SHOCK BUBBLE INTERACTION: NUMERICAL SIMULATION

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Introduction

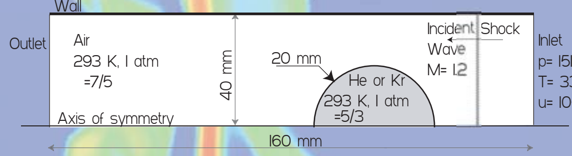
The present work deals with the Richtmyer-Meshkov instability in spherical configuration. It corresponds to the interaction of a shock wave with a spherical inhomogenity i.e. a bubble filled with a gas different from the surrounding one.

Numerical simulations of a plane shock-spherical bubble interaction have been realized to be compared to previous experiments conducted in our laboratory. Both cases heavy/light (air/helium) and light/heavy (air/krypton) have been investigated. The experimental diagnostic technique used is a high speed camera multiple shadowgraph exposure and allows to follow the development process of the phenomena. However, due to the visualization integration along the shock width, we are not able to localize the different gases during the mixing process. Thus, the goal of the present numerical study, realized with our CARBUR code, is to complete the description of the bubble behaviour by giving the values of species concentrations, vorticity and volume.

Numerical model and study case

Our numerical code is based on the discretization of Navier-Stokes's equations by a finite volume method. A second order scheme, for both space and time, with a Van Leer slope limiter has been used. Moreover, convective fluxes are calculated with an exact Riemann solver, diffusive fluxes are estimated by the means of a centered finite difference method.

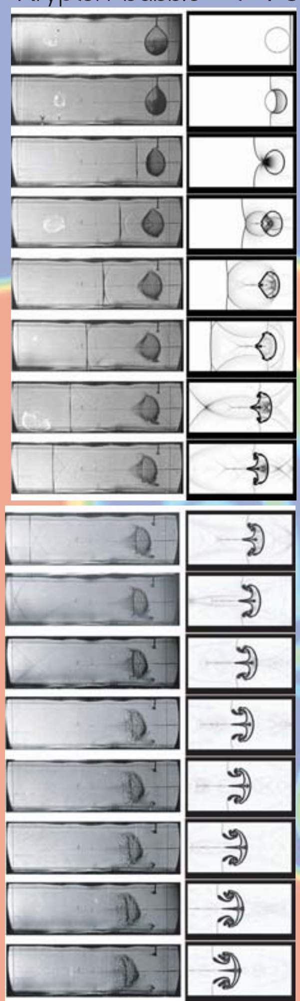
The geometry and the fluid flow are supposed to be axisymmetric. The flow is considered as laminar.



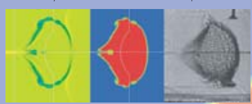
Results and discussion

The distortion mechanism of the bubble in the light/heavy (air/helium) as well as the light/heavy case (air/krypton) is well described by the simulation. In the same way, all shocks are well captured.

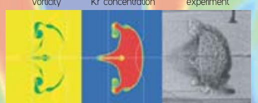
Krypton bubble t= 70 s



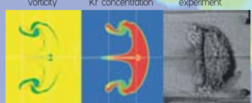
Experimental shadowgraph Numerical schlieren



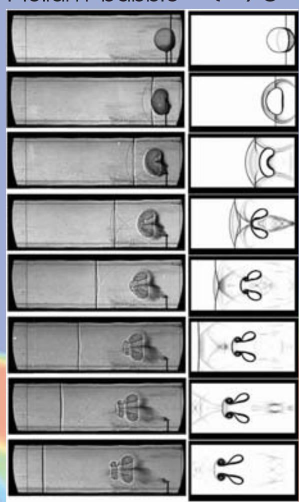
The vorticity is concentrated on the bubble frontiers.
A reverse jet in the spike is noticed.



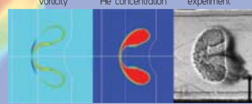
The vorticity increases the mixing.
The reverse jet in the spike moves back.



Helium bubble t= 70 s



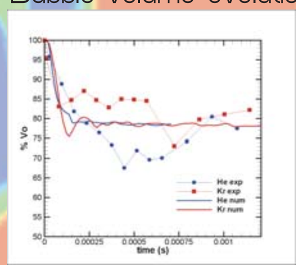
Experimental shadowgraph Numerical schlieren



As for the Krypton, the vorticity is concentrated on the bubble frontiers.
The mixing has not yet started.

The bubble is completely reversed.
The vorticity increases the mixing zone in the front ring.

Bubble volume evolution



One can note the initial compression of bubbles.

The final volume seems to be constant and equal of about 80 % of the initial volume.

Conclusion

Our numerical results are in good agreement with experiments.

The numerical simulation shows the link between the mixing zone and the vorticity zone.

The simulation as well as the experiment, point out the initial compression of the bubble.
The final values of the bubble volume are close.

Numerically, the bubble volumes are constant after the initial compression.