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GPU Parallel Algorithm for Hypersonic Flow Around Asteroid

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ABSTRACT

The GPU heterogeneous parallel algorithm for hypersonic flow around asteroid is established by using a hierarchical parallel computing model. The flowfield solver is applicable to structured meshes. The finite volume NND scheme is used for spatial discretization and the Diag-DPLUR algorithm is used for time iteration. The domain decomposition model is used to build task parallel algorithm among structured mesh blocks, and the single instruction multiple thread(SIMT) model is used to build data parallel algorithm among grid cells. MPI communication is used between computing nodes, while peer-to-peer communication is used between GPU devices within same computing node. Multiple CUDA streams are used to manage the execution of CUDA kernels to improve the utilization of GPU devices. According to the case of numerical simulation of chemical nonequilibrium flow around Apollo command module, the aerodynamic data calculated in this paper are in agreement with the flight test results, which shows that the proposed algorithm is reliable. And the test result show that for dual Tesla P100 GPU device, parallel computing can get a

speedup ratio of about 200 times, greatly improving computational efficiency. Using 2 GPUs, the numerical calculation of chemical nonequilibrium flow around Tunguska meteor can be accomplished in 20 minutes.