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Hydrodynamic wave-particle dualities

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Since the discovery of the quantum world and the formulation of quantum mechanics, scientists have continuously attempted to define the border between classical and quantum physics. In the last fifteen years, this border has been moved forward by the discovery of a form of macroscopic wave-particle duality. Millimetric liquid droplets can self-propel by bouncing on the surface of a vertically vibrating bath of the same liquid [1]. At each bounce a droplet generates a wave, and the compound object comprising the particle and the wave field has been called a "walker". Walkers exhibit several features previously thought to be restricted to the microscopic, quantum realm, e.g., quantised orbits and angular momentum in the presence of a central force, and wavelike statistics in corrals [2]. In the first part of the seminar, I will introduce the walker system and briefly describe the quantum-like behaviours that it exhibits. I will then discuss in detail the hydrodynamic analogues of single-particle diffraction and interference [3,4] (Fig. 1a) and spin lattices [5] (Fig. 1b). In the last part, I will present a recently discovered system in which solid particles are driven by the waves they generate on the surface of a vibrating bath [6] (Fig.1c), and discuss future directions in terms of hydrodynamic quantum analogues with this novel type of macroscopic wave-particle association.

[1] Y. Couder, S. Protière, E. Fort, and A. Boudaoud, Nature, 437, 208 (2005).
[2] J.W.M. Bush, A.U. Oza, Rep. Prog. Phys., 84, 017001 (2021).
[3] Y. Couder and E. Fort, Phys. Rev. Lett., 97, 1–4 (2006).
[4] G. Pucci et al. , J. Fluid Mech. 835, 1136–1156 (2018).
[5] P.J. Sáenz, et al. , Phys. Rev. Fluids, 3, 4–6 (2018).
[6] G. Pucci,et al. Video submitted to the Gallery of Fluid Motion of the APS 2020. https://doi.org/10.1103/APS.DFD.2020.GFM.V0032.

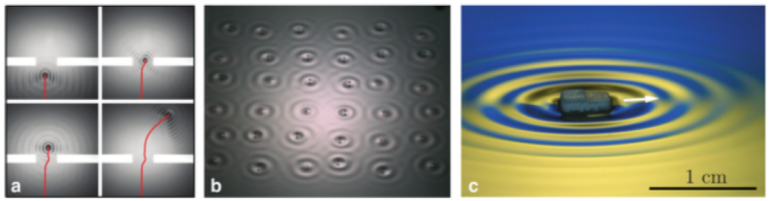

Figure 1. (a) A walking droplet crossing a single slit (top view). (b) Spin lattice of walking droplets (oblique view). (c) A capillary surfer (oblique view).

Short Bio: Giuseppe Pucci is reasearcher at CNR NANOTEC since January 2021. His primary research lies in phenomena at the fluid interface, including active systems and hydrodynamic analogues. He graduated in Physics of Matter at the Univ. of Calabria. He received his PhD in 2011 from the Univ. Paris Diderot under the supervision of Prof. Yves Couder, in joint supervision with Prof. Riccardo Barberi at the Univ. of Calabria. He was a post-doc at Univ. of Calabria from 2012 to 2015, where he worked on liquid crystals and the human cornea under the supervision of Prof. Barberi. From 2015 to 2017 he was a post-doc at MIT under the supervision of Prof. John Bush, where he worked on walking droplets and hydrodynamic quantum analogues. From 2017 to 2018 he was a post-doc at Brown University under the supervision of Prof. Daniel M. Harris, where he worked on solid bodies on fluid interfaces. He has been temporary researcher at the Institute of Physics of Rennes from 2018 to 2020, with a CNRS grant, and worked on self-organisation at the fluid interface.

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