Allocation: Illinois/284 Knh
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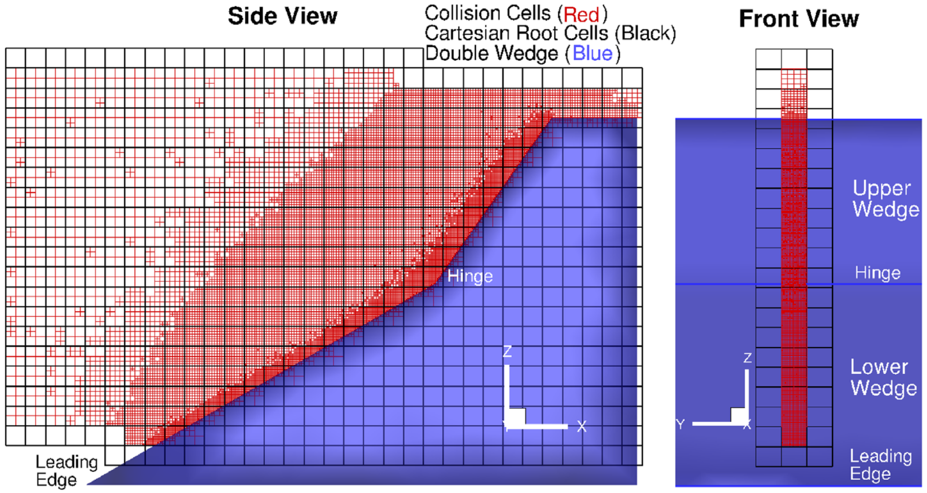

Decomposition of the computational domain held by a single of the 32 processors. Collision and root grids are shown in red and black, respectively. Multiple shocks form as the fluid encounters the wedge and reflected material collides with the incoming fluid forming secondary shocks.

FULLY THREE-DIMENSIONAL KINETIC SIMULATIONS OF UNSTEADY SHOCK-BOUNDARY LAYER INTERACTIONS

Research Challenge

Air flows encountered during hypersonic flights are characterized by significant gradients in gas density, high temperatures, and a large degree of nonequilibrium. In such flows the shock wave–boundary layer interaction has a significant role in determining aerothermodynamic quantities such as heat transfer, skin friction, and pressure loads. The particle-based Direct Simulation Monte Carlo method provides the highest fidelity in strong shock regions but its high computation requirements require a state-of-the-art resources such as Blue Waters to simulate a large number of particles .

Methods & Codes

The team used the particle-based Direct Simulation Monte Carlo code SUGAR, which is developed by the team. SUGAR uses octree based adaptive mesh refinement for multiscale physics in an unstructured grid. It handles gas-surface interactions efficiently, optimizing memory access for best cache utilization.

Results & Impact

The results for the case presented above were simulated using 20,000 processors, a number that would only be possible on Blue Waters. This simulation provided a detailed understanding of the structure of the shocks formed along the wedge and the exact temperature and density distribution along the wedge.

Why Blue Waters

The time-accurate, large-scale DSMC simulations performed require on the order of 100,000 node-hours, 24 billion computational particles, and 2.2 billion collision cells to reach 1 millisecond of simulated time. Blue Waters is one of the few computer architectures that can host and execute these simulations