Introduction to Electric Discharge Module

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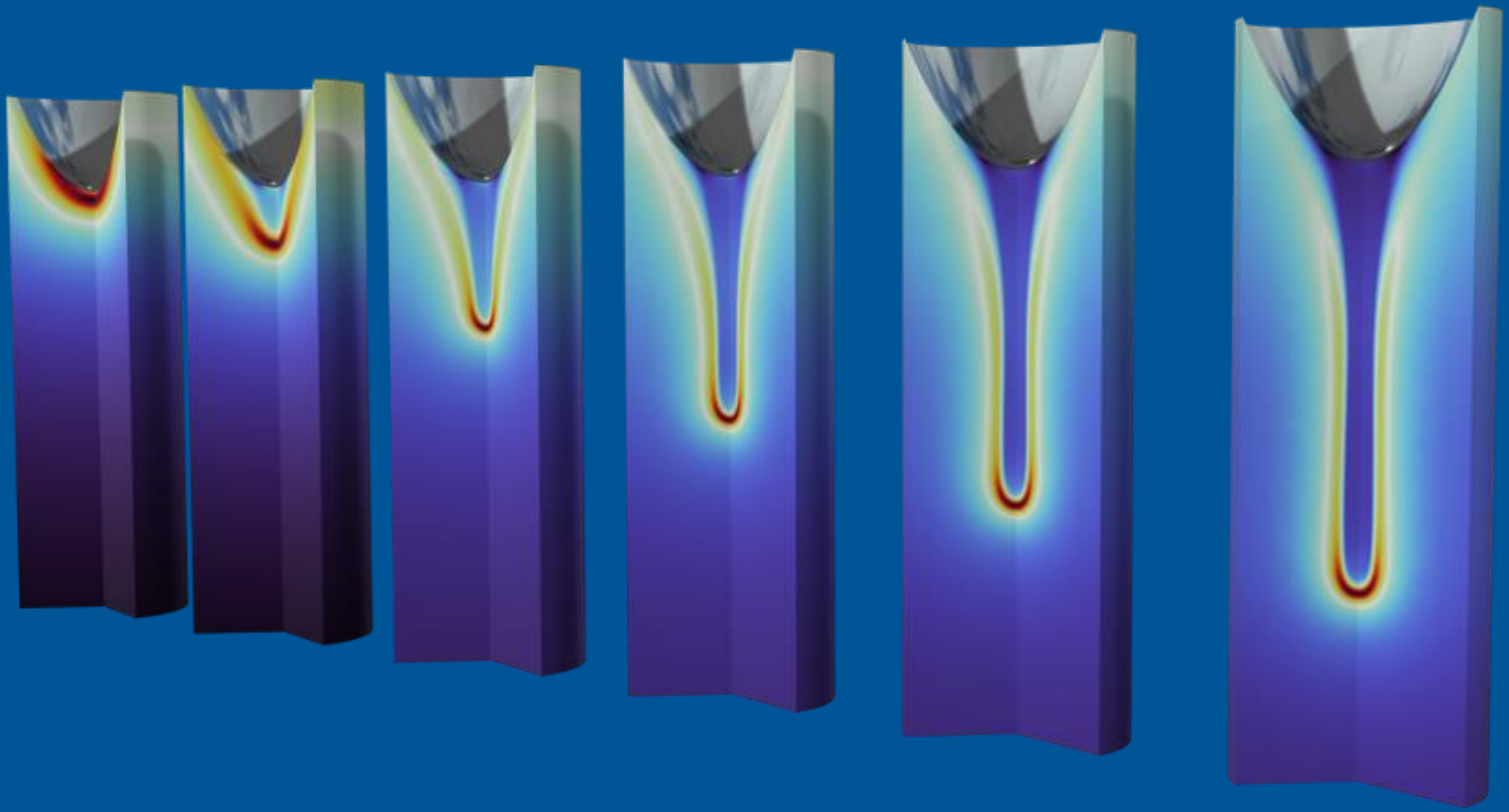
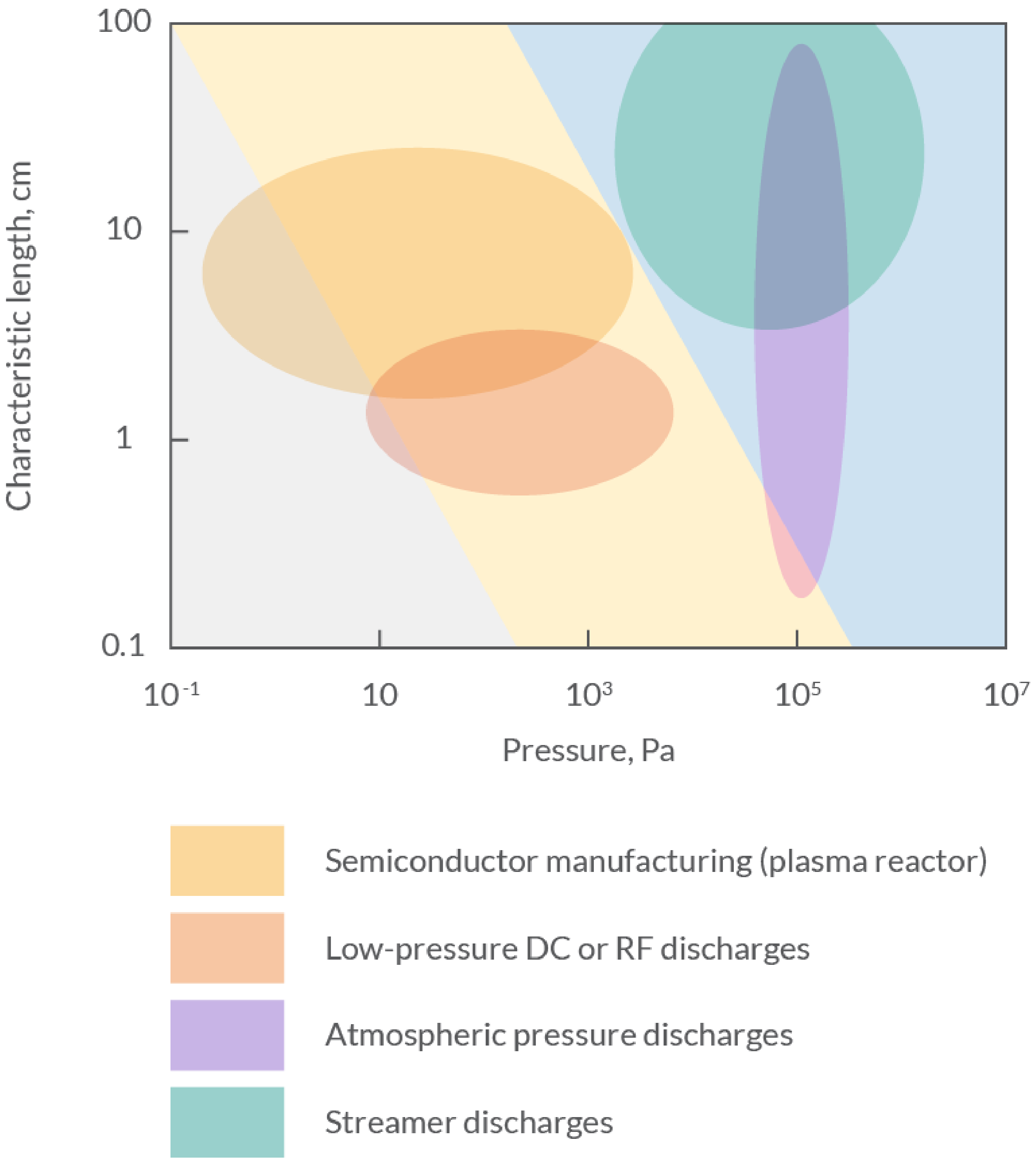


Electric Discharge Module

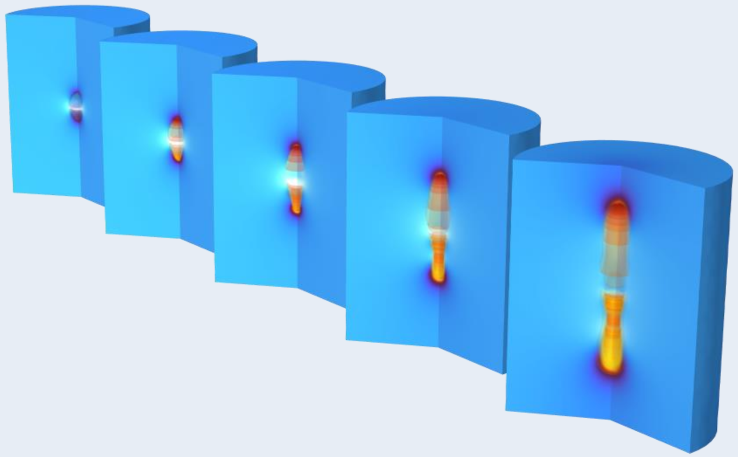
Electric Discharge Module or Plasma Module?

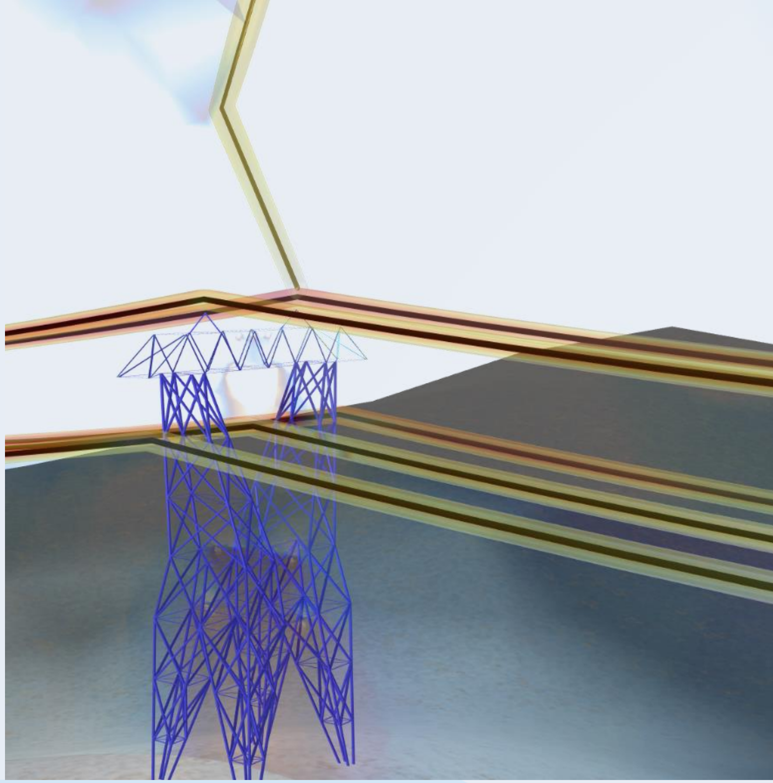
- The Electric Discharge Module is designed for atmospheric and high-pressure gas discharges, while the Plasma Module focuses on low-pressure gas discharges
- The Electric Discharge Module also enables simulations of discharge and charge transport in liquids and solids, unlike the Plasma Module, which is limited to plasma modeling in gases

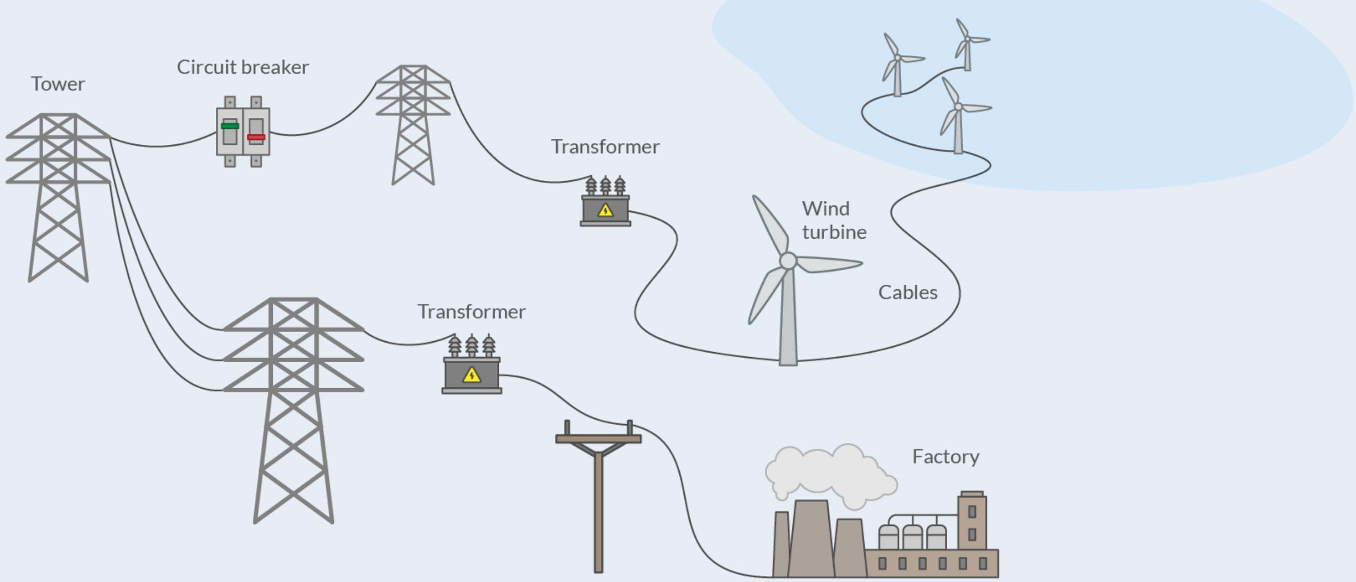


Electrical Insulation in Power Systems

- Internal insulation
  - Transformers
  - Circuit brakers
  - Cables
  - Gas-insulated switchgear (GIS)
- External Insulation
  - Insulators (overhead lines)
  - Bushings
  - Switching overvoltage
  - Lightning overvoltage

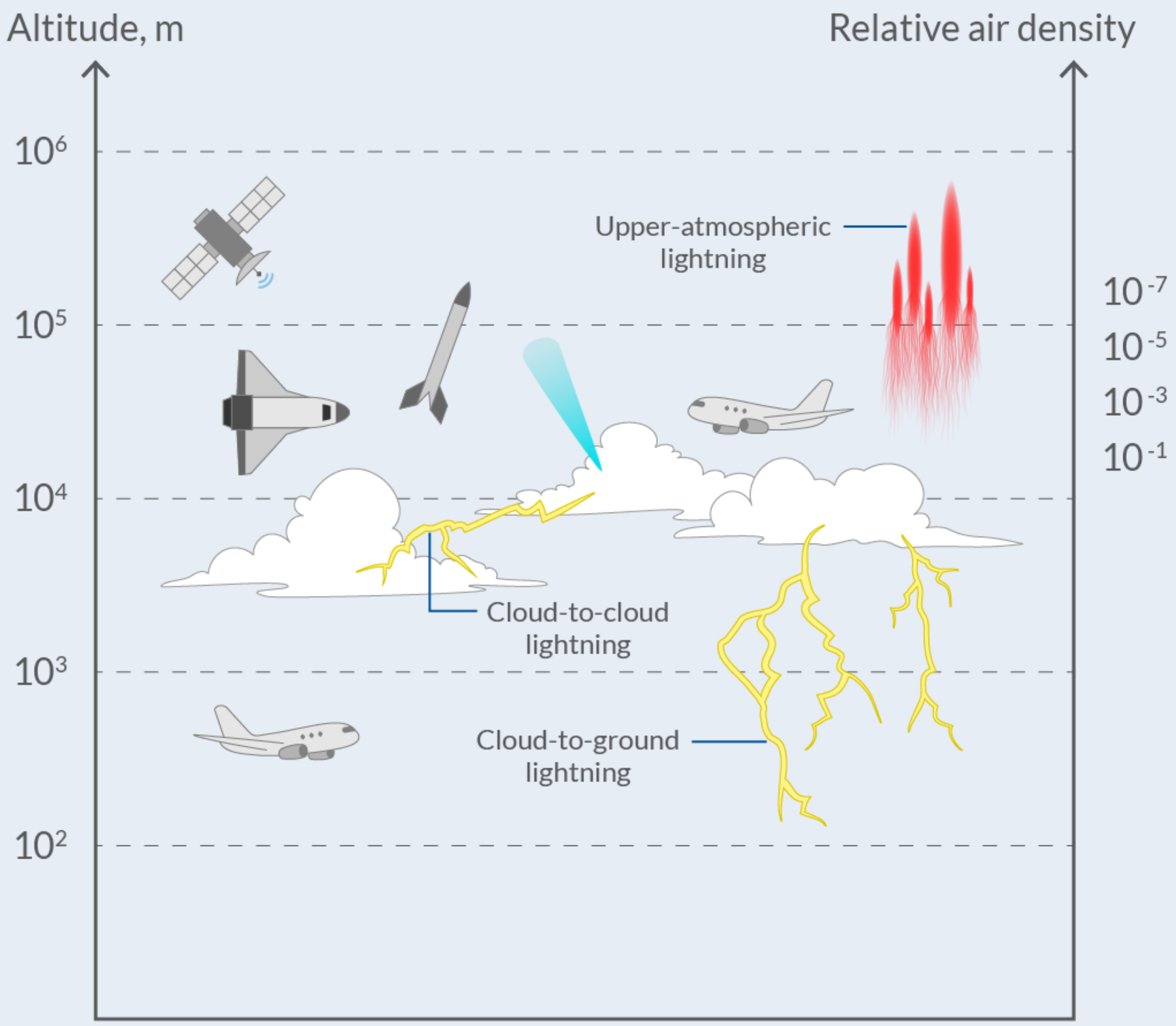






Electrical Insulation in Aerospace

- Aerospace vehicles are subject to a variety of electric discharges that can cause electrical insulation failure:
  - Internal discharge such as electric arcs
  - External discharge such as lightning
- The aerospace environment can be extreme, and the discharge is highly dependent on air pressure.
- Sustainable and clean energy drives greater use of composites, making electrical insulation more challenging.
- Simulation is an important tool for understanding and designing new insulation systems before experimentation.



Electric Discharge Processes

Charge

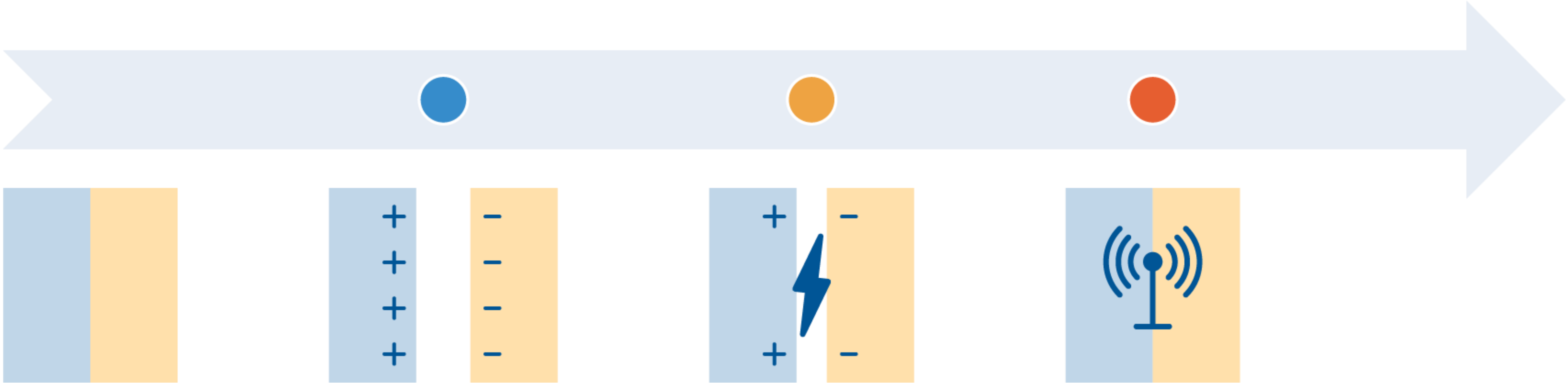
- Charge generation:
  - Charge separation
  - External charging
- Charge accumulation

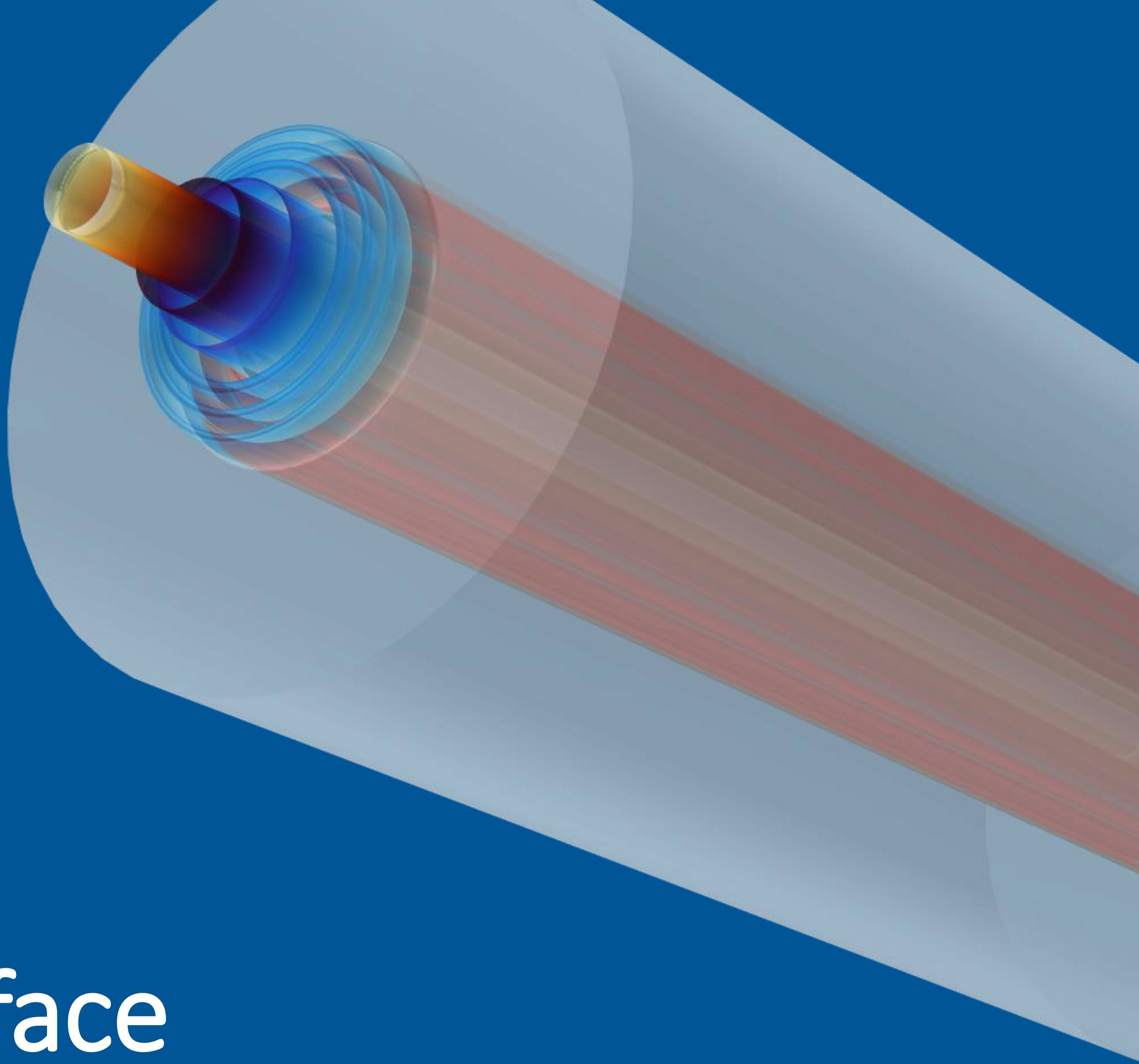
Discharge

- Charge relaxation
- Electric discharge:
  - Conductor–conductor
  - Insulator–conductor

After Discharge

- Direct effects
- Indirect effects:
  - Electric field coupling
  - Magnetic field coupling

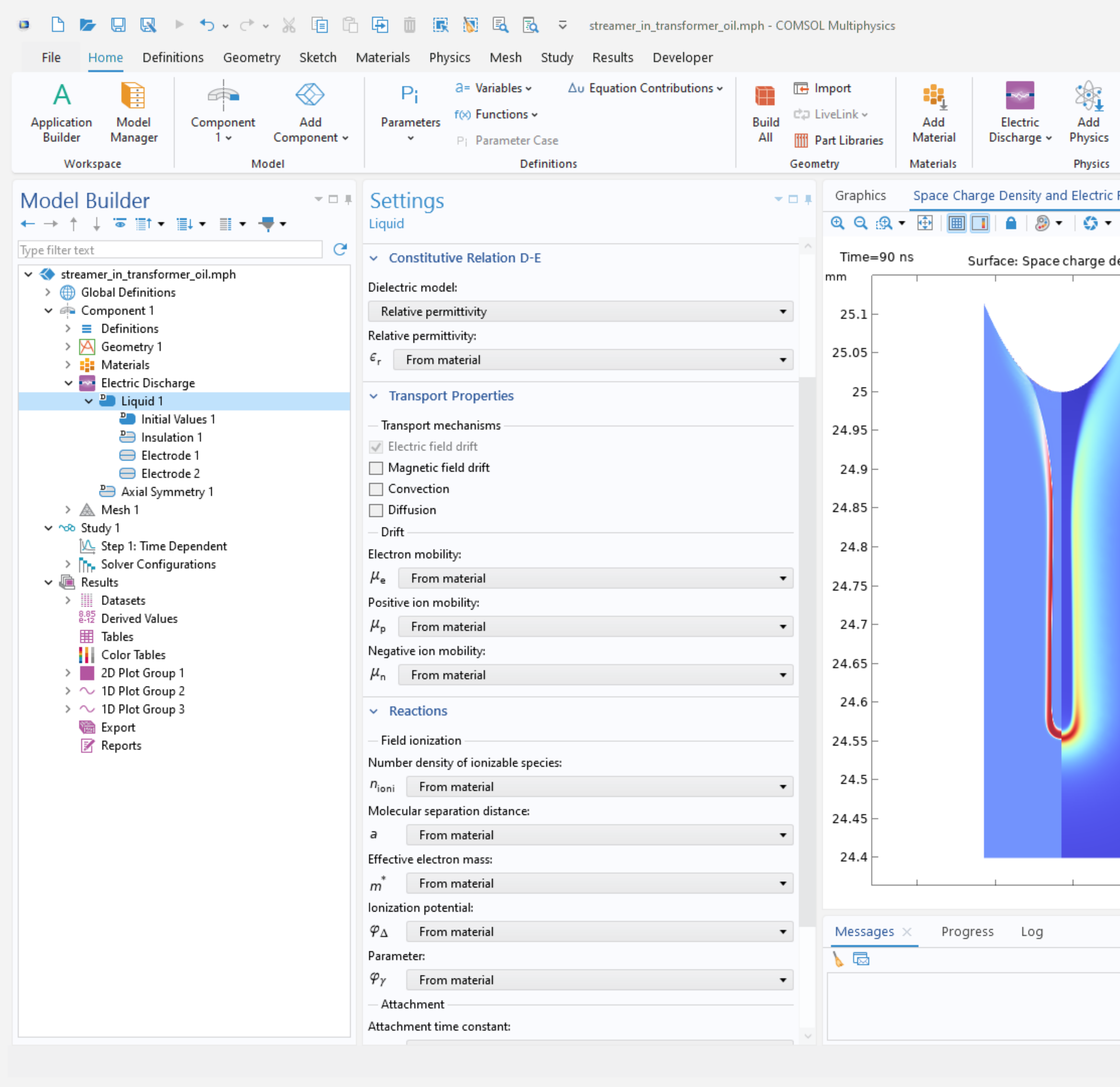




Electric Discharge Interface

Gas/Liquid/Dielectric Discharges

- Define your medium:
  - Model atmospheric and high-pressure gas discharges using fluid and local field approximations
  - Model liquid dielectrics, such as transformer oil
  - Model solid dielectrics, such as a polyethylene layer
- Solve transport equations for electrons, positive ions, and negative ions
- Incorporate processes like impact ionization, attachment, and recombination



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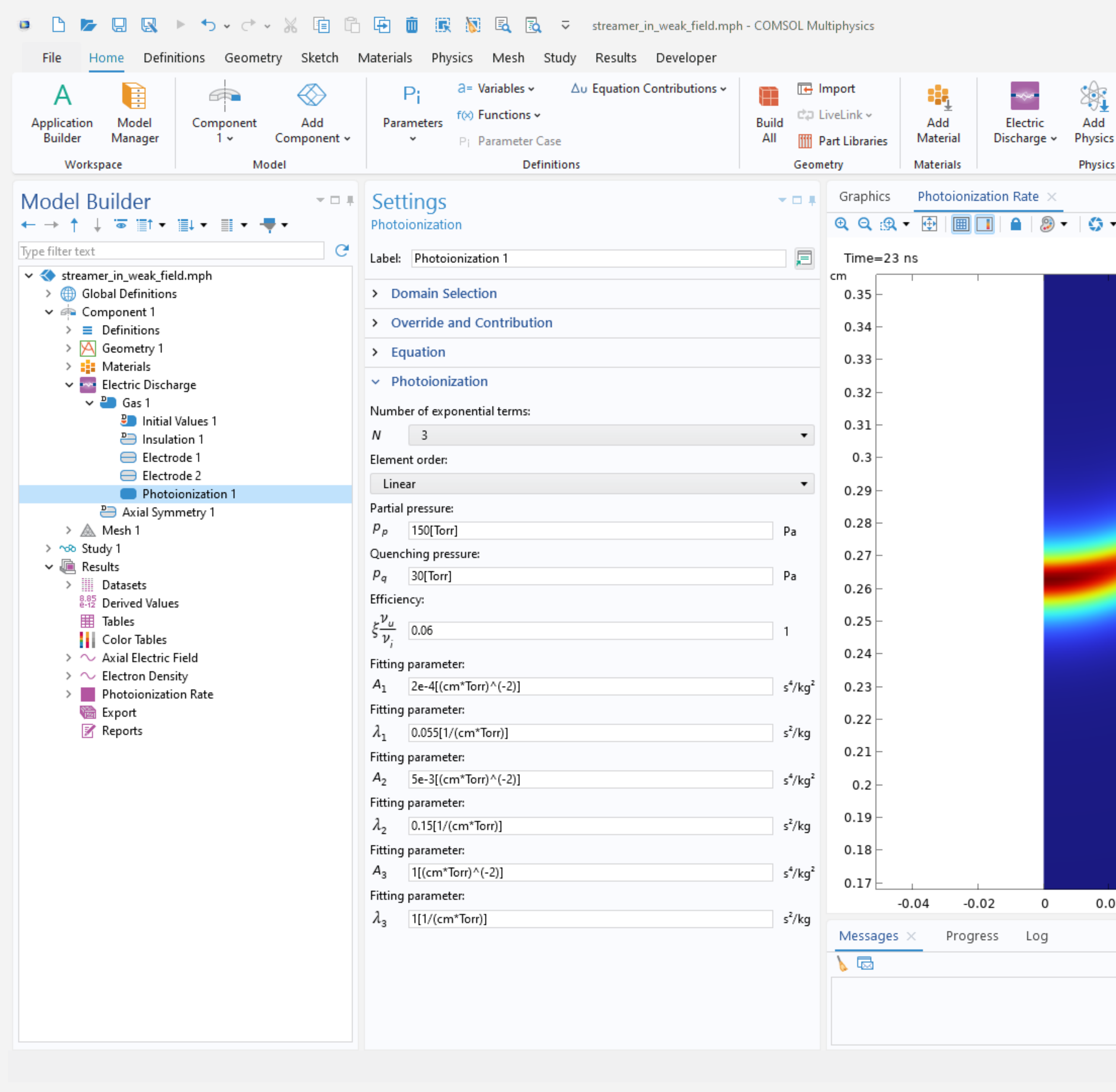
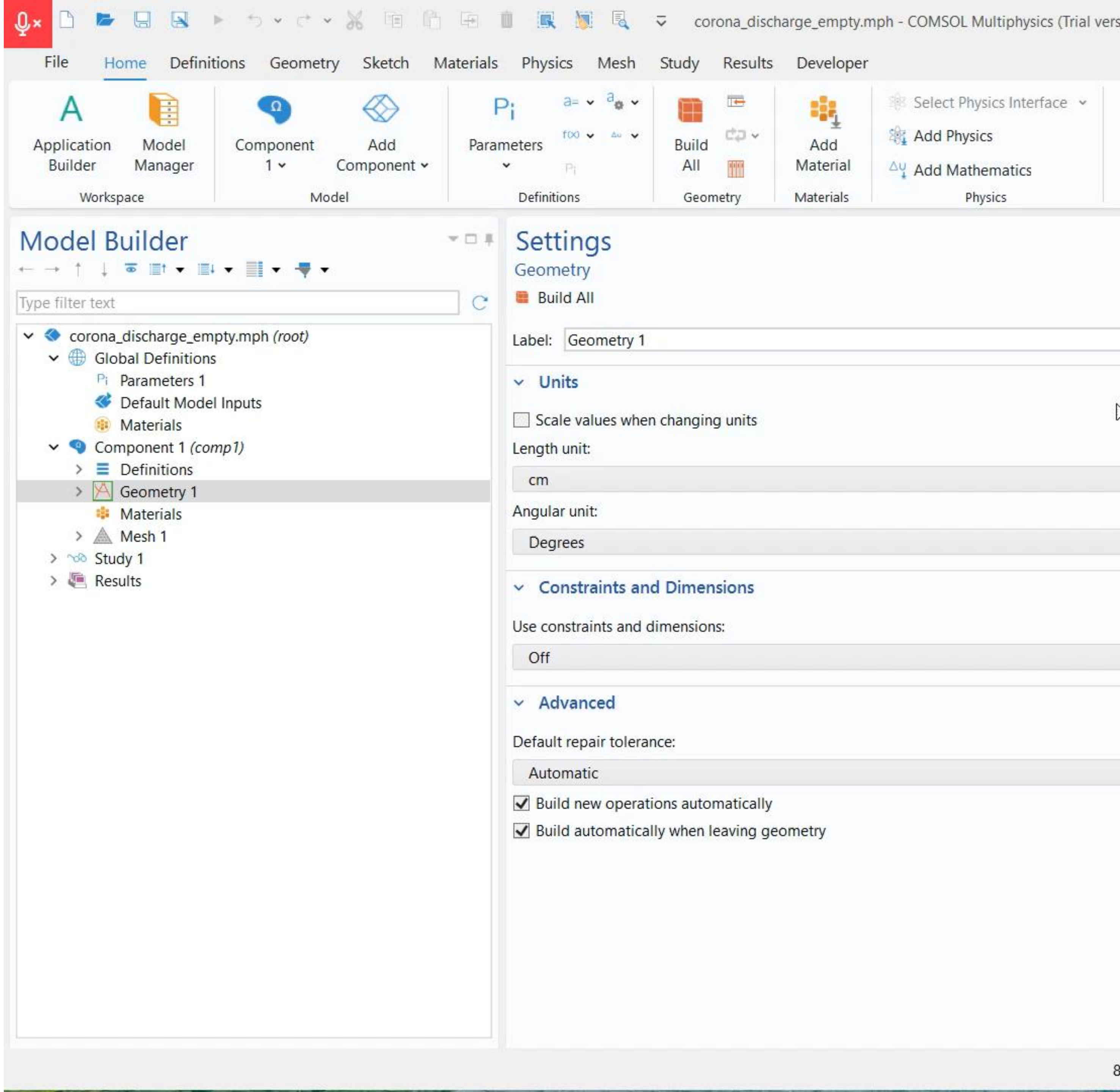
Photoionization

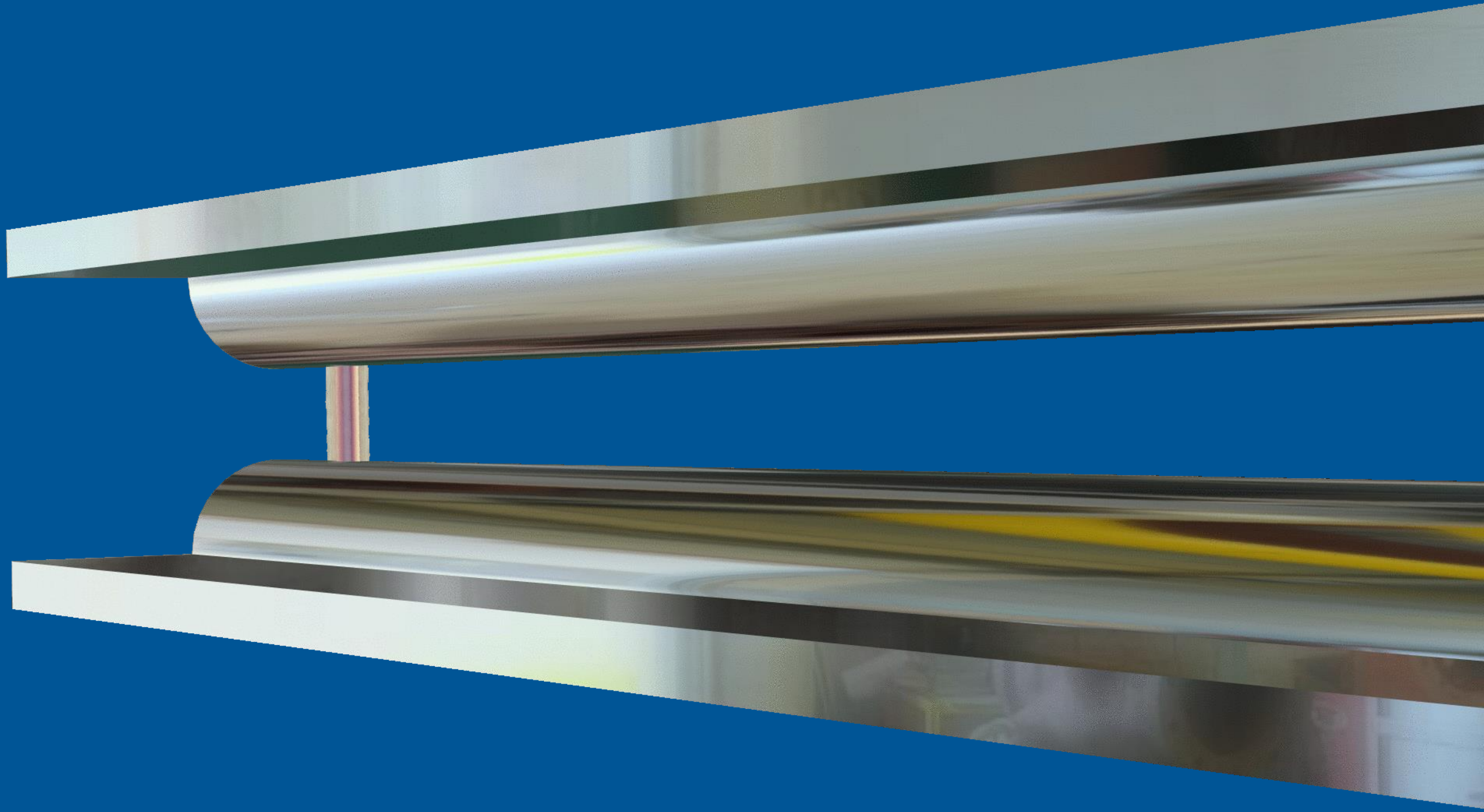
- Photoionization plays a critical role in positive electric discharges
- The built-in photoionization model is based on the radiative transfer method, enabling efficient computation of the photoionization rate
- Up to seven exponential terms are available to approximate the photoionization process



DEMO:
Corona Discharge

- Corona discharge between two wires with high voltage difference
- Electrons and ions are generated in the process
- Resulting in electrohydrodynamic force





Arc Discharge Interface

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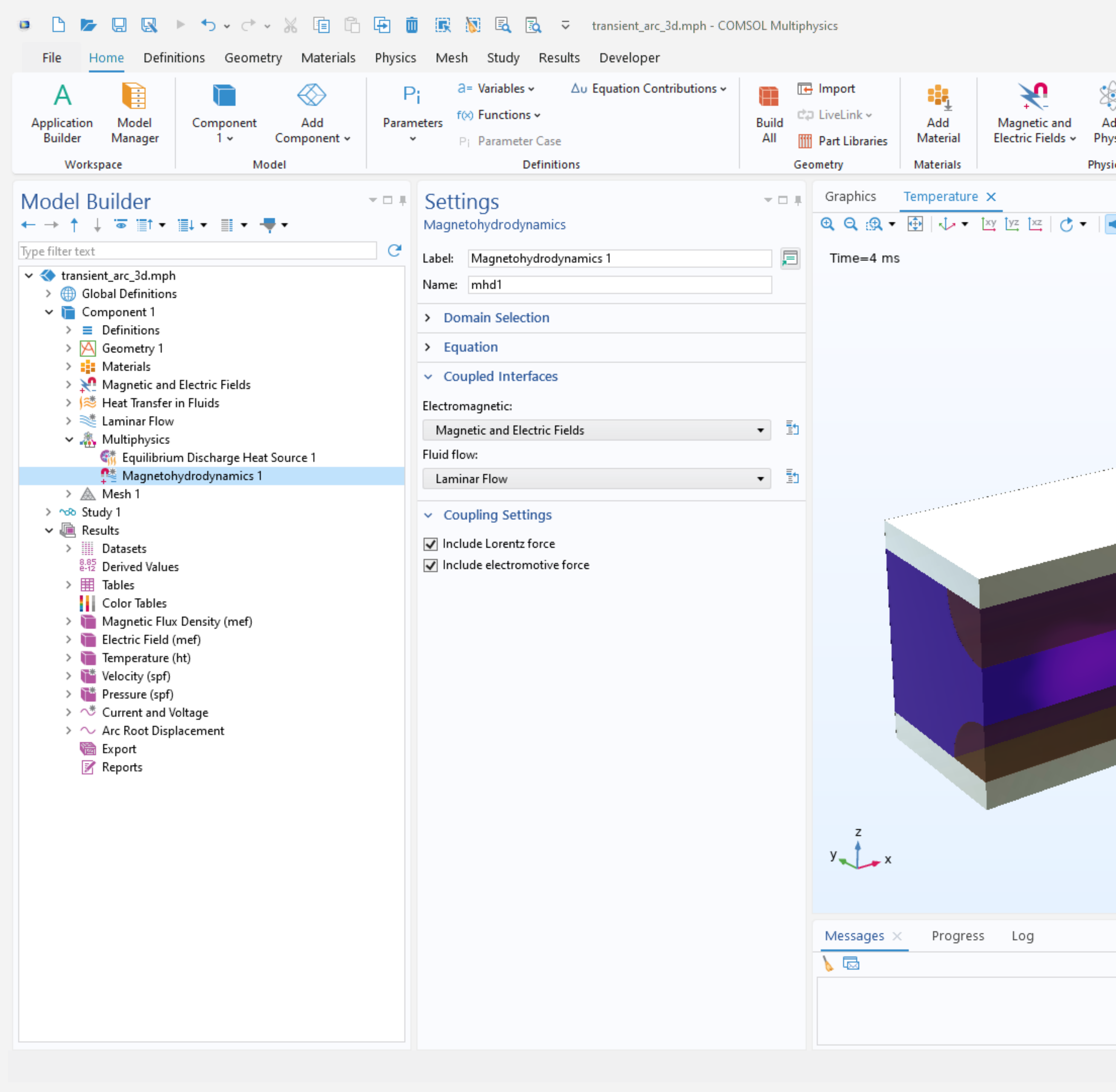
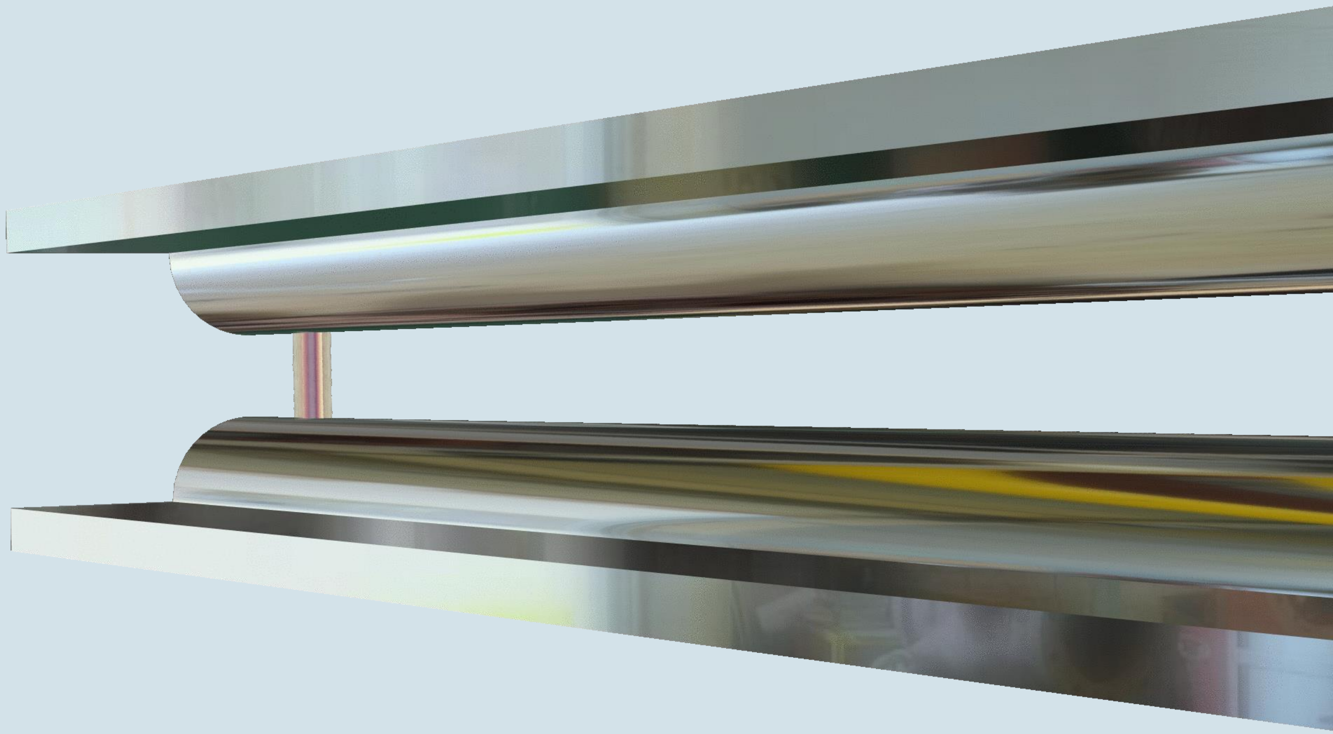
Arc Discharge Interface(s)

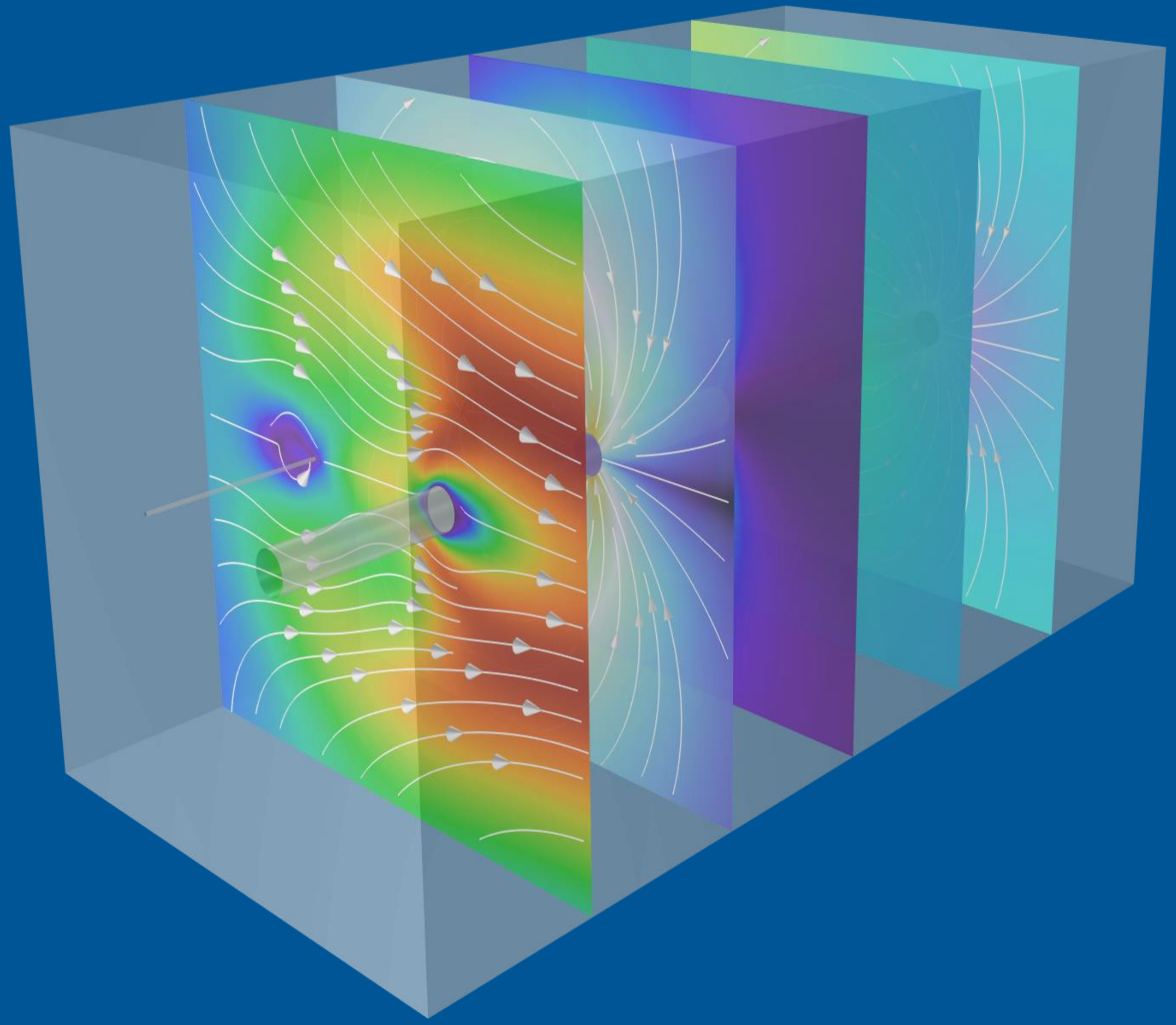
- Dedicated multiphysics interface for modeling high-temperature arc discharges
- Coupled physics interfaces:
  - Magnetic and Electric Fields
  - Heat Transfer in Fluids
  - Laminar Flow
- Multiphysics couplings:
  - Magnetohydrodynamics
  - Equilibrium Discharge Heat Source
  - Nonisothermal Flow



Modeling Arc Discharge

- A magnetohydrodynamics approach is used to describe the discharge as a single fluid with one temperature
- Couplings between electromagnetics and fluid flow: Lorentz force and electromotive force
- Couplings between electromagnetics and heat transfer include enthalpy transport, Joule heating, and radiation loss

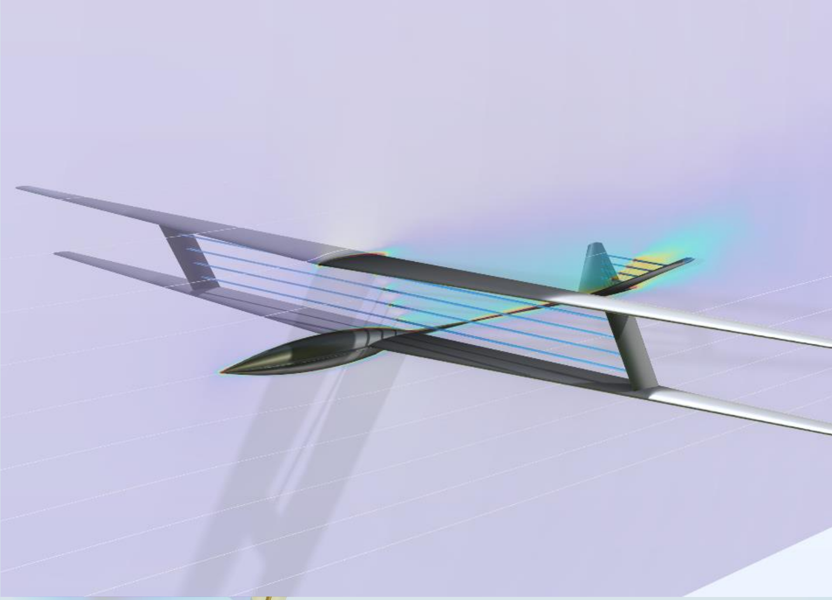


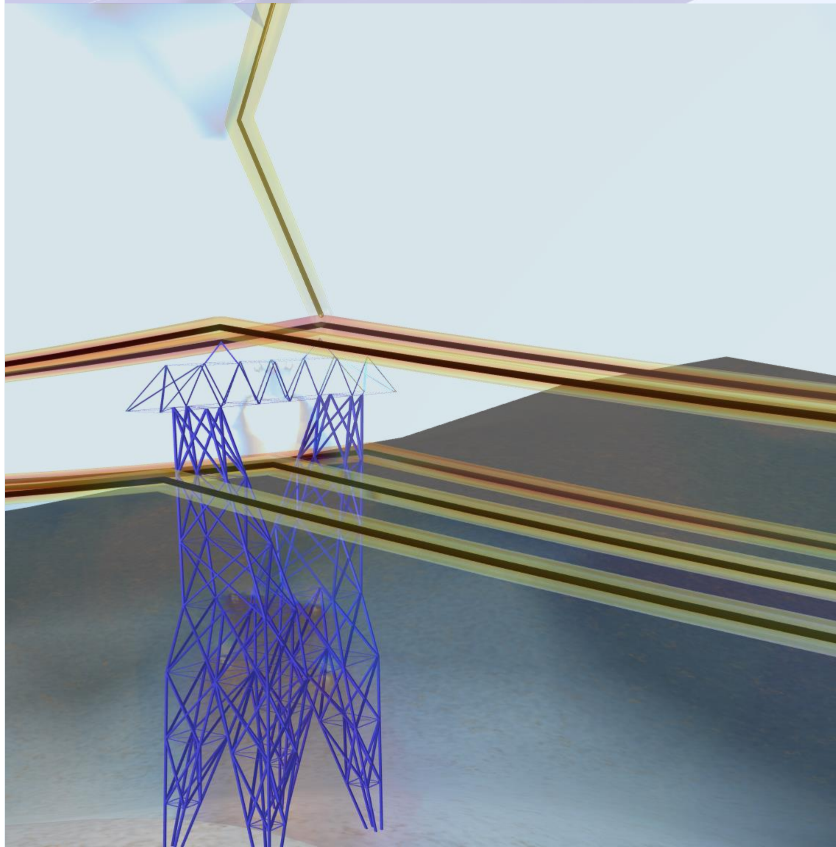


Discharge-Induced Effects

Discharge-Induced Effects

- Lightning-Induced Voltage
  - Simulate lightning-induced electromagnetic pulses and design lightning-proof electrical components, equipment, and systems
- Discharge-Induced Multiphysics Effects
  - Seamlessly integrate with other COMSOL products, including those for electromagnetics, structural mechanics, fluid flow, and heat transfer





DEMO:
Ionic Wind

- Applying the electrohydrodynamic force on the surrounding air driving the airflow
- Applications
  - Propulsion systems
  - Cooling of electronics