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PROGRESS SIMULATING LOW TEMPERATURE COLLISIONAL PLASMAS WITH A PIC-DSMC METHOD

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ABSTRACT

In this work we will present the current state of our low temperature plasma simulation code, Aleph. Its target application regime is low temperature plasmas that straddle the non-continuum to continuum regime, specifically including collisional effects and chemistry. Of particular importance to us is that the code be production quality, applicable to industrial problems. In pursuit of that goal, Aleph is based on unstructured meshes, is massively parallel, and includes dynamic load balancing.

Our plasma model consists of weighted particles for each constituent present (ions and neutrals of differing species, and electrons) coupled to an electrostatic (ES) field. The ES field is computed via the finite element method (FEM) every time step by aggregating particle charges on an element-by-element basis. Particles within an element interpolate the electric field to their position for use in the particle move algorithm. Thus, we are performing a very simple particle-in-cell (PIC) simulation. Subsequent to particle moves, collisions are accounted for via a direct simulation Monte Carlo (DSMC) method. And subsequent to collisions, chemistry events are accounted for. Of special relevance to plasma simulation is charge exchange.

To address realistic problems, we operate on 3D unstructured meshes in a massively parallel environment (to thousands of processors). To improve scaling of the overall

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method we employ advanced solvers (including preconditioning) and dynamic load balancing. Because the mesh decomposition that optimally balances the FEM is in general different from the one that optimally balances particle calculations, we use multiple decompositions of the same mesh.

This presentation will relate our experiences in applying the simulation technique to test and application problems, including scaling efficiency and the impact of improvements to solving the coupled particle/field problem.

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