Cavitation inception in binary liquid mixtures

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Cavitation inception in water upon a sufficiently large tension has long time only be attributed to the presence of hydrophobic stabilized gas pockets, being present on small impurities or on container walls. Only recently, the atomically smooth interface of Perfluorocarbon (PFC) droplets in water has been identified as a nucleation site for cavitation bubbles. The high gas solubility of PFC and a low interfacial tension with water support the transport of gas to the liquid-liquid interface. Upon pressure reduction, the nitrogen molecules from the PFC phase diffuse to the interface and eventually form nucleation sites[1].
Here we study the liquid-liquid interface between silicon oil and water as a potential site for cavitation nucleation. Experiments are performed in a thin liquid filled gap, where silicone oil and water form a single interface. A pulsed nanosecond laser is focused into the liquid, creating a region of high pressure and forming a primary cavitation bubble. Additionally, a high amplitude Rayleigh wave is excited that results to strong tension within the liquid gap. This rarefaction wave nucleates secondary cavitation bubbles radially surrounding the laser focus. The cavitation event is monitored with a high-speed camera and stroboscopically illuminated such that each frame is illuminated with light pulse from a femtosecond laser. Snapshots of the experiments are shown in Fig. 1. Secondary cavitation bubbles are mainly formed in the water phase, and only mild cavitation activity is found in the oil phase (Fig. 1 (a) and (b) at $t = 0.2\,\mu$s). Here, tiny bubbles close to the resolution limit are nucleated.
These observations again can be explained with the help of molecular dynamics simulations. These show, that due to the higher solubility of nitrogen in silicon oil as compared to water, upon pressure reduction, nitrogen molecules from the oil phase diffuse into the water phase and eventually form cavitation bubbles.

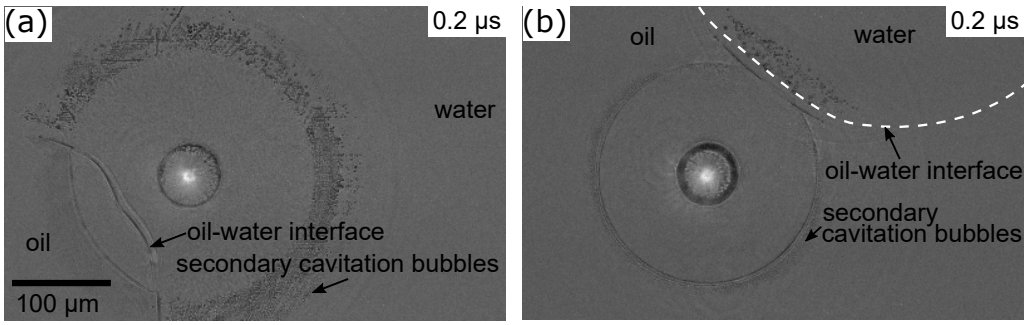

Figure 1: Experimental snapshots of a laser induced breakdown creating a primary cavitation bubble and secondary cavitation at the oil-water interface. (a) The laser is focused in the water phase and secondary cavitation bubbles are formed at a radial distance indicating the location of the rarefaction wave. These secondary cavitation bubbles are mainly formed in the water phase, only a weak activity is seen in the oil phase. (b) Laser focus in the oil phase resulting to pronounced secondary cavitation in the water phase.

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[1]Pfeiffer et al., *Nat. Phys.* **18**, 1431–1435 (2022)