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Boundary conditions revisited

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In this contribution, we study boundary conditions for lattice Boltzmann schemes. We refer to Zou and He [4], Bouzidi *et al* [1], d'Humières and Ginzburg [3] for classical bounce-back boundary condition, anti-bounce-back boundary condition and the determination of so-called "magic" parameters to enforce the precision of the scheme. In a previous contribution [2], we have used the Taylor expansion method to analyse precisely the numerical behaviour of a lattice Boltzmann scheme with an external force, focusing on a precise determination of the numerical boundary. In this contribution, we follow the same idea to recover precise physical data from linear combinations of the particle distributions and appropriate numerical corrections.

To fix the ideas, we consider an homogeneous bounce-back boundary condition for a fluid flow simulated with a D2Q9 scheme and a bounce-back boundary condition to enforce a zero-velocity at the boundary. The question is to capture with a good approximation the wall friction $\tau \equiv \nu \, \frac{\partial u}{\partial y}$ for a boundary located along an horizontal boundary $y = 0$. When we analyze the transfer of momentum due to particles crossing the boundary, a natural expression is given by : $T_b \equiv f_5 - f_6 + f_7 - f_8$. Then we expand the previous expression as powers of the mesh size. We put in evidence the viscous tension τ plus additional terms of higher order associated to second order derivatives of the velocity field. These terms are estimated with finite differences.

We test the previous ideas for a Poiseuille flow and an "accelerated pipe" defined as follows. On left (resp. right) boundary, a given pressure $+P$ (resp $-P$) is imposed. On bottom and top boundaries, a given velocity is null for $x \leq -L$ and for $x \geq +L$. It is a smooth increasing function for $-L \leq x \leq 0$ and a smooth decreasing function for $0 \leq x \leq L$.

The previous study has been also applied to the computation of pressure on a wall and the adaptation of anti-bounce-back boundary condition for a precise implementation of a given pressure boundary condition. The results will be presented at the conference.

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References

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