# Simulation of liquid/gas interface break-up with a coupled Level Set/VOF/Ghost Fluid method

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**Abstract:** Recent progress in numerical simulations allows reproducing the primary breakup of liquid systems in gaseous media. Our approach is based on the coupling of Level Set, Ghost Fluid and VOF methods. Results concern bubble trapping during liquid jet atomization and liquid/gas interface break-up with a high density ratio and a strong velocity difference between the two phases.

*Keywords* Level Set method,, Two phase flow, atomization.

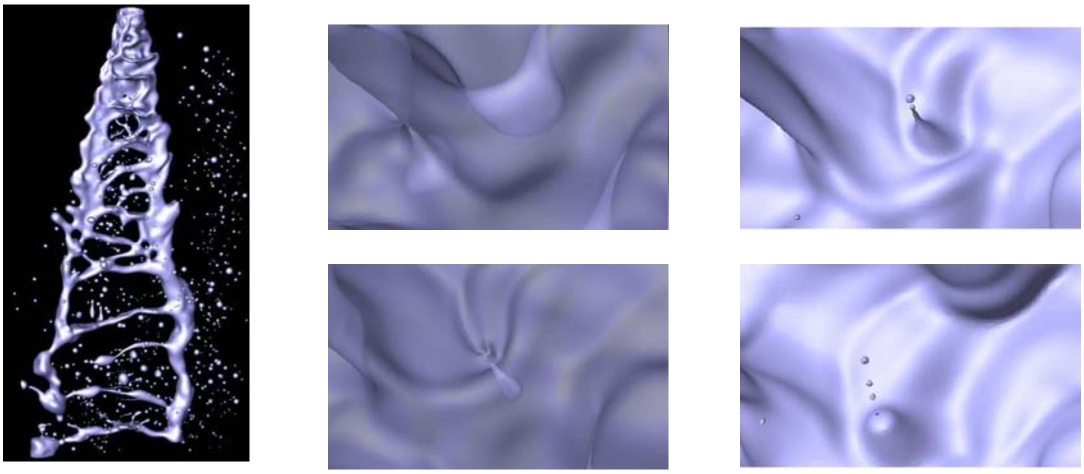
## 1 Introduction

Numerical simulations are a very powerful tool to investigate a wide field of physical processes, thanks' to constant developments and high efficiency of computer resources. A major interest of simulations lies in their ability to produce extensive 3D data on complex phenomenon, with a large amount of information that can help in physical understanding. In two phase flow, the main challenge is obviously to capture the interface behavior with enough accuracy, and we thus developed a code (ARCHER) for interface tracking in order to describe the dynamics of liquid/gas interface.

In liquid atomization, a lot of topological changes occur (interface pinching or merging, droplet coalescence or secondary break-up) and the numerical method should describe the interface motion precisely. Moreover we observed that much more reliable results are obtained when the method handles jump conditions at the interface without artificial smoothing, and obviously when it respects mass conservation. We thus decide to couple the most suitable methods, that means interface tracking is performed by a Level Set method, the Ghost Fluid Method is used to capture accurately sharp discontinuities, and a coupling between the Level Set and VOF methods is made to ensure mass conservation. A projection method is used to solve incompressible Navier-Stokes equations that are coupled to a transport equation for the level set function. Poisson equation is solved with second order central scheme, and a multigrid algorithm for preconditioning a conjugate gradient method is used. Extensive discussions on the methods and numerical validations are reported in Ménard et al [1, 2]. Finally specific care has been carried out to improve simulation capabilities with MPI parallelization. One of the first detailed simulations of jet primary break up has been carried out by Ménard et al [1] and several papers have then reported on similar cases such Herrmann [3], Desjardins et al [4], and a highly refined (6 billion points) study by Shinjo & Umemura [5].

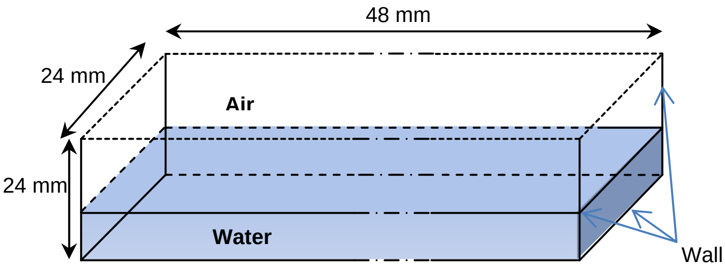
## 2 Problem Statement

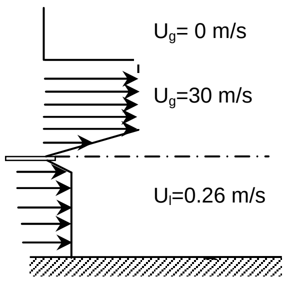
The paper will recall the numerical schemes briefly, and then report on the last developments of the code. The first case concerns a coupling between internal flow and primary breakup simulations in the case of a compound nozzle with a complex geometry and focusses on some remarkable behaviors of the liquid phase, such as bubble trapping inside the liquid jet and jet forming when they burst at the interface (Figures 1).



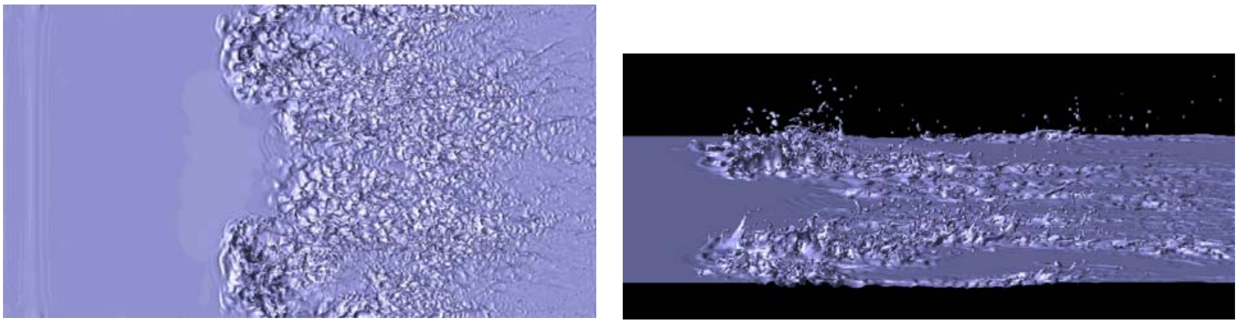
Figures 1: Simulated jet Trapped bubble Bubble burst & jet forming

The second case concerns a configuration that remains quite difficult to simulate, that is liquid/gas interface break-up with a high density ratio (about 1000) and a strong velocity difference between the two phases (10 to 100m/s). The geometry is:




Simulations are still under developments, and first results for a 512x512x1024 grid are presented on Figures 2



Figures 2: Top view of the liquid interface Side view (zoom) of the liquid interface

## References

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