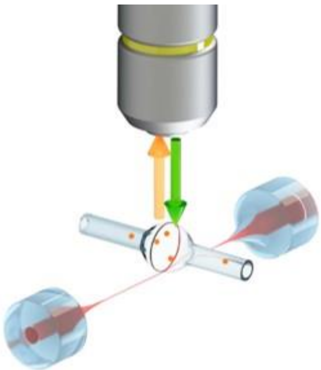
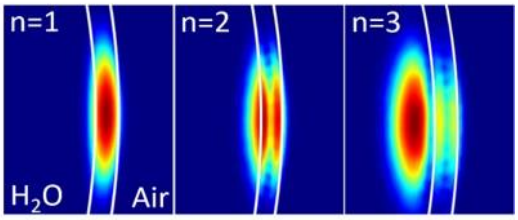
Enhanced Nanoparticle Detection with Quasi-droplet Modes

Jonathan Ward[1], *Fuchuan Lei*[1], *Yong Yang*[1], *Xiao-Chong*[2] *Yu, Yun-Feng Xiao*[2] *and Síle Nic Chormaic*[1]
[1]*Light-Matter Interactions Unit, Okinawa Institute of Science and Technology Graduate University*
Onna-son, Okinawa, Japan 904-0495
[2]**State Key Laboratory for Mesoscopic Physics and School of Physics, Peking University, Beijing 100871, China**
E-mail: jonathan.ward@oist.jp

The unique properties of hollow whispering gallery resonators (WGRs) should lend to the advancement of bio/nano sensing applications [1][2]. For these applications, hollow WGRs, such as the microbubble, have shown to have an improved sensitivity due to the large evanescent field penetrating into the liquid core of the resonator [3]. A microbubble WGR, is essentially a thin glass shell supported on a hollow stem that allows fluids to be passed through the core of the resonator. WGMs are supported in the wall of the hollow resonator and create an evanescent field along the inner and outer wall surfaces [3]. For thin walls, the mode can enter into the quasi-droplet regime and it strongly interacts with the material in the core. Minute changes to the environment result in a change of the WGM spectrum so the strongly interacting quasi-droplet modes make hollow WGRs uniquely suited for sensing applications.





Schematic of experimental setup showing microbubble with nanoparticles, the tapered optical fibre for exciting whispering gallery modes and the objective for imaging. COMSOL simulation of the optical mode profile in a thin-walled, water-filled microbubble resonator

Here, we demonstrate, for the first time, single nanoparticle detection using truly quasi-droplet WGRs and show that they can outperform solid WGRs in terms of dispersive and dissipative sensitivity [4]. We also observe a number of interesting effects, such as regenerative self-modulation driven by the particle motion arising from strong scattering at the waveguide/cavity coupling junction.

References

1. M. Baaske et al., J. Phys. Chem **13**, 427–436 (2012).
2. L. Yang, et al., Opt. Express **19**, 16195–16206 (2011).
3. W. Lee, et al., Appl. Phys. Lett. **99**, 091102 (2011).
4. J. M. Ward, et al, Optica **5**, 674-677 (2018).