure minima at the focal point, such as acoustical vortices. After providing an overview of the nonlinear physics underlying particle manipulation with acoustics [2], we will show how we were able to miniaturize ATs to perform the first demonstration of single cells selective manipulation and organization in a microfluidic environment [3,4]. Then we will explore the intriguing possibility for an acoustic source to be transported by its own acoustic field. We will demonstrate that the asymmetry resulting from the Doppler effect can lead to a self-induced radiation force [5,6] amplifying small translational perturbations of the source. This work opens the possibility for acoustic sources transported by "a pilot wave", analogous to the concept introduced by de Broglie in quantum mechanics and the hydrodynamic quantum analogues [7] unveiled in 2005 by Couder & Fort [8].

References:

[1] A. AShkin et al., Observation of a single-beam gradient force optical trap for dielectric particles, *Optic Lett.,* **11:** 288-290
[2] **M. Baudoin** & J.L. Thomas., Acoustic tweezers for particle and fluid manipulation, *Annu. Rev. Fluid Mech*., **52**, 205–234 (2021)
[3] **M. Baudoin et al.,** Spatially selective manipulation of cells with single beam acoustical tweezers, *Nature Commu*., **11**: 4244 (2020)
[4] **M. Baudoin, et al.** Folding a focalized acoustical vortex on a flat holographic transducer: miniaturized selective acoustical tweezer, *Science Advances*, 5: aav1967 (2019)
[5] A. Roux, J.P. Martishang, **M. Baudoin**, Self radiation force on a moving monopolar source, *J. Fluid Mech*. **952**: A22 (2022)
[6] J.P. Martishang, A. Roux, **M. Baudoin**, Acoustic dipole surfing on its own acoustic field: toward acoustic quantum analogues, *submitted (2023)*
[7] Bush, J.W.M. and Oza, A.U., Hydrodynamic quantum analogues, *Rep. Prog. Phys*. **84**: 017001 (2020)
[8] Couder Y et al., Walking and orbiting droplets, *Nature* **437:** 208 (2005)

TUESDAY, APRIL 30, 2024
2:30 PM – 3:30 PM
Building 2, Room 449

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