Materials Sciences in Space (G)
Gravitational Effects on Physico-Chemical Processes (G01)

CAVITATION STUDIES IN MICROGRAVITY

Philippe Kobel, kobel@mps.mpg.de
Max Planck Institut fur Sonnensystemforschung, Katlenburg-Lindau, Germany
Danail Obreschkow, danail.obreschkow@gmail.com
Germany
Mohamed Farhat, mohamed.farhat@epfl.ch
Laboratoire des Machines Hydrauliques, EPFL, 1007 Lausanne, Switzerland, Switzerland
Nicolas Dorsaz, nicolas.dorsaz@epfl.ch
Switzerland
Aurele De Bosset, aurele.debosset@a3.epfl.ch
Switzerland

The hydrodynamic cavitation phenomenon is a major source of erosion for many industrial systems such as cryogenic pumps for rocket propulsion, fast ship propellers, hydraulic pipelines and turbines. Erosive processes are associated with liquid jets and shockwaves emission following the cavity collapse. Yet, fundamental understanding of these processes requires further cavitation studies inside various geometries of liquid volumes, as the bubble dynamics strongly depends the surrounding pressure field. To this end, microgravity represents a unique platform to produce spherical fluid geometries and remove the hydrostatic pressure gradient induced by gravity.

The goal of our first experiment (flown on ESA's parabolic flight campaigns 2005 and 2006) was to study single bubble dynamics inside large spherical water drops (having a radius between 8 and 13 mm) produced in microgravity. The water drops were created by a micro-pump that smoothly expelled the liquid through a custom-designed injector tube. Then, the cavitation bubble was generated through a fast electrical discharge between two electrodes immersed in the liquid from above. High-speed imaging allowed to analyze the implications of isolated finite volumes and spherical free surfaces on bubble evolution, liquid jets formation and shock wave dynamics. Of particular interest are the following results: (A) Bubble lifetimes are shorter than in extended liquid volumes, which could be explain by deriving novel corrective terms to the Rayleigh-Plesset equation. (B) Transient crowds of micro-bubbles (smaller than 1mm) appeared at the instants of shockwaves emission. A comparison between high-speed visualizations and 3D N-particle simulations of a shock front inside a liquid sphere reveals that focus zones within the drop lead to a significantly increased density of induced cavitation. Considering shock wave crossing and focusing may hence prove crucially useful to understand the important process of

cavitation erosion.

The aim of our future microgravity experiment is to assess the direct effects of gravity on cavitation bubble collapse through a comparison of single cavitation bubbles collapsing in microgravity, normal gravity, and hypergravity. In particular, we shall investigate the shape of the bubble in its final collapse stage and the amount of energy dissipated in the dominant collapse channels, such as liquid jet, shock wave, and rebound bubble. The highly spherical bubbles will be produced via a point-like plasma generated by a high power laser beam. One major hypothesis that we will test is an increase in shock wave energy with decreasing gravity as a consequence of the higher final sphericity and suppression of liquid jets. To support this, we introduce an analytical model for the gravity-perturbed asymmetric collapse of spherical bubbles, and demonstrate that all initially spherical bubbles develop a gravity-related vertical jet along their collapse.