Non linear stability of Lattice Boltzmann scheme for under resolved simulation using global optimisation

Dubois François, Saint-Jean Christophe, Tekitek Mohamed Mahdi

Laboratoire de Mathématiques d'Orsay, bâtiment 307, F-91405 Orsay, France
Conservatoire National des Arts et Métiers, LMSSC laboratory, F-75003 Paris, France;
MIA laboratory, La Rochelle University, 17000 La Rochelle, France

Previous works [2,3] showed that D2Q9 BGK are unstable for test case given in [1] but D2Q9 MRT still stable for such nonlinear problem. In other hand, to investigate the stability of LB scheme, it is possible only numerically using von Neumann analysis [4], and only for linear case. In this work, the Minion et al. [1] test case stability is investigated for a fixed viscosity.
Regarding relaxation parameters(free, no effect up to order 2), the stability zone is investigated and characterized using a decision tree, a machine learning technique focused on interpretability. In order to go further, a simple global optimization method (genetic algorithm) is used to yield a set of stable relaxation parameters for the Minion et al. [1] and Taylor-Green test cases. Finally, we show that this optimization method also leads to find a stable non-trivial (non-physical) LB parameter set for the non-linear case.

[1] M.L. Minion, D.L. Brown, Performance of under-resolved two-dimensional incompressible flow simulations II, J. Comput. Phys., vol. 138, (1997).
[2] P.J. Dellar, Bulk and shear viscosities in lattice Boltzmann equations, Phys. Rev. E, 64 (2001).
[3] D. Ricot, Simon Marié, P. Sagaut, C. Bailly, Lattice Boltzmann method with selective viscosity filter, J. Comput. Phys., vol. 228, (2009).
[4] P. Lallemand, L.-S. Luo, Theory of the lattice Boltzmann method: Dispersion, dissipation, isotropy, Galilean invariance, and stability, Phys. Rev. E, vol. 61, 2000