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Lattice Boltzmann Method:
Beyond Navier-Stokes

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In the last few decades, the lattice Boltzmann method (LBM) has emerged as an effective tool to simulate the hydrodynamics of Newtonian fluids governed by Navier-Stokes Equation. The kinetic origin of LBM has motivated us to extend it to the field of non-Newtonian fluids like polymer solution. The slow dynamics of probability density associated with internal degrees of freedom of polymer molecule suggests that the situation is apt for bottom-up modeling via lattice-Boltzmann based direct discretization approach. Various physical properties exhibited by polymer solution like shear-thinning, coil-stretch transition, shear induced migration are captured by this novel computational scheme which demonstrates the competency of this approach.

Another natural extension of LBM is to the regime of small-scale flows where the slip occurs at the fluid-solid interface. At this level, the continuum approximations may break down and hence the the Navier-Stokes solvers may not be valid. Owing to its kinetic origin, the slip effect at the interface can naturally be implemented in LBM just by the applying appropriate kinetic boundary at the interface. One such boundary condition is the discrete form of Maxwell diffusion boundary condition. Basically, in this boundary condition, particles that reach the wall are redistributed in a way which is consistent with the mass-balance and normal-flux conditions. This boundary condition is shown to reproduces the desired flow properties in slip-flow regime.