A multi-fluid SPH algorithm for high density ratios implemented on GPU

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ABSTRACT

The Smoothed Particle Hydrodynamics (SPH) method is a recent numerical method to particularly represent free surface flows. Because of the particle discretization of the continuum the spatial resolution of the free surfaces is not dependent on the quality of an underlying grid like in grid-based methods that prescribes the possible forms of the surfaces. Designed for the simulation of astrophysical problems, SPH successfully established itself in oceanographic simulations for example to calculate wave impinge upon on- and off-shore structures.

For realistic simulations of fluid problems in a broader range of applications it is necessary to extend the method on multi-fluid (or multi-phase) flows. Through its easy nature the main routines of the SPH method can easily be extended to result in a free surface multi-fluid flow model. However, numerical experiments on the resulting multiphase flows showed stability problems for density ratios greater than 2 [1]. The instabilities in these cases result from the density jumps at the interfaces between the phases. Due to the different densities, the lighter particles get accelerated more than the heavier ones which leads to large velocities in the lighter phase. To solve this issue, the variables for calculation of acceleration have to be adjusted. If adjusted in a physically correct way by taking the real speed of sound of each fluid in accordance, this leads to minuscule time steps. If adjusted in terms of reasonable time steps and stability the model tends to become unphysical as the speed of sound of the lighter fluid has to be larger than in the heavier one [2].

In the current work multi-fluid models were implemented in the GPU-based open-source SPH framework DualSPHysics [3] that is basically designed for oceanographic problems with solid boundaries and solid swimming bodies. The focus of this work is to survey the implementations with regard to stability and computational effort for multi-fluid simulations as well as the possibility of an implementation on a GPU.

REFERENCES

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