Ultrasoft Whispering Gallery Mode Cavities

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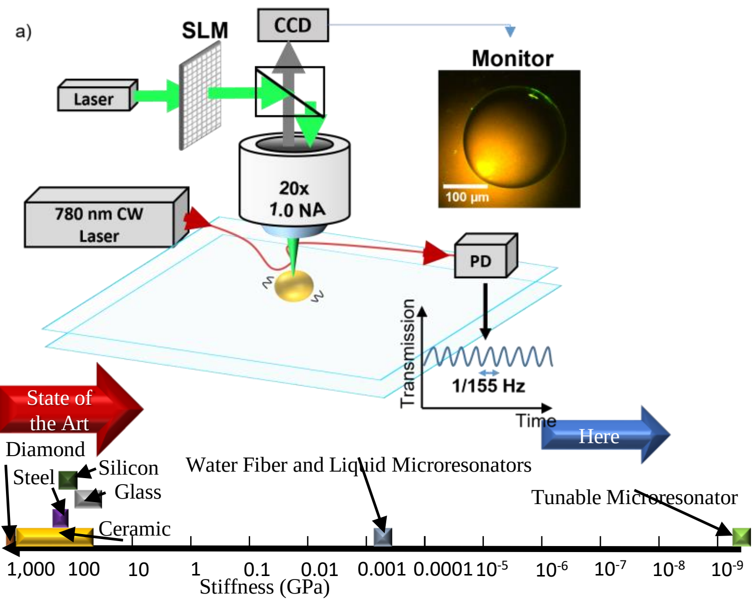


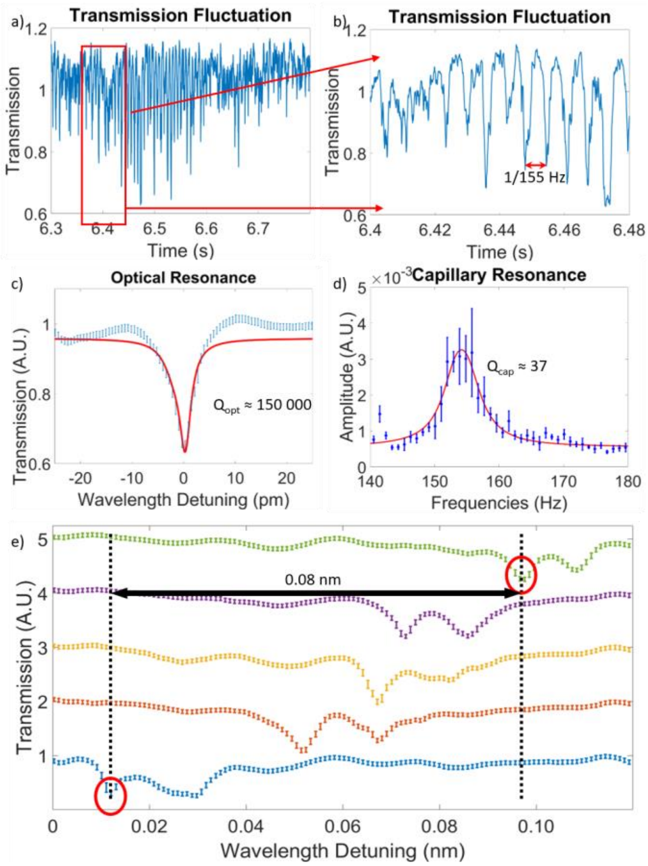
An n-heptane oil droplet (golden) in a water chamber (blue) is interrogated withasingle wavelength laser via a tapered fiber coupler(red) and read out via a photoreceiver. Fourier transforming the transmission signal reveals the capillary oscillation.

Common solids softness compared with that of water-walled waveguides and the here presented Ultrasoft WGM Cavity

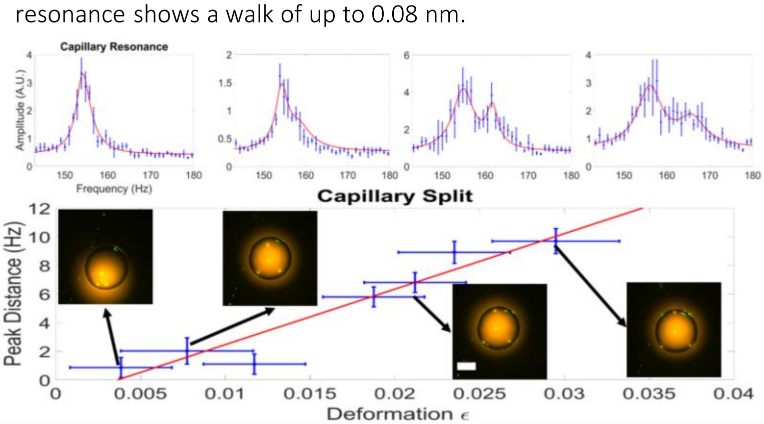
Ultrasoft devices are expected to have giant Brownian-fluctuations with improved optical cooling. However, most solids used in nanotechnology are as stiff as steel. Differently, in surface science, mixing liquids with emulsifiers permits interfacial tension with nearly zero-resistance to force. Such emulsifier-soften interfaces were never used to build devices. Assisted by optical cavities made from oil droplets submerged in water with emulsifiers adsorbed at the interface, we demonstrate here an ultrasoft device where large Brownian-fluctuations are measured via their effect on an optical whispering-gallery resonance. Benefitting from mutual resonance-enhancement with **capillary quality-factors Q of 37** and **optical Q of 150000**, which defines it as a hybrid opto capillary-cavity, we measure thermal fluctuations with **6 nm** amplitude at eigenfrequencies **155 Hz**

In our experiment, we observe the capillary vibrations of an n-heptane droplet submerged in water by coupling light into the droplet's whispering gallery mode and observing the transmission fluctuations. We trap and deform the submerged n-heptane droplet in water with optical tweezers.

We touch the resonator with the fiber coupler without scanning the laser wavelengths and observe a periodic change in our otherwise DC transmission signal. Fast Fourier Transforming the measurement from the time into the frequency domain reveals a distinguished frequency peak at155 Hz with a full-width half max (FWHM) of 4.2 Hz, resulting in a quality factor of 37.We suspect that Brownian capillary waves modulate the radius periodically and therefore fulfill the optical resonance conditions. To test our hypothesis, we operate our laser in wavelength scanning mode and couple evanescently to the drop micro-resonator and measure a single optical resonance with quality of 150000. We now identify a characteristic optical mode split resonance and trace it over 15 consecutive measurements. During which, the resonance shows a walk of up to 0.08 nm.



TOP: Transmission fluctuations through the optical tapered fiber coupler reveal periodic oscillations at 155 Hz. Note: We hold the laser at a single wavelength, and the resonator radius oscillations are responsible for the periodically fulfilling the resonator conditions. c) Fast Fourier transforming into the frequency domain shows a single peak at 155 Hz with a capillary quality factor of 37. d) A typical optical resonance with a Q of150000. e) The same optical mode pair traced in timely separated measurements. We observe a periodic optical resonance drift of up to 0.08nm. The measurements have been selected out of 15 consecutive measurements and have been arranged for visual purpose.



LEFT: Parametric studies: The capillary resonance splitting while deforming the droplet. Bottom: Capillary resonance split over resonator deformation. Blue shows experimental results. Red represents a linear fit. Smaller top plots show the experimentally measured capillary resonance with a fitted two peak Lorentzian function. The inlet shows the corresponding microresonator photography. The white bar represents 100 µm. Resonator size is 300 µm diameter.