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Rahman Prize Lecture: Lattice Boltzmann simulation of complex states of flowing matter

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Over the last three decades, the Lattice Boltzmann (LB) method has gained a prominent role in the numerical simulation of complex flows across an impressively broad range of scales, from fully-developed turbulence in real-life geometries, to multiphase flows in micro-fluidic devices, all the way down to biopolymer translocation in nanopores and lately, even quark-gluon plasmas. After a brief introduction to the main ideas behind the LB method and its historical developments, we shall present a few selected applications to complex flow problems at various scales of motion. Finally, we shall discuss prospects for extreme-scale LB simulations of outstanding problems in the physics of fluids and its interfaces with material sciences and biology, such as the modelling of fluid turbulence, the optimal design of nanoporous gold catalysts and protein folding/aggregation in crowded environments.