A pressure non-equilibrium two-phase model for simulating bubble clusters in heterogeneous cavitation

Mandeep Saini*[1], Fabian Denner[2], and Kevin Schmidmayer[1]

[1]Universite de Pau et des pays des l'Adour, INRIA Bordeaux – LMAP (Laboratoire de Mathématiques et de leurs Applications de Pau) – France

[2]Department of mechanical engineering, Polytechnique Montreal, Qubec – Canada

Résumé

Bubble clusters appear across many length scales in applications such as lithotripsy (kidney-stone treatment), noise reduction using bubble curtains in offshore drilling, and several others. In most of these applications, the clusters interact with pressure waves, which makes these systems inherently multiscale. Resolving every single bubble in direct numerical simulations is therefore extremely expensive and often impractical, making subgrid modeling essential. In this work, we model a bubble cluster as a subgrid mixture of the gas inside the bubbles and the surrounding liquid. The numerical framework is based on a pressure non-equilibrium two-phase model that has previously been used for simulating both fluid mixtures and pure fluids. Phase change is omitted to model heterogeneous cavitation. This model was recently combined by Schmidmayer (1) with finite pressure relaxation, for accurately simulating shock-wave interaction with diffused interfaces. We build on their approach and extend the model to bubble cluster dynamics by proposing closures based on Keller-Miksis equation for spherical bubble dynamics. We validate the model using two test cases: the collapse of a single bubble and the evolution of a bubble cluster inside a cylindrical droplet impacted by a Mach 2.4 shock wave. The proposed model provides a practical tool for design and control of systems in which bubble clusters play a key role. (1) Schmidmayer, K. and Caze, J. and Petitpas, F. and Daniel, E. and Favrie, N., {Modelling interactions between waves and diffused interfaces}, International Journal for Numerical Methods in Fluids, 95, 215–241, 2023.

*Intervenant