A Fast Iterative Synthetic Lattice Boltzmann Method for Steady-State Flow Simulations

S. Naris and D. Valougeorgis

Department of Mechanical and Industrial Engineering
University of Thessaly, Pedion Areos, Volos, 38334, Greece

The lattice Boltzmann method (LBM), when applied to steady flow calculations, due to its explicit nature, which is subject to the CFL constrain, suffers from slow convergence rates. As it is well known there is a close relation between the LBM and the discrete velocity method (DVM) commonly applied in the areas of kinetic theory and rarefied gas dynamics. Researchers implementing the DVM are well aware, of its slow convergence when steady-state phenomena are simulated, particularly for small values of the Knudsen number (slip and continuum regimes). Recently a new accelerated algorithm has been introduced to speed up the slow convergence of the DVM [1,2].

In the present work we extend these ideas in steady LB calculations and we develop suitable accelerated algorithms to speed up the slow convergence rate of the classical LBM. The proposed algorithm is based on the formulation of moment equations, the so-called "synthetic equations", which are solved coupled with the transport equation. It turns out that the additional computational effort per iteration is insignificant compared to the computational gain due to the small number of iterations required. The efficiency of the novel iterative scheme is proved theoretically by applying a Fourier stability analysis and estimating its spectral radius, which is compared to the spectral radius of the typical LBM. In addition the superiority of the synthetic discrete velocity scheme is demonstrated experimentally by solving some typical steady-state model problems. It is found that the required number of iterations and CPU time for convergence, compared to those of the typical LBM are significantly reduced. Finally, as it is expected, in all cases tested the discretized synthetic acceleration LB scheme (i.e. experimental results) performs equally well or even better than the exact scheme, applied on the continuous form of the transport and synthetic equations (i.e. theoretical results).

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REFERENCES

[1] D. Valougeorgis and S. Naris, SIAM, J. Sci. Comp., **25**, 2, 534-552 (2003).
[2] S. Naris, D. Valougeorgis, D. Kalempa and F. Sharipov, Physica A, 336, 3-4, 294-318, (2004).