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Ultrasound-induced microbubble coalescence by parametric instability

Michiel Postema,^{1,2*} Philippe Marmottant,³ Charles T. Lancée,¹ Sascha Hilgenfeldt,³ Nico de Jong^{1,2,3}

¹Department of Experimental Echocardiography, Thoraxcentre, Erasmus MC, Rotterdam;

²Interuniversity Cardiology Institute of the Netherlands (ICIN), Utrecht;

³Physics of Fluids, Department of Applied Physics, Faculty of Science and Technology, University of Twente, Enschede.

Micrometer-sized gas bubbles in a liquid will oscillate upon insonification by ultrasound. During the expansion phase, bubble coalescence is frequently observed. We give a description of the microbubble coalescence mechanism, based on high-speed optical observations and theoretical modeling.

Ultrasound-induced microbubble coalescence is the fusion of two or more microbubbles. As adjacent bubbles expand, the following stages can be distinctly observed: flattening of the bubble surfaces prior to contact, drainage of the interposed liquid film toward a critical thickness, rupture of the liquid film, and formation of a single bubble. Locally the critical thickness is more quickly reached than might be explained from film drainage alone, due to thickness perturbations induced by secondary radiation forces and amplified by a parametric instability. The coalescence process is thus sped up to durations of less than 1 μ s for ultrasound contrast agent microbubbles in the micron diameter range.

The coalescence mechanism presented here has potential clinical applications in harmonic imaging, noninvasive blood pressure measurements, and targeted drug delivery.

