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SERIAL AND PARALLEL PERFORMANCE CHARACTERISTICS OF THE LATTICE BOLTZMANN METHOD

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Summary. The lattice-Boltzmann Method (LBM) is a rapidly evolving method in computational physics that has been shown to have great utility for simulating flow in porous medium systems at the pore scale. Such simulations provide a basis for fundamental advances in understanding of transport phenomena and enable development of closure relationships for macroscale models. An impediment to capitalizing on the promise of the LBM is the computational effort needed to simulate a sufficiently large system such that a representative elementary volume (REV) is obtained in the continuum limit. While the REV constraint is media and process dependent, it is not atypical that the set of simulations required exceed 100,000 CPU hours on a fast workstation. This computation is not feasible. The computational limitations of the LBM can be relaxed in three ways: through the use of massively parallel implementations utilizing many processors, through the use of many thread implementations on a graphics processor unit (GPU), and through combinations of these methods. In this work we investigate various implementations of the LBM for CPU- and GPU- based computational platforms. We investigate algorithmic approaches for optimizing performance, and show that above the L2 cache limit, methods scale well. Due to the memory intensive nature of the LBM, GPU implementation demonstrates significant advantages relative to CPU implementation.