Multi-GPU accelerated gas-liquid-solid three-phase lattice Boltzmann model

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In this work, an efficient three-phase lattice Boltzmann model for gas-liquid-solid has been developed. The state of art 2D mass-conserving immiscible two-phase lattice Boltzmann model [1] has been extended to 3D model. The immersed boundary method has been applied to deal with the floating bodies penetrating the free surface of water and air. To be capable of the large-scale simulations, the advanced GPU direct-MPI hybrid framework with uniform mesh has been developed. Several 3D benchmarks including rising bubble, free fall liquid drop and breaking ocean waves have been simulated to investigate the parallel performance of the developed multi-GPU technique. Then the water entry and exist phenomena in ocean engineering are simulated to test the accuracy, robustness and efficiency of the present 3-phase lattice Boltzmann model. The results indicate that the present solver has achieved around two orders of magnitude speed-up ratio compared with the series counterpart. The proposed three-phase model has been the promising tool in dealing with physical problems in ocean engineering.

[1] Abbas Fakhari, Martin Geier, Taehun Lee, A mass-conserving lattice Boltzmann method with dynamic grid refinement for immiscible two-phase flows, Journal of Computational Physics 315, 2016, 434-457