PhD Proposal 2017

School: Ecole Centrale de Lyon	
Laboratory: LMFA	**Web site: http://lmfa.ec-lyon.fr/**
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Collaboration with other partner during this PhD: **In France:**	**In China:**

Title: Oscillating bubble clouds
Scientific field: Fluid mechanics, Acoustics
Key words: CFD, compressible flows, two-phase flows

Details for the subject:

Background, Context:

Bubbles oscillate in volume and shape when exposed to variations in the ambient pressure and flow, as a result of a coupling between the volume and shape of bubbles with the fluid flow.
The present aim is to determine the response of a bubbly mixture to such external forcing, and whether a mixture of bubbles is stable. The dynamics of a single oscillating bubble has been studied previously, albeit under simplified model assumptions, but not much is known regarding the dynamics of a cloud of bubbles. In a way, a bubbly liquid is therefore a kind of effective material, with mechanical properties about which not much is known.

For a single oscillating bubble, classical theory is mostly within the context of potential flow for incompressible liquids. Although this theory is well advanced, and includes non-linear shape mode oscillations, it does remain within this simplification. Some numerical simulations have been conducted to allow for shape deformation that is not small, but still within the same framework of incompressible potential flow (as in boundary integral methods). Early numerical methods for the full problem (compressible, viscous) have been found to be not sufficiently efficient to deal with the large range of time scales involved.

The dynamics of several bubbles, or bubble clouds, is different from that of isolated bubbles. This is because the dynamics of each bubble changes the flow in the liquid around it, and this disturbance of the flow is "felt" by other bubbles, which in turn modify the flow around all other bubbles. As a result, oscillating bubbles may attract or repel each other, and this changes the composition of a bubbly mixture. The dynamics of a bubbly mixture is therefore that of interacting individual bubbles. The resulting collective behaviour, and microstructure of the entire mixture remains an open problem in the literature.

Research subject, work plan:

This project aims to develop a computational model of oscillating bubbles, and to use this to simulate oscillating bubbly mixtures. Specifically, the interest is to determine the dynamics of individual bubbles in a mixture, and to compare their dynamics with that of an isolated bubble.

The work plan is to first conduct an initial literature study. This may include bubble dynamics, numerical methods for partial differential equations, and/or computer programming, depending on the background of the PhD student.
Next, a computational method will be implemented for a basic setup, and to simulate the dynamics of a single oscillating bubble. The results can also be compared against prior results in the literature, as validation of the numerical method.
Subsequently, two interacting oscillating bubbles will be simulated, and finally a mixture of bubbles. The results will then be used to answer the questions set out above: what is the collective behaviour of a bubbly mixture?

The successful completion of this PhD subject would require a strong background in theoretical fluid mechanics, numerical methods for solving partial differential equations, and computer programming. The supervisors have a track record that is well-established internationally in numerical simulations and theoretical modelling in fluid mechanics, and are experienced supervisors of PhD projects.