Inviscid Oscillations of Constrained Bubbles in Drops

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Inviscid oscillations of constrained bubbles and drops

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In the instruments for measurements of the interfacial elasticity and viscosity, shape oscillations of the bubble or drop may occur when the drop is forced at higher frequencies. For better understanding of these shape oscillations, a linear inviscid theory is developed using variational principles[1] (via Lagrange's equations and Lagrange's lambda-multipliers). The theory allows determining eigenmodes (i.e. eigenfrequencies, eigenmode shapes and damping of eigenmode oscillations), but also response of the bubble shape to a motion of its support or to volume variations. Present theory covers also the cases previously analyzed by Strani and Sabetta[2] and Bostwick and Steen[3]. It can be applied to both bubbles and drops. Overall, the theory is flexible, as it can easily adapt to any type of constraints, and compared to previous treatments, it is also easy and intuitive.

The theory prediction has been compared to experiments. Good agreement is found for the case of small bubbles, which have spherical static shape. Experimental results for larger bubbles and drops deviate from the theory, as a neck is formed. It is shown that this deviation correlates well with a ratio of bubble volume to the volume at its detachment.

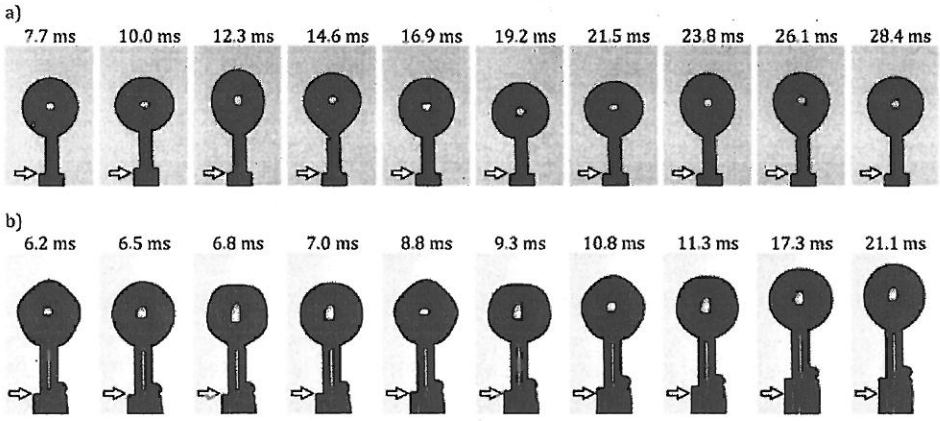

Figure: High-speed record of a ubble oscillating at a tip of capillary, a) $D = 1.48$ mm, bubble oscillates mostly at first eigenmode, b) $D = 1.19$ mm, oscillates mostly at third eigenmode

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[2] Strani, M., Sabetta, F. (1984): Free vibrations of a drop in a partial contact with a solid support. *J Fluid Mech* **141**, 233.

[3] Bostwick, J. B., Steen, P. H. (1995): Capillary oscillations of a constrained liquid drop. *Phys Fluids* **21**, 032108.