Investigation of Transient Regime Transition in Inductive Plasma Generators

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Motivation

Electrodeless EP using IPG

- ➜ Improves propellant flexibility and lifetime
- ➜ Enables new operating concepts:
  - In-situ resource utilisation (ISRU)
  - Atmosphere-breathing electric propulsion (ABEP)

Objective

Develop an experimental technique that:

- Investigates regime transition, to control propulsion characteristics
- Is non-intrusive, to avoid disturbing conditions
- Is time-resolved, to capture effects due to non-steady power supply or modulation

Theory

- Antenna current ➜ antenna–plasma coupling
- Magnetic field strength ➜ function of antenna current and plasma currents
- Light emission in visible range ➜ skin depth, location of plasma current

Experiment

3 channels captured simultaneously at 5 MHz:

- HOKA probe ➜ antenna current
- Linear stage ➜ radially-resolved:
  - Magnetometer ➜ axial magnetic field strength
  - Photodiode ➜ light emission in visible range

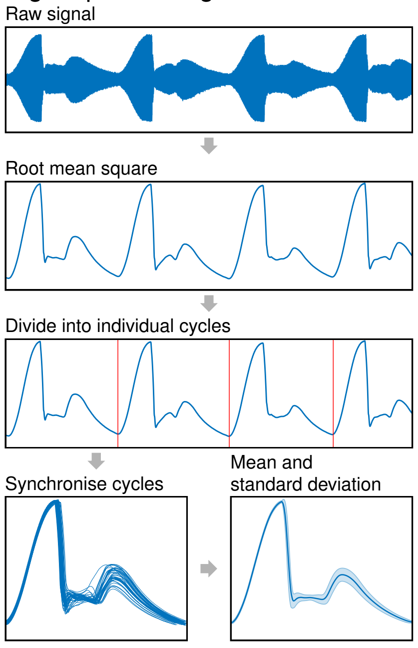
Conditions:

- $f_{driven} \approx 586$ kHz
- $f_{cycle} \approx 300$ Hz
- $p_{tank} = 28.5$ Pa
- $p_{injector} = 5.8$ kPa
- $\dot{m}_{gas} = 2.7$ g/s
- Capacitive and inductive regimes

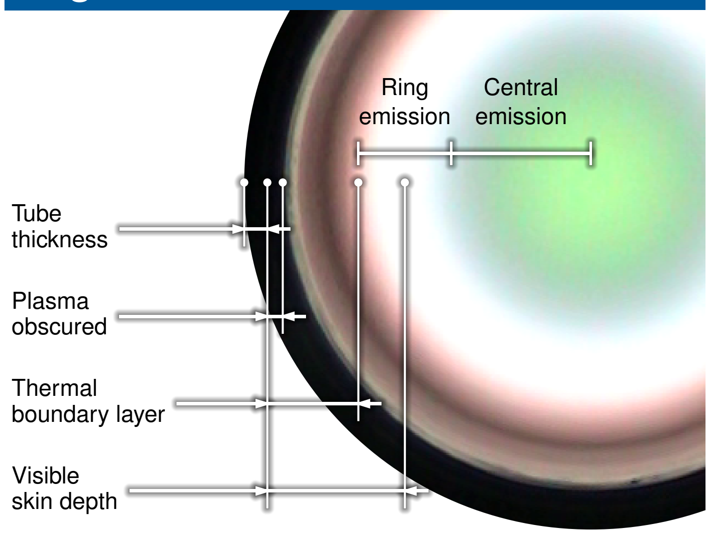
Gases tested:

- Nitrogen
- Argon–oxygen (2:1 by volume)

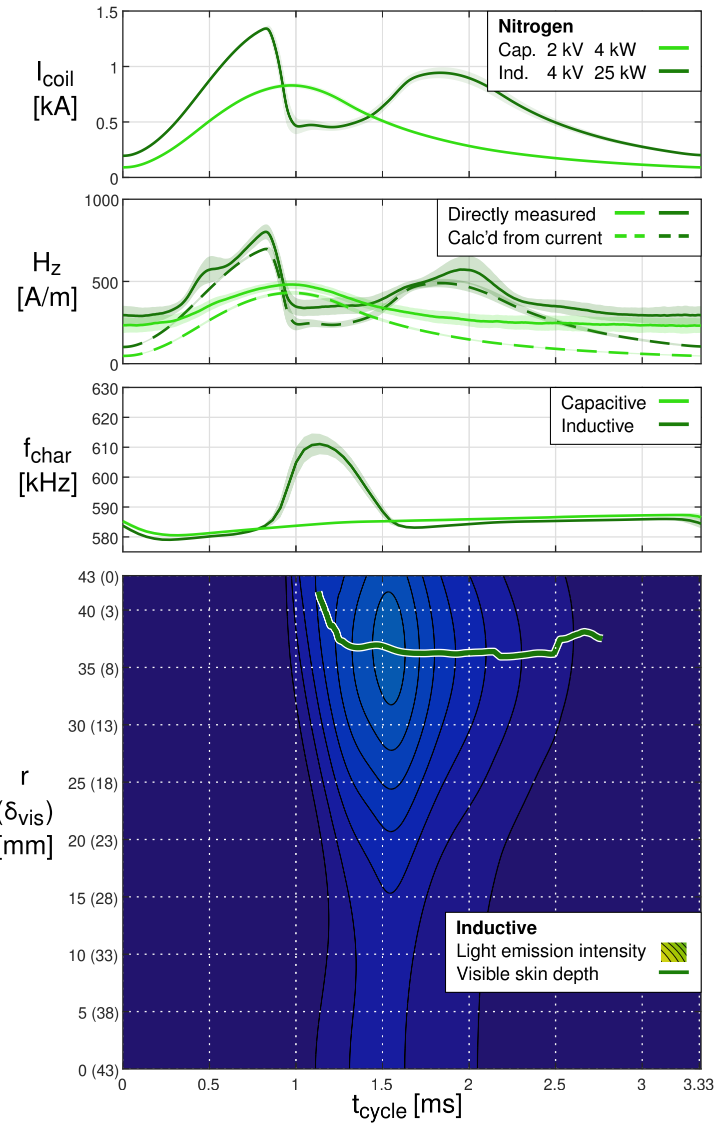
Signal processing:

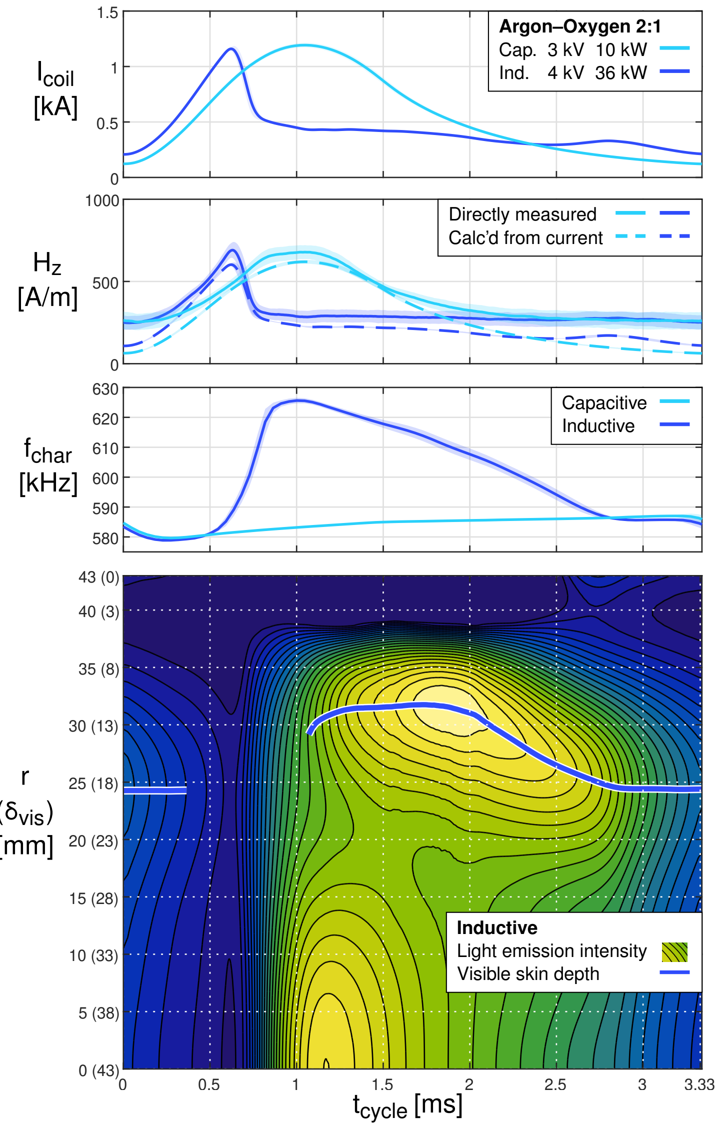


Light Emission Distribution



Preliminary Results



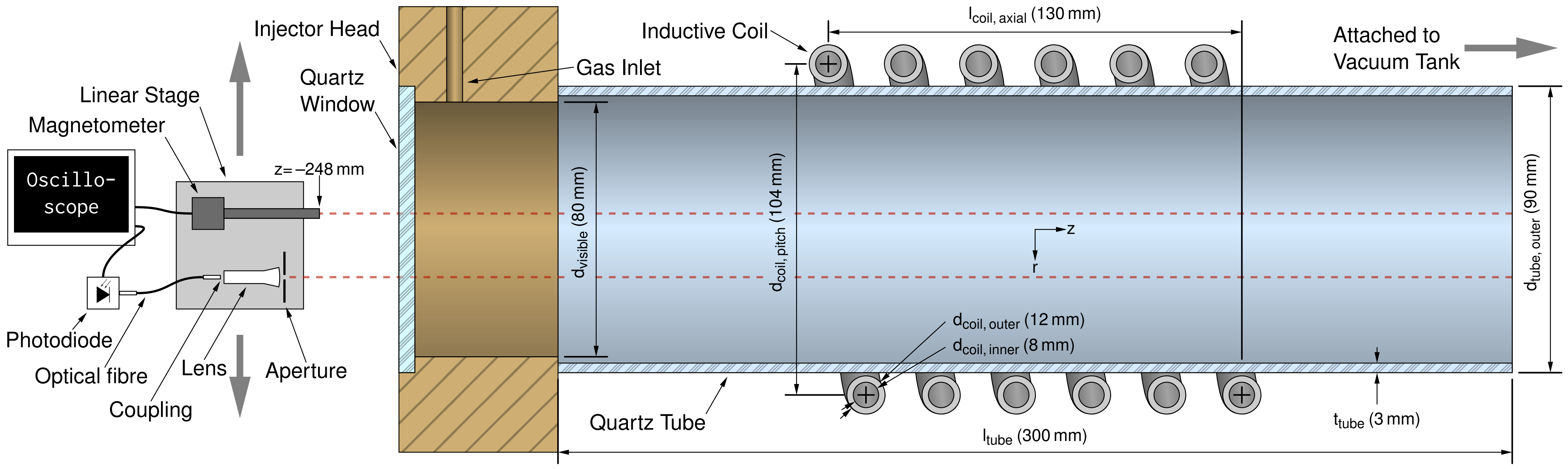


- Antenna current and characteristic frequency
  - ➜ Clearly identify regime transition due to development of plasma current
  - ➜ Duration of inductive coupling affected by propellant choice
- Measured and calculated axial magnetic field agree
  - ➜ Plasma current has little effect, likely located downstream far from probe
- Argon–oxygen: ring and central emission appear at different times

Conclusions

- Identification of regime transition, and plasma current behaviour, possible at time-scale of discharge cycle
- Plasma current appears to be localised in small, downstream region
- Numerical models may need to consider transient behaviour

IPG7 and Experimental Setup



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