Trapping of Macroscopic Spinning Particles in Hydrodynamic Vortex Lattice

Jean-Baptiste Gorce[1,2], Hua Xia[2], Nicolas Francois[2], Horst Punzmann[2], Gregory Falkovich[3,4], Michael Shats[2]

[1] Université Paris Cité, CNRS, MSC, UMR 7057, F-75013 Paris, France
[2] Research School of Physics, The Australian National University, Canberra, ACT 2601, Australia
[3] Department of Physics, Weizmann Institute of Science, Rehovot 76100, Israel
[4] Photonics Center, Novosibirsk State University, Novosibirsk 630090, Russia
jean-baptiste.gorce@u-paris.fr

Recent advances in the confinement and manipulation of microparticles and ultracold atoms using optical waves have inspired new ideas related to the control of particles at liquid-gas interfaces using hydrodynamic vortex lattices [1]. These lattices consist of two orthogonal standing waves, which generate surface flows of counter-rotating vortices, guiding floating particles along closed trajectories. The specific shape and geometry of these vortices are determined by the phase shift and frequency of the waves, with the dimensions of the vortices corresponding to half of the wavelength.

The present study shows that by incorporating macroscopic active spinning disks, referred to as "spinners" into such vortex lattices, one can create a powerful tool for manipulating and self-assembling macroscopic spinning particles [2]. We will show that the spinners' orbits in the vortex lattice can be precisely tuned by changing their angular velocity while reversing the sign of the angular velocity moves the spinner to an adjacent vortex. In addition, multiple spinners within a vortex can self-organize into stable patterns orbiting around the center of the vortex.

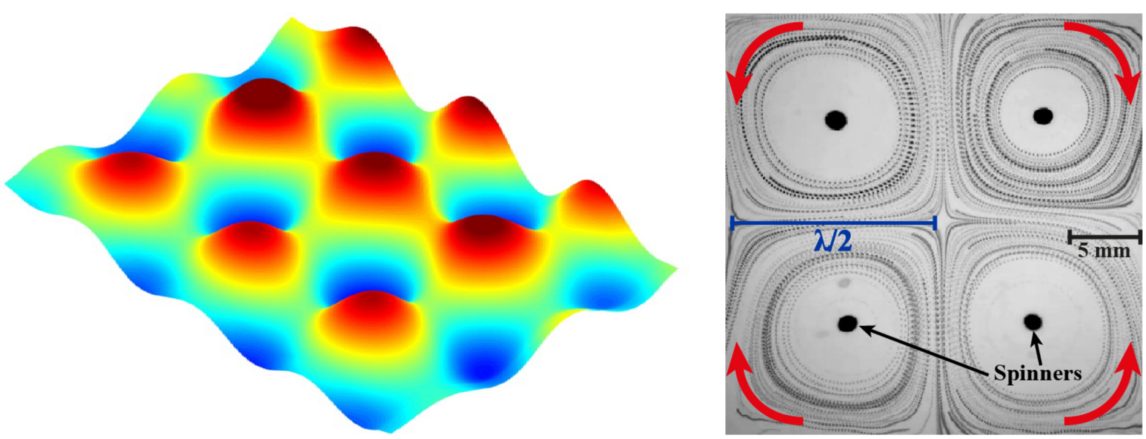

Figure 1. Left: Measured surface elevation snapshot of the vortex lattice derived from a diffusive light imaging analysis. The hot colors in the colormap correspond to peaks, while the cold colors represent troughs. Right: Trapping of 1 mm spinners within four different vortices. The red arrows represent the rotation direction of the vortices. The angular frequency of the spinners is 30 Hz.

References

1. N. Francois, H. Xia, H. Punzmann, PW. Fontana, & M. Shats, Wave-based liquid-interface metamaterials, *Nat. Commun.*, **8**, 1, 14325 (2017).
2. J.B. Gorce, H. Xia, N. Francois, H. Punzmann, G. Falkovich, & M. Shats, Confinement of surface spinners in liquid metamaterials, *Proc. Natl. Acad. Sci. U.S.A.*, **116**, 51, 25424-25429 (2019).