IEC Theory

- Inertial-Electrostatic Confinement (IEC) Devices operate by ionizing fusion fuels and accelerating ions into a spherical potential well which is created by concentric spherical electrodes.

- Present gridded IEC devices operate at relatively high pressures, making losses to atomic processes dominant.

- IEC Device Operating at ~7mT

- Reducing neutral pressure will reduce losses, such as charge exchange and ion-neutral collisions. A computational and experimental campaign is underway to explore this.

Ion Source

- A helicon ion source is used to achieve high current and low pressure.

- The source is mated to an IEC and high voltage is used to inject the ions.

PDS-1

- 1-D MC-PIC code written by UC-Berkeley, adapted by R. Nebel at LANL and K. Tomiyasu at UW-Madison for IEC.

- Models atomic, nuclear and some surface interactions.

- Code predicts low-temperature trapped plasma.

Sample output from PDS-1

- Potential structure and fusion rate vs. radius can be modeled:

- Code has been run at 2 mTorr pressure and will be adapted for simulation near 50 µTorr.

Ion Flow Analysis

- Inward attenuation on a partial pass (similar outward equation), grid attenuation not shown:

\[ f_{in}(r, s) = \exp \left[ - \int \frac{1}{\gamma} n_e \sqrt{F(s, q)} \, dq \right] \]

- Infinite number of passes gives the total current, \( J(r, s) \), at r from ions born at s [total current \( J(s) \)]:

\[ J(r, s) = J(s) \frac{f_{in}(r, s)}{1 - f_{in}(r, s)} + \frac{f_{in}(r, s)}{1 - f_{in}(r, s)} \]

where

\[ J(s) = \int f_s(s, q) 4 \pi r^2 \, dq \]

- Ion source, \( S(r, s) \) using flux conservation:

\[ S(r, s) = \frac{\sqrt{f_s(s, q) 4 \pi r^2}}{4 \pi r^2} \]

- Resulting equation is a Volterra equation of the 2nd kind, which will be solved numerically.

Summary

- Experimental theoretical, and computational campaigns are underway to investigate IEC core physics.

- Helicon ion source constructed to achieve core convergence experimentally.

- PDS-1 has shown trapped plasma population in core at 2 mTorr.

- Ion flow analysis allows lifetime tracking of ions.