Experimental Investigation of Bubble Dynamics with a Shock Tube

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In this talk, we would like to present our recent experimental work on bubble dynamics conducted with a setup that combines a shock tube and a gelatinous medium as the liquid carrier medium for pure gas bubbles. We will discuss first results, possibilities of the setup as well as challenges and limitations.

The chair of aerodynamics and fluid mechanics acquired and set up a shock tube in recent years. To complement the numerical expertise at the chair, we conduct experiments on corresponding topics, such as bubble collapse and droplet breakup.

For bubble collapses, our recent experimental method relies on two aspects to achieve a constant surrounding pressure and well-defined boundary conditions. First, the shock tube generates a planar shock front which provides an instantaneous pressure jump to a constant high pressure. Second, a gelatinous mixture is used as a water-like carrier medium to contain pure gas bubbles at rest. Although both aspects – using a shock tube and placing bubbles in gelatin – have been used individually in previous studies, the combination expands the methodology in bubble dynamics research and allows getting insight into new aspects.

Capitalizing on the strengths of the setup, our initial research efforts include comparing aspherical bubble collapses using bubbles of different gas content. By using gases with a vapor pressure slightly above atmospheric pressure, also the aspect of phase change during the collapse can be studied. In addition, the setup is very powerful for investigating pairs of bubbles or multi-bubble interaction. Bubble pairs of various size ratios and at various distances can be produced and their reaction to the pressure rise can be studied. Recent work showed that four types of interaction for gas bubble pairs in the free field can be defined by non-dimensional parameters. This classification differs from the literature in some respects due to the use of pure gas bubbles instead of vapor bubbles. Lastly, the aspherical collapse and continuous oscillation of bubbles near solid and soft surfaces is a point of interest that can be studied by carefully placing bubbles adjacent to boundaries.

Apart from the advantages and possibilities of the setup, we also would like to highlight some challenges. An inherent problem of using gelatin is to produce a clear and homogenous mixture that does react as a liquid and does not influence the bubble collapse significantly. In addition, it is essential to create spherical bubbles while not affecting the homogeneity of the gelatin, which makes the bubble production challenging.

Upon conducting experiments, we also realized that the applied pressure rise of several bar can lead to a small but rapid deformation of our metal test sections, which strongly affects rise time and evolution of the pressure. A test section with solid side walls (up to 130mm) shows a fast rise time and a constant pressure that remains at a high value (albeit not at the expected value predicted from ideal wave motion). A test section with side walls of 40 mm thick aluminum alloy plates displays only a slow pressure rise that is insufficient to cause strong bubble collapse. This indicates a strong dependency of results on the applied setup, which should be of interest when looking at other experimental setups in the literature.

The talk can be given in German or in English.

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