

Diffuse interface models & methods for compressible multiphase flows

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May 8-12, 2017, CSRC, Beijing, China

What is multiphase flow ?

General features: Existence dispersed phases (fluid-like or not) in underlying flow separated by interfaces, e.g.,

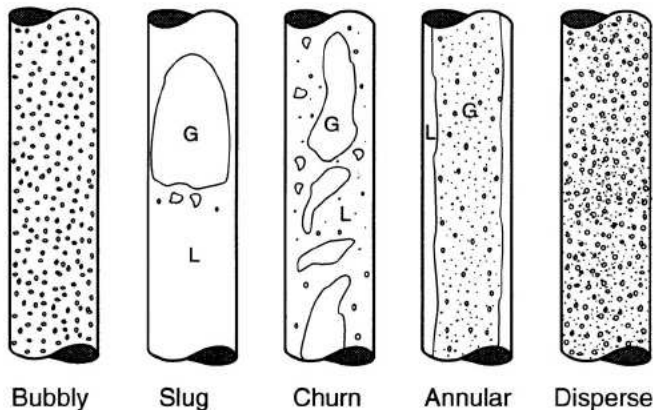


Figure 7.7. Sketches of flow regimes for two-phase flow in a vertical pipe. Adapted from Weisman (1983).

Examples from C.E. Brennen: Fundamentals of Multiphase Flow, Cambridge, 2005

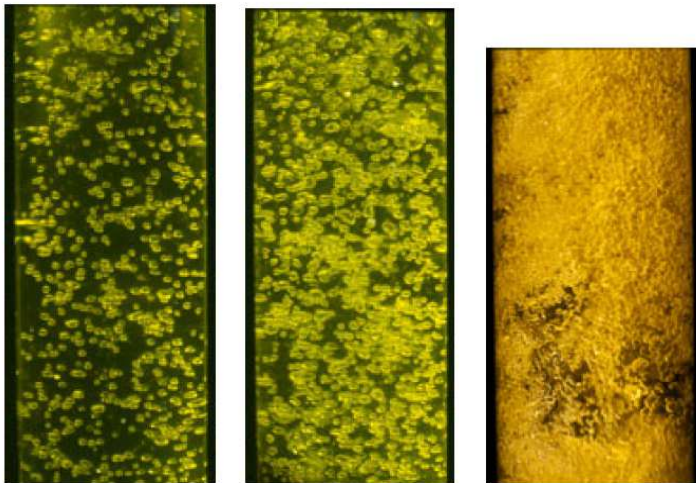


Figure 7.9. Photographs of air/water flow in a 10.2cm diameter vertical pipe (Kytömaa 1987). Left: 1% air; middle: 4.5% air; right: > 15% air.

Examples from C.E. Brennen: Fundamentals of Multiphase Flow, Cambridge, 2005

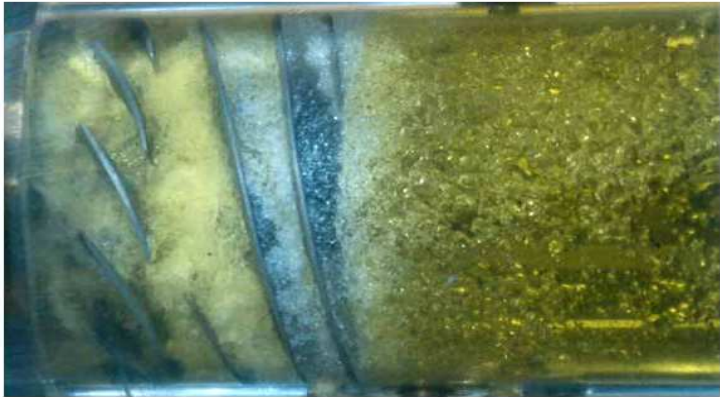


Figure 7.12. A bubbly air/water mixture (volume fraction about 4%) entering an axial flow impeller (a 10.2cm diameter scale model of the SSME low pressure liquid oxygen impeller) from the right. The inlet plane is roughly in the center of the photograph and the tips of the blades can be seen to the left of the inlet plane.

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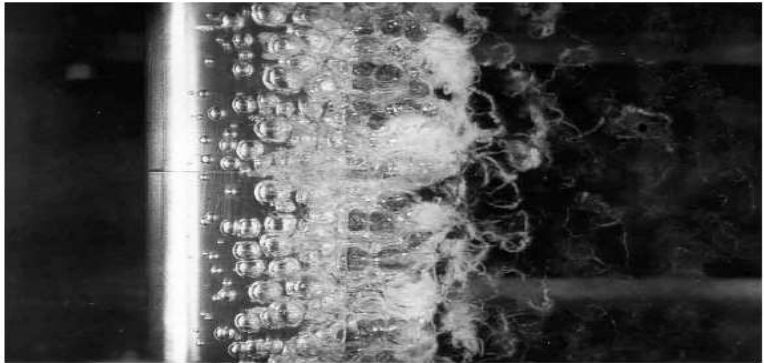
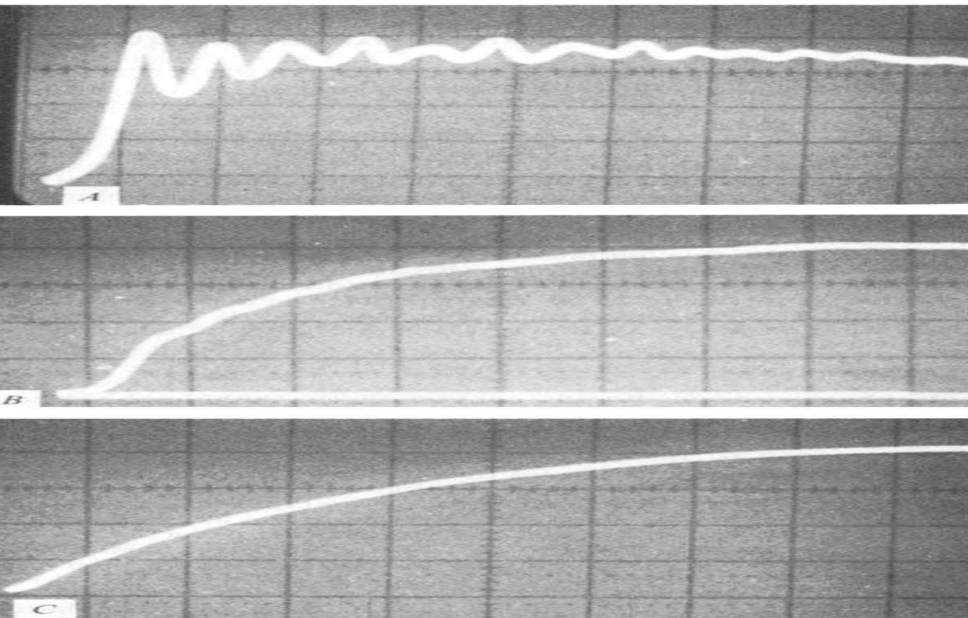
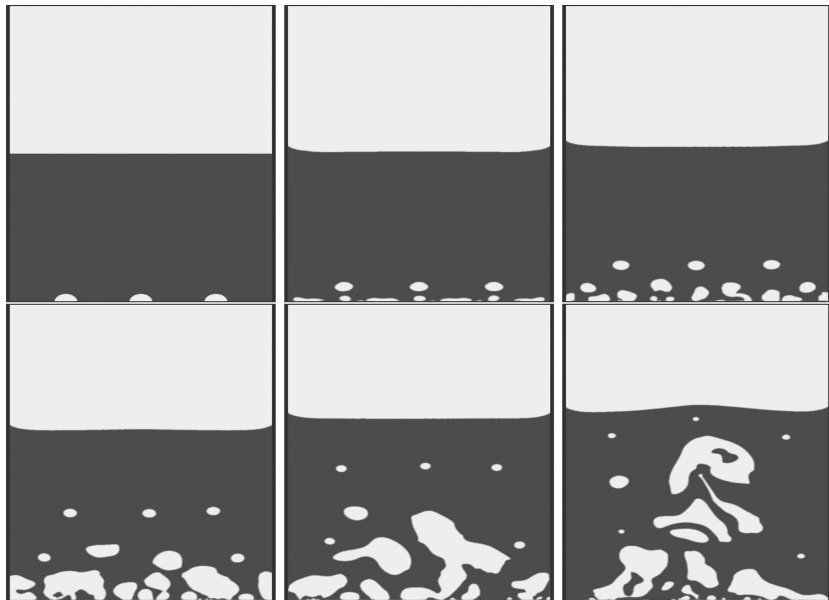


Figure 7.14. Traveling bubble cavitation on the surface of a NACA 4412 hydrofoil at zero incidence angle, a speed of 13.7 m/s and a cavitation number of 0.3. The flow is from left to right, the leading edge of the foil is just to the left of the white glare patch on the surface, and the chord is 7.6 cm (Kermeen 1956).

Pressure wave in bubbly liquid



Boiling flow (Saurel et al CAF 2016)



Bubble collapse over flat surface

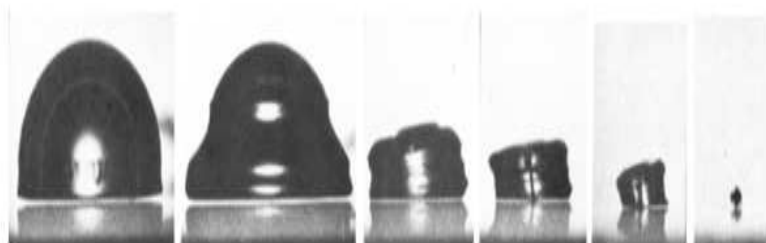
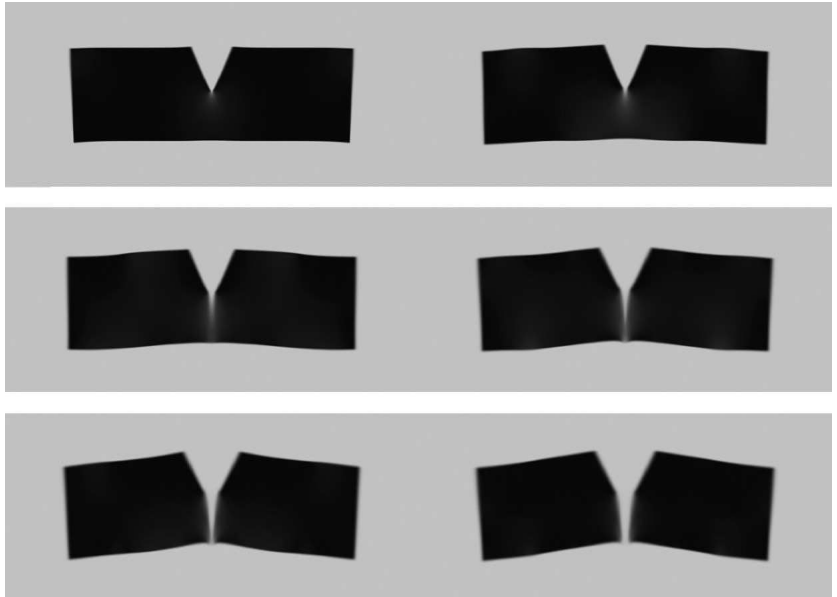


Figure 5.7. Series of photographs of a hemispherical bubble collapsing against a wall showing the *pancaking* mode of collapse. From Benjamin and Ellis (1966) reproduced with permission of the first author.

Condensation fronts



Fracturing of solid plate (Ndanou etal JCP 2015)



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- Mathematical models: Average (fluid-mixture) type
- Numerical methods: Discontinuity-capturing type

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References

- D. Jamet: Diffuse interface models in fluid mechanics (technical report)
- D. M. Anderson, G. B. McFadden, & A. A. Wheeler: Diffuse-interface methods in fluid mechanics, Annu. Rev. Fluid Mech., 1998, 32:139-65

Lecture outline

Single phase → Two phase → Three phase & more

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That is,

- 1 & 2. Fluid-mixture type models & methods for compressible multicomponent flow
- 3 & 4. Homogeneous relaxation models & methods for compressible two-phase flow
- 5 & 6. Homogeneous relaxation models & methods for compressible three-phase flow & more

Joint work with

- F. Xiao (Tokyo Tech., Japan): Eulerian interface-sharpening
- M. Pelanti (ENSTA, Paris Tech., France): Two- & three-phase models & algorithms