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Abstract
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Title
Modelisation of plasma discharge for aerospace applications: Streamer to arc transition.

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Abstract

Streamer and electric arc discharges play a very important role in many aerospace applications. The former are related to many safety issues, as for example lightning stroke to aircraft [1], or arc ignition in on-board high power networks for future electrical aircrafts [2]. Streamer discharges are much less energetic, but they are involved in the triggering phase of any electric arc discharge: Lightning precursors (leaders) triggered by aircraft flying in thunderstorm conditions [3], or partial discharges (PD) in high power grids [4]. Another field of research where these two plasma discharges arise is plasma assisted combustion and flow control. DBD (Dielectric Barrier Discharge) actuator technologies have been studied for decades for flow control at moderated velocities [5]. One of the biggest issues in the design of such devices is the difficulty to model streamer discharge propagation on dielectric surfaces and perform predictive simulations. Plasma actuators for high velocity flow control or plasma assisted combustion rely most of the time on DC, AC or pulsed electric arcs [6]. MHD (Magneto-Hydro-Dynamics) models have been successfully used to model electric arcs [7], but their ignition and dynamics may be influenced by the propagation of streamers in high field regions [8]. The absence of model in the literature able to deal with both discharge regime is a serious limitation to the understanding and progress in these different field of research. The main reason are the very different physics involved in these plasma regimes: In electric arcs, the plasma is quasi-neutral, possibly magnetized, and at local thermal equilibrium (LTE), which is well suited for MHD. Streamers on the other hand are non-neutral due to the presence of space-charges, and highly out of thermal and chemical equilibrium, making MHD approaches inappropriate. To model streamer discharges, non-neutral multi-fluid drift diffusion models have proven successful [9]. However, these models require timesteps and cell sizes decreasing dramatically as the plasma becomes more and more conductive, making the transition to an arc regime out of reach. The goal of this work is to propose an innovative numerical scheme, based on recent discretization technics called AP (Asymptotic Preserving) that could make it possible to unify streamer and arc models consistently [10-11].

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