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DEVELOPING A DOMAIN-SPECIFIC LANGUAGE FOR LATTICE BOLTZMANN MODELLING

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Abstract.

Nowadays, researchers in lattice Boltzmann modelling are facing many challenges. While the method is very friendly to parallel computing, we still need to devote significant efforts to port a code into heterogeneous computing platforms (e.g., a GPU cluster), which have been chosen for constructing supercomputers at exascale [1]. Meanwhile, mesh management remains a traditional time-consuming task, in particular, the multi-block technique and adaptive mesh refinement (AMR).

To address such challenges, we are developing a domain-specific language (DSL) [2] approach for lattice Boltzmann modelling. The purpose is to hide the implementation details from either an end user or an application developer, so that the users can focus on the algorithm and application. By splitting a lattice Boltzmann simulation into a few stages including preparing the case (geometry and boundary), choosing the model and iterating, we are proposing a set of concise functions for users to simulate a problem or develop new models. The underlying capabilities of heterogeneous computing and AMR are implemented by linking the function sequence into two open-source libraries, the Oxford Parallel Library for Structured-mesh solvers (OPS) [3] and the AMReX library [4].

The project is split into two phases. In the first phase, we are developing the function sequence that will enable the user to combine the provided lattice Boltzmann models (e.g., various equilibrium functions and forces terms) to simulate a scientific problem. The second phase will provide the functionality for the researchers to use the DSL to define their own equilibrium functions and force term.

In this talk, we will introduce the progress for the first phase and demonstrate the usage and performance of the DSL on both single-phase and multi-phase flows based on the OPS library on a range of computational platforms.

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[3] The Oxford Parallel Library for Structured-mesh solvers, https://www.oerc.ox.ac.uk/projects/ops, and https://github.com/OP-DSL/OPS.

[4] The AMReX library, https://amrex-codes.github.io/amrex/index.html.