Explaining the Delay in Theta-Pinch Gas Breakdown

Questions with no clear answers;
• How is the pre-plasma gas evolving at early times?
• What is the most beneficial method of pulsed inductive PI?
• When is a bias magnetic field necessary?
• Why is a delay in gas breakdown seen in biased pulsed inductive devices?

Our numerical approach;
✓ model particle physics at early times in theta-pinch device
✓ show correlation with experiment
✓ elucidate how well the field energy is used during initial breakdown and provide explanation for ionization delay
✓ propose selection criteria when designing a bias and main discharge for pulsed inductive devices
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Pulsed Inductive Test Article

- Missouri Plasmoid Experiment
  - Pulsed inductive test article for studying fundamental plasma processes
  - Electric and magnetic probes diagnostics
  - Internal plasma probe diagnostics: shunted probe, ion saturation probe
  - Future: spectroscopy, fast framing camera diagnostics
Building MPX Internal Probe Diagnostics

Goals for internal probes;
✓ design and fabricate Langmuir probe pair for use in the MPX pulsed power environment
✓ verify removal of noise to acceptable levels
✓ generate rough picture of plasma discharge activity

☐ verify azimuthal symmetry
☐ bias probe to ion saturation levels to quantify additional plasma characteristics
☐ refine picture with fine spatial resolution via the 2-D translation stage and couple with external measurements to proved a full picture of the plasma evolution

Dual probes used for MPX test article consisting of an exposed probe (top) and a dielectrically shielded null probe (bottom).

Time-lapsed exposure of MPX operation at 30 mTorr along side shunted probe voltage data taken at 14 mTorr.
I. Differential probe design
   - Removes common mode (capacitive coupling, electrostatic) noise from probe signal
   - Constructed on Printed Circuit Board (PCB)
     - Ensures consistency between probes
   - Calibrated using pulsed-power Helmholtz coil
     - $1.60 \times 10^5$ T/V-s