Enhancement of the Stability of Lattice Boltzmann Methods by Dissipation Control

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Artificial dissipation is a well known tool for the improvement of stability of numerical algorithms. However, the use of this technique affects the accuracy of the computation. We analyse various approaches proposed for enhancement of the Lattice Boltzmann Methods (LBM) stability. In addition to some previously known methods, the Multiple Relaxation Time (MRT) models, the entropic lattice Boltzmann method (ELBM), and filtering (including entropic median filtering), we develop and analyze new filtering techniques with independent filtering of different modes.

All these methods affect dissipation in the system and may adversely affect the reproduction of the proper physics. To analyze the effect of dissipation on accuracy and to prepare practical recommendations, we test the enhanced LBM methods on the standard benchmark, the 2D lid driven cavity on a coarse grid (101*101 nodes). The accuracy was estimated by the position of the first Hopf bifurcation points in these systems.

We find that two techniques, MRT and median filtering, succeed in yielding a reasonable value of the Reynolds number for the first bifurcation point. The newly created limiters, which filter the modes independently, also pick a reasonable value of the Reynolds number for the first bifurcation.