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Large-Scale DNS of Gas-Solid Flow on Mole-8.5

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Direct numerical simulation (DNS) for gas-solid flow is implemented on a multi-scale supercomputing system, Mole-8.5, featuring massive parallel GPU-CPU hybrid computing, for which the lattice Boltzmann method (LBM) is deployed together with the immersed moving boundary (IMB) method and discrete element method (DEM). A two-dimensional suspension with about 1,166,400 75-micron solid particles distributed in an area of 11.5cm x46cm, and a three-dimensional suspension with 129,024 solid particles in a domain of 0.384cm x1.512cm x0.384cm are fully-resolved below particle scale and distinct multi-scale heterogeneity are observed. Almost 20-fold speedup is achieved on one Nvidia C2050 GPU over one core of Intel E5520 CPU in double precision, and nearly ideal scalability is maintained when using up to 672 GPUs. The simulations demonstrate that LB-IMB-DEM modeling with parallel GPU computing may suggest a promising approach for exploring the fundamental mechanisms and constitutive laws of complex gas-solid flow, which are, so far, poorly understood in both experiments and theoretical studies.

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