regular use. Nevertheless, it remains to be seen whether this approach can replace or improve upon conventional dark-field microscopy across a variety of applications. In the current realization, the imaging is limited to a relatively narrow range of wavelengths per substrate even if a mixture of light emitters at different wavelengths is to be used, because achieving broadband angle selectivity in a thin, flat structure is challenging[7]. Still, the authors provide a compelling vision for multiplexed electrical excitation of light emitters at different wavelengths within such a substrate to enable multispectral dark-field imaging using simple bright-field microscopes. ❐

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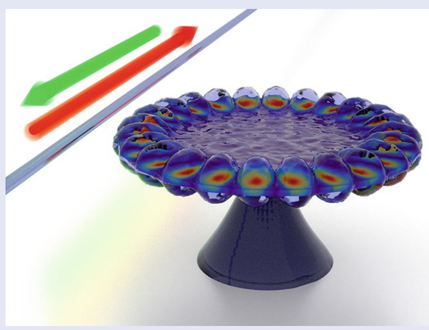
OPTOMECHANICS

Superfluid coating

Interaction between light and matter can result in Brillouin scattering, a fundamentally important phenomenon. The concept enables precise optical technology on-chip, as well as in optical fibres, but also has undesired consequences, such as introduction of noise in optical communications.

Now Xin He, Glen Harris, Christopher Baker and colleagues at the University of Queensland in Brisbane, Australia, have reported that key compromises when designing Brillouin-based photonic technologies can largely be circumvented, in addition to revealing a new form of intracavity Brillouin process, counter-modal Brillouin scattering (*Nat. Phys.* https://doi.org/10.1038/s41567-020-0785-0; 2020). This was achieved by coating optical resonators with self-assembled nanometre-thick films of superfluid helium. Optical fields were able to deform the photonic cavity, changing its size by 1%, and shifting the optical resonances by several thousand times their linewidth. The team demonstrated microwatt-threshold Brillouin lasing.

Baker, corresponding author on the paper, explained to *Nature Photonics* that regions of high light intensity inside the resonator (pictured) continuously deform the superfluid interface by drawing in more superfluid by means of an optical gradient force (the mechanism behind optical tweezers) and the superfluid fountain effect, in which optical absorption-induced entropy gradients induce superfluid flow. This results in the formation of a superfluid 'bulge' around the perimeter of the resonator where the light is located.



Credit: Christopher Baker

"We demonstrated ultralow-threshold Brillouin lasing and strong coupling between counter-propagating photon modes, mediated by the superfluid phonons," Baker stated. "Indeed, the superfluid Brillouin wave forms a travelling refractive index grating. Above the Brillouin lasing threshold, the backscattering generated from this grating is sufficiently strong to enter a regime of mechanically mediated photon–photon strong coupling, that is, where photons cycle between the pump and Stokes resonances at a rate faster than the decay rate of the optical fields. This form of strong coupling is a key capability for Brillouin reconfigurable optical switches and circuits, for photonic quantum interfaces and to generate synthetic electromagnetic fields."

Working with superfluid helium at millikelvin temperatures is challenging enough without the need for optical access. Superfluid helium can escape from minute gaps in the sample chamber and the superfluid film is also invisible. Baker said that the team is developing fully integrated photonic chips for easier experiments in the future.

The team hopes that the approach can be improved and femtowatt-level lasing thresholds achieved. Also, by exploiting the superfluid fountain effect, single-photon absorption events may be detectable, potentially enabling photon-number-resolving detectors. Further, the team hopes that the approach could be used for high-efficiency reconfigurable routing of light on a silicon chip, as well as to mix liquids and to do pico-chemistry, or even to build gyroscopes that measure the flow of liquids at the microscale, providing new insight into turbulent fluid dynamics and ultimately the dynamics of quantum liquids. ❐

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