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Compressible lattice Boltzmann method for rotating overset grids

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Lattice Boltzmann method (LBM) is considered as a powerful approach for many industrial applications thanks to its low computational cost for high fidelity resolutions. Although the method suffers from instability issues in the compressible or high Reynolds number flows, they can be successfully overcome by using different collision operators, such as the recursive regularized collision model [1, 2, 3, 4].

An important issue is whether the compressible LBM model is still able to maintain its stability and accuracy in the context of complex numerical systems, using overset grids for instance (so called, Chimera mesh). The rotating overset grid is one of the classical methods to actualize the rotating geometries in computational fluid dynamics, and it has been analyzed in the LBM framework in the context of athermal (weakly compressible) flows [5, 7, 6, 8]. However, to the author's best knowledge, no LBM model has demonstrated so far its capability to simulate compressible flows over the overset grids.

In this work, we use the compressible recursive regularized collision model to stabilize the high-Mach flow conditions. Fictitious forces inside the rotating region are discretized using the Guo's forcing term. Quadratic interpolations are applied at the border of the rotating and fixed grids to perform the communications between both grids. Thermal properties are computed through the entropy equation which is solved based on high order MUSCL-Hancock scheme.

The results show that the proposed numerical LBM framework is able to capture the essential physics of high mach flows through rotating geometries, with the expected accuracy and relatively low computational cost.

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