A comparative study of incompressible and weakly-compressible multi-fluid flows in SPH and their performance

Jan-Philipp Fürstenau*, Bircan Avci and Peter Wriggers
G. W. Leibniz Universität Hannover
Institute of Continuum Mechanics
Appelstraße 11, 30167 Hannover, Germany
e-mail: fuerstenau@ikm.uni-hannover.de
web page: http://www.ikm.uni-hannover.de

ABSTRACT

The contact of multiple fluids and their mixing is a problem appearing in a highly diverse manner in technical and biomedical applications. In practice, the simulation of multi-fluid problems is nevertheless a topic with only few satisfying solutions. The main issue in multi-fluid flows with Lagrangian methods is the jump in several fluid properties which may not affect the pressure field. In the literature one can find several approaches applied on weakly-compressible and incompressible smoothed particle hydrodynamics (SPH) to overcome these issues.
In a previous work a combination of the pressure and viscous terms from [1] in combination with the surface tension from [2] showed its capabilities for the simulation of high density ratios with a weakly-compressible approach. For the simulation of incompressible flow the pressure is acquired via the pressure-Poisson-equation (PPE) discretized by three discretization approaches described in [3]. For the solution of the PPE one can choose between direct solvers and iterative solvers. In this work the solutions of preselected direct and iterative solvers are compared with the approach of [4] who uses a fix-point-method for the solution without saving the equation system.
In this work two comparisons will be given: Firstly, a comparison of the stability and quality of the four physical approaches. Secondly, a comparison of the quality of the solution, the memory usage and computational speed of the different mathematical solutions for the PPE.
The multi-fluid models and solvers were implemented in the GPU-based open-source SPH framework DualSPHysics [5] that is basically designed for oceanographic problems with solid boundaries and gives a good basis for extensions of the code.

REFERENCES

[1] Monaghan, J. J., and Ashkan Rafiee. "*A simple SPH algorithm for multi-fluid flow with high density ratios.*" International Journal for Numerical Methods in Fluids 71.5 (2013): 537-561.
[2] Hu, Xiang Yu, and Nikolaus A. Adams. "*A multi-phase SPH method for macroscopic and mesoscopic flows.*" Journal of Computational Physics 213.2 (2006): 844-861.
[3] Fatehi, R., M. Fayazbakhsh, and M. T. Manzari. "*On discretization of second-order derivatives in smoothed particle hydrodynamics.*" Proceedings of World Academy of Science, Engineering and Technology. 30 (2008): 243-246.
[4] Ihmsen, Markus, et al. "*Implicit incompressible SPH.*" IEEE Transactions on Visualization and Computer Graphics 20.3 (2014): 426-435.
[5] Crespo, A. J. C., et al. "*DualSPHysics: Open-source parallel CFD solver based on Smoothed Particle Hydrodynamics (SPH).*" Computer Physics Communications 187 (2015): 204-216.