Effects of detailed charge exchange interactions in DSMC-PIC simulation of a simplified plasma test cell
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MOTIVATION & METHODOLOGY

Key Motivation: Desire to evaluate heavy-species collision models in a plasma environment which is much simpler than a Hall effect thruster.

Specific Goal: Refine heavy-species interactions for kinetic methods.

Methodology: Use kinetic, particle-in-cell (PIC) tool, MONACO-PIC (MPIC) to study elastic and inelastic heavy-species processes.
-- Perform numerical counterpart to representative experiment @ UCLA
-- Upgrade and refine new differential cross-section and post-collision scattering models.
-- Compare results and analyze disparities

NUMERICAL APPROACH

DSMC-PIC method for non-equilibrium plasma:
-- Developed since the 1960’s.
-- Charged particles move in physical space.
-- Particles possess molecular properties, e.g. u’ (thermal velocity).
-- Cell size dx=6, time step dt=1/6u.
-- Self-consistent electric fields, E.
-- Collisions handeled statistically.
-- Charge (CIE) and momentum (MEX) exchange.

Our tool: MONACO-PIC (MPIC)
-- 2d cylindrical.
-- Parallelized.
-- Ions & neutrals = particles.
-- Electrons → Boltzmann.

Our domain: the “test cell” by Wirtz, et al(1), @ UCLA:
A=3 symmetric domain.
-- Held at specific background pressures.
-- Injection beam of 1500 eV xenon ions.
-- Two regions of interest: Inner Cylinder (IC) and Exit Plate (EP)

General Numerical Parameters: 700,000 to 8,000,000 particles, 1x10^9 s timestep, corresponding to an injection beam velocity of 47,000 m/s @ 29 nA.

ELECTRODE CURRENT COMPARISONS

REPRESENTATIVE SIMULATION RESULTS

Anisotropic (300 V): 
-- Scattering behaviour fundamentally different.
-- New model leads to less intermediate angle scattering (predicted).

Spatial distribution of current is important for future experimental design:
-- Can visualize decrease in intermediate scattering angles.
-- Future experimental comparisons possible due to segmented electrode design.

SUMMARY & FUTURE

Successfully increased fidelity of heavy species interaction models in MONACO-PIC
-- Refined, anisotropic model fits best with experimental comparison.
-- Future experimental methods will allow spatial current collection comparison.
-- There is a need for more physics: SEE current adjustment, metastable species, etc.