XVIII International Conference on Hyperbolic Problems
Theory, Numerics, Applications
Málaga, June 20-24, 2022

An all-speed scheme for isentropic two-phase flows

Andrea Thomann*, Mária Lukáčová-Medvid'ová*, Gabriella Puppo†

We are interested in the numerical simulation of liquid-gas mixtures, where the sound speed of the liquid phase is consistently faster than the one of the gas phase. If in addition, the material wave is significantly slower than the individual acoustic waves, the system can exhibit three different scales of wave speeds. In these regimes, which are characterized by small, potentially different phase Mach numbers, using an explicit scheme requires a time step that scales with the smallest appearing Mach number. This is especially problematic when phenomena are monitored over a long time period. Moreover, the main interest often lies on a sharp resolution of slow dynamics which would allow for a much larger time step. Therefore, we use implicit-explicit (IMEX) time integrators where fast waves are treated implicitly leading to a CFL condition which is restricted only by the local flow velocity.

In this talk, we present an all-speed finite volume scheme for isentropic two-phase flows based on a symmetric hyperbolic thermodynamically compatible model given in [1, 2]. Since the flow regimes can range from compressible for gases to almost incompressible for some liquids, a consistent discretisation of the limit equations in the singular Mach number limit is important. This so called asymptotic preserving (AP) property together with the correct numerical viscosity are essential for the simulation of weakly-compressible flows. Since the flow regime of the two-phase flow model from [1, 2], is characterized by two potentially distinct phase Mach numbers, different singular Mach number limits can be obtained which depend on the constitution of the mixture. The AP property of our IMEX scheme [3] is obtained by using a reference solution approach based on the profound knowledge of well-prepared initial data. Further, the reference state is used to linearise pressure based quantities avoiding the necessity for nonlinear implicit solvers. The consistency with single phase flow, accuracy and the approximation of material waves in different Mach number regimes is illustrated in numerical simulations.

Acknowledgements

A.T. and M.L. have been partially supported by the Gutenberg Research College, JGU Mainz. Further, M.L. is grateful for the support of the Mainz Institute of Multi-Scale Modelling. G.P. is a member of GNCS and acknowledges the support of PRIN2017 and Sapienza, Progetto di Atteneo [RM120172B41DBF3A].

References

[1] E. Romenski and E. F. Toro. Compressible Two-Phase Flows: Two-Pressure Models and Numerical Methods. *Comput. Fluid Dyn. J.*, 13, pp. 403–416, 2004.

[2] E. Romenski, D. Drikakis and E. F. Toro. Conservative Models and Numerical Methods for Compressible Two-Phase Flow. *J. Sci. Comput.*, 42, pp. 68–95, 2010.

[3] M. Lukáčová-Medvid'ová, G. Puppo and A. Thomann. An all Mach number finite volume method for isentropic two-phase flow. *arXiv preprint: https://arxiv.org/abs/2202.01577*

*Institut für Mathematik, Johannes-Gutenberg-Universität Mainz, Staudingerweg 9, 55099 Mainz, Germany. Email: athomann@uni-mainz.de, lukacova@mathematik.uni-mainz.de

†Dipartimento di Matematica, La Sapienza Università di Roma, Piazzale Aldo Moro 5, 00185 Roma, Italy. Email: gabriella.puppo@uniroma1.it