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System for Characterization of the Discharge Process in a High-Pressure Pulsed Arc Discharge

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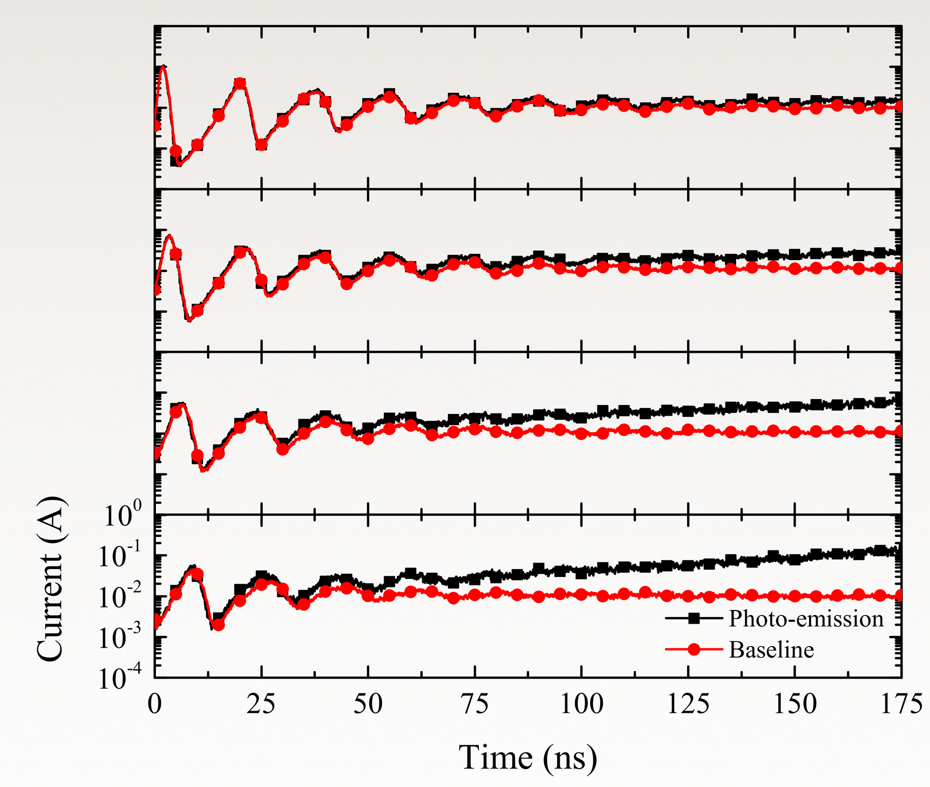
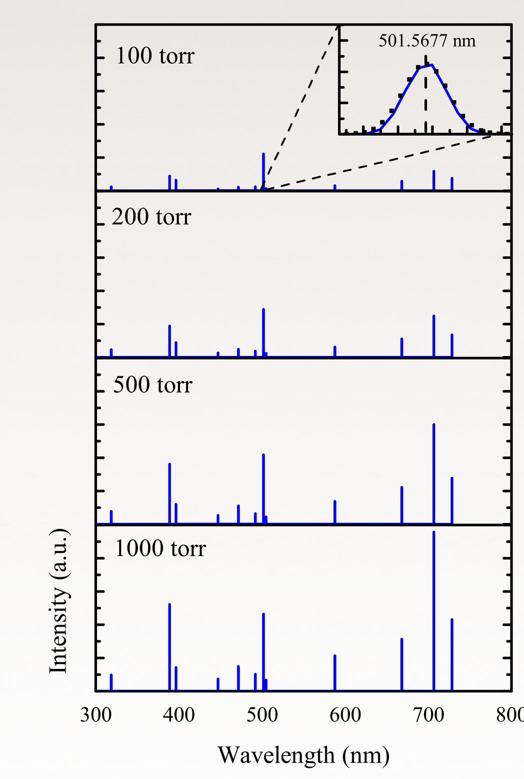
1. Motivation

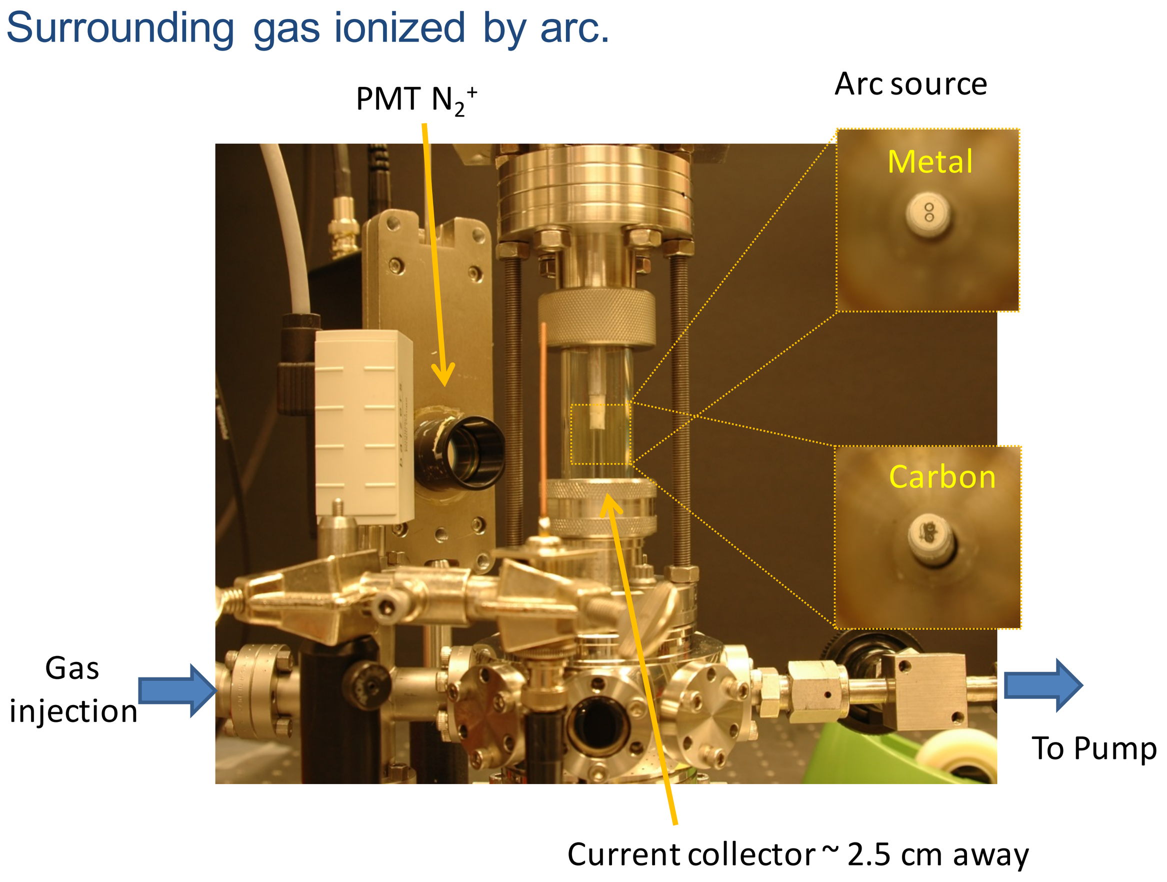
- In a discharge, various processes contribute to overall discharge characteristics.
  - Electron chemistry (ionization, excitation, elastic collisions, recombination).
  - Photonic processes (photoionization, photoexcitation, spontaneous emission).
  - Surface interaction (ion impact, photoelectric current, field and thermionic emission).
- Pressure also plays a role in determining which processes are dominant.
  - Three-body collisions (attachment, recombination) dominant electron loss mechanism in high pressures.
  - Photonic processes operate on inherently different timescale than electronic processes.
- Radiation transport implemented in a Particle-in-Cell (PIC) simulation with Direct Simulation Monte Carlo (DSMC) for electron-neutral interaction.
  - Quantify effects of photons on discharge current in a Townsend discharge.
  - Simplified kinetic model of helium to check implementation before modeling air.





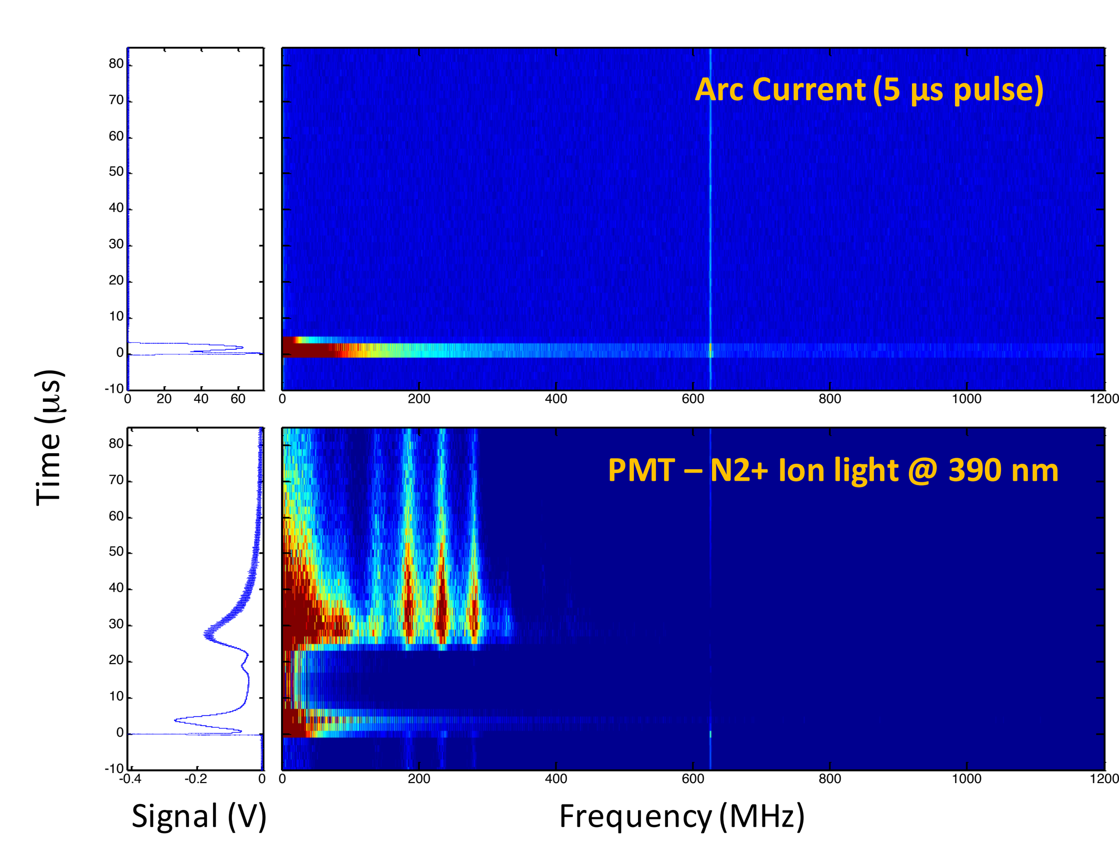
2. Arc Discharge Experiment

- Lab-scale experiments to compare and validate model.
  - Helium for baseline validation; air discharge to inform modeling efforts.
  - Study discharge and emission characteristics for pure and dusty plasmas.
- Quartz tube contains electrodes for arc source and collector plate to measure collected current due to discharge.
  - Open to laboratory air, but gas/vacuum system being incorporated for helium study.
  - Compare current collection and photoemission with model results.
- Electrodes for arc source separated by mm-distance.
  - Nanosecond pulser supply high voltage for arc generation across electrodes.
  - Surrounding gas ionized by arc.



3. Preliminary Optical Data

- Demonstrated ability to collect optical emission from discharge.
- 5-μs arc source generated with pulser in laboratory air at atmospheric pressure.
  - Grounded current-collecting plate will measure the current pick-up due to discharge in post-arc environment.
- PMT with 390-nm filter collects $N2^+$ emission from the resulting post-arc discharge.
  - Different wavelength filter can collect different emissions to compare with model results, along with pressure dependence.
- Data show emission during arc, as well as post-arc peak and subsequent decay.
  - FFT shows higher-order frequency components in the post-arc discharge, that do not appear to be associated with the arc generation.



4. Next Step – Nanosecond Arc Characteristics

Pulser Upgrade

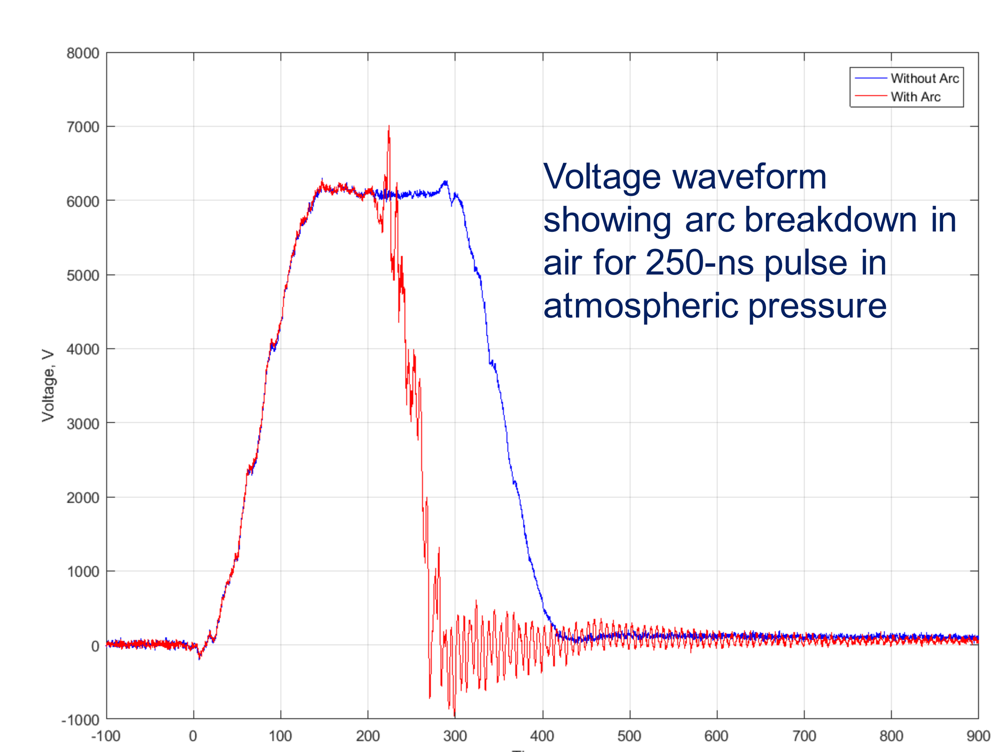
- Need to better isolate post-arc from during-arc environments for model comparison.
  - Purpose of arc source is to ionize the background gas only.
  - Use shorter pulse; graph shows arc generated with a 250-ns pulse.
- Current pulser has a voltage fall time of ~60 ns.
  - Begin to experiment using a new 20-kV pulser capable of 15-20 ns fall.

Varied Gas/Pressure Conditions

- Preliminary data showed (lab) air discharge; helium will be used to validate model..
  - Air discharge chemistry and process cross sections less characterized than helium → more challenging to model, experiments serve to inform model development.

Particle Injection

- Introduce known distribution of particle size/mass to study dusty plasma environments.
  - Currently aluminum shavings epoxied to electrode tips.



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