MODELING PLASMA FLOWS WITH KINETIC APPROACHES USING HYBRID CPU-GPU COMPUTING

Research Challenge
Ion thruster engines, which are used on spacecraft (satellites), create plasma plumes. Improving prediction of long-term effects of engine emissions on spacecraft surfaces will improve their efficiency and longevity.

Characterize the backflow contamination environment due to the plasma created by electric-propulsion (EP) plumes, and their interaction with the spacecraft environment and neutralizer sources.

Methods & Codes
Plasma modeling method based on modified DSMC (Direct Simulation Monte Carlo) code, CHAOS (Cuda-based Hybrid Approach to Octree Simulations).

For modeling the electric field, using AMR (Adaptive Mesh Refinement) invovled single and multiprocessor stages.

To compute volume of cut-leaf nodes, it utilizes the Morton Z-curve octree structure, a volume-of-fluids (VOF) method, and ray-tracing, which is very efficient on GPUs.

Why Blue Waters
Blue Waters has allowed testing and development of algorithms on a large number of GPUs for three-dimensional, fully kinetic plasma simulations. Compared to the present state-of-the art plasma simulations, a uniform grid in 3D would require a factor of at least ten more cells than the use of AMR/octree. The use of GPUs vs. CPUs decreased the runtime by at least another factor of five.

Results & Impact
High level: Satellites that are more efficient and last longer will save money, as billions of dollars are spent annually building and launching these craft.

Able to model the actual xenon-to-electron mass ratio for three-dimensional geometries (previous modeling of electrons as a separate species in electric-propulsion plumes was limited to two-dimensional cases).

Results support the hypothesis that the ion beam is trapping the electrons, which, in turn, damps the electron oscillations.