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Lattice Boltzmann Methods: Fundamentals and Perspectives

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Abstract:

The talk is aimed at delivering the main features of the Lattice Boltzmann equation (LBE), a minimal form of Boltzmann kinetic equation which is meant to simulate the dynamic behavior of fluid flows without directly solving the equations of continuum fluid mechanics. In the corresponding methods, called Lattice Bolztmann Methods (LBM), macroscopic fluid dynamics emerges from the underlying dynamics of a fictitious ensemble of particles, whose motion and interactions are confined to a regular space-time lattice. I will briefly discuss the distinctive features and the advantages of LBMs with respect to traditional fluid dynamics, specifically the simplicity in computational implementation, the space-time locality, and the efficiency to solve specific fluid dynamic problems. Due to its properties, LBE research has known a burgeoning growth, which has led to an extremely elegant and computationally efficient approach with an impressive array of applications across virtually all fields of fluid dynamics and related disciplines. These range from low-Reynolds single and multiphase flows in highly heterogeneous (porous) media, all the way to fully turbulent flows in complex geometries of direct industrial relevance, such as real-life cars and airplanes. In hindsight, the most fundamental asset of LBe rests with its mesoscopic nature, lying in between the kinetic and continuum descriptions of fluid flows. This may allow LBe to combine some advantages of the two approaches: the geometrical flexibility of kinetic methods with the large scale resolution of continuum methods. In this talk I will also present some of the most recent successful applications of the lattice Boltzmann method.