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Entropic Multi-Relaxation Time Lattice Boltzmann Model for Complex Flows

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Abstract content
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Entropic lattice Boltzmann methods (ELBM) were introduced to overcome the stability issues of lattice Boltzmann models for high Reynolds number turbulent flows. However, to date their validity has been investigated for only simple flows due to the lack of appropriate boundary conditions.
We present an extension of entropic multi-relaxation time lattice Boltzmann models to complex flows in three dimensions. We study in detail the setup of a simplified internal combustion engine with a valve/piston arrangement. This arrangement allows us to probe the non-trivial interactions between various flow features such as jet break-up, jet-wall interaction, formation and break-up of large vortical structures among others in a comparison to high-order spectral element DNS simulations and experimental data. Moreover, we show that the implicit subgrid features of the entropic lattice Boltzmann method can be utilized to further reduce the grid sizes and the computational costs, providing an alternative to modern modeling approaches such as Large-Eddy Simulations (LES) for complex flows.
Further, exploiting the stability properties of ELBM, those models are employed in combination with a novel multi-domain, grid refinement algorithm allowing for an increased accuracy. The numerical scheme is validated using standard benchmarks such as the turbulent channel flow for Re=180,…,590 (based on the friction velocity) and the flow past a sphere at Re=10000. After validation it is applied to full two-way coupled fluid-structure interaction simulations of self-propelled swimmers in three dimensions, yielding insight into the fundamental mechanisms of propulsion occurring in nature.

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