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Multi-architecture Adaptive Mesh Refinement Lattice-Boltzmann Method for multi-phase and porous media flows

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The work presented herein proposes an implementation of an Adaptive Mesh Refinement (AMR) algorithm for Lattice Boltzmann Methods, focusing on code portability and optimisation on different architectures. The Kokkos [1] C++ scientific computing library is used, to exploit various available high performance computing (HPC) resources, CPUs or GPUs, shared or distributed memory systems alike, and stay up-to-date with their technological advancements.

The proposed method employs a single time-step, the BGK collision operator and a Lax-Wendroff [2] spatial scheme, to accommodate computational cells of different sizes. The domain is discretised by a cell-centred mesh, organised in a block-based octree structure; computations, refinement or coarsening are performed per-block. Block communication uses ghost cells' layers, filled by quadratic polynomial interpolations. The refinement accounts for normalised gradients and coarsening occurs automatically when refinement is not required on neighbouring blocks. Preliminary assessment and validation, indicate that computations and hard disk I/O operations get accelerated up to 5 times, compared to a fully refined uniform mesh, without loss of accuracy.

The method shows a great potential for application on complex physical problems of industrial interest.

References

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