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Surface cavitation on micro- and nanometer scales

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Heterogeneous bubble nucleation at surfaces has been notorious because of its irreproducibility. Here controlled multi-bubble surface cavitation is achieved by heterogenous nucleation of bubbles on a hydrophobic surface patterned with micro-cavities. The expansion of the nuclei in the micro-cavities is triggered by an impulsive lowering of the liquid pressure. The procedure allows to control and fix the bubble-distance within the bubble cluster. We observe a perfect quantitative reproducibility of the cavitation events where the inner bubbles in the two-dimensional cluster are shielded by the outer ones, reflected by their later expansion and their delayed collapse. Apart from the final bubble collapse phase (when jetting flows directed towards the cluster's center develop), the bubble dynamics can be quantitatively described by an extended Rayleigh-Plesset equation, taking pressure modification through the surrounding bubbles into account.
When repeating the same experiments with flat polyamide and hydrophobized silicon surfaces populated with surface nanobubbles (as can be seen through atomic force microscopy), these nanobubbles do not act as nucleation sites for cavitation bubbles, in contrast to the expectation. This implies that surface nanobubbles are not just stable under ambient conditions but also under enormous reduction of the liquid pressure down to -6MPa. We denote this feature as superstability.