



Editorial conclusions to the special issue on electrical discharges for aerospace applications

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Editorial Conclusions to the Special Issue on Electrical Discharges for Aerospace Applications, Journal of Physics D: Applied Physics, 2019-2020.

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This Special Issue, dedicated to the fundamentals and applications of electrical discharges for active control of gas flows and combustion, space propulsion, diagnostics and simulations, has 17 new manuscripts representing research performed in 8 countries. This success reflects a broad interest of the plasma physics and aerospace communities in the integration of plasma technology into aerospace applications.

The topic on plasma-based flow control includes several contributions, with papers related to plasma-flow interactions, shock wave control, boundary layer actuation, magnetohydrodynamics, and numerical simulations. Among of those, surface barrier discharges (DBD) are of a major focus. Several papers explored discharge properties and characterize the plasma-induced flowfield and disturbances introduced by the discharge on the flow. Another category addressed the effects that plasmas have on external flows, including boundary layer modification. The work of Thomas et al [1] announced major progress in skin friction drag reduction in turbulent boundary layers, where a “pulsed-DC” DBD “produces unprecedented levels of drag reduction in excess of 70%”, and is “achieved with net power savings”. The authors attributed the effect to preventing lift-up of low-speed streaks, which play a key role in wall bounded turbulent flows. A similar idea was exploited by Moralev et al [2], who describes the control of the low-velocity streak in a turbulent flow as an adaptive mechanism, suitable for plasma flow actuation. The mechanism, effectiveness, and scalability of the plasma-flow interaction are critical to furthering engineering applications as the potential for this technology has been disputed for some time. The paper of Singh and Little [3] discussed this concern further. Since the DBD is a small scale actuator that produces a low level of gas velocity fluctuations, applications are expected to be limited to low-speed applications unless it is used to trigger natural flow instabilities. Such an approach is the focus of the perspective in the paper of Samimy et al [4], whose approach for extending the range of parameters to high-speed and high-Reynolds number flows are based on a more localized geometry and a shorter pulse waveform both corresponding to a flow structure and stability margins. The authors use a heart-breaking term - “reinventing the wheel”, which is sure to attract readers. In a similar approach for supersonic flow control, a localized energy deposition, in the form of a plasma lattice, is applied by Watanabe et al [5] for the active control of shock position on a compression ramp. In this paper, the research is focused on understanding the impact on the system response time.

The topic of plasma space propulsion includes papers related to Hall thrusters. While reaching a level of maturity in flight, Hall thruster have tremendous untapped potential as advances continue to be made on simulations of detailed physical phenomenon critical to improving designs that push performance. The paper of Chernyshev et al [6] describes state-of-the-art 2D3V particle-in-cell (PIC) simulations with direct simulation Monte Carlo collisions to capture plasma structures and disturbances that propagate axial and azimuthally. The simulations are able to predict important features such as strong diamagnetic effects occurring during plasma ignition, and fluctuation-induced electron transport, which is attributed to both gradient-drift and electron cyclotron instabilities. The 2D3V simulations, however, do not capture effects associated with losses to the walls along the radial direction. PIC simulations that do resolve the radial direction is the subject of the paper by Domínguez-Vázquez et al [7]. This paper highlights the role played

by secondary electron emission from the dielectric walls in the formation of a magnetized near-wall conductivity, and in reducing the sheath potential, which serves to enhance electron wall loss and further generate anisotropy in the electron energy distribution. The paper of Gurciullo et al [8] addresses the increasing interest in the possibility of operating Hall thrusters on air, which may be harvested from the ambient environment in very low earth orbit. In that experimental study, a Hall thruster was operated on mixtures of xenon, nitrogen, and oxygen, with mass-specific ion energy distributions characterized using a Wein filter downstream of the thruster exit. While it is no surprise that of the molecular constituents, N_2^+ appears to contribute most to the total ion flux, one surprising result is that the lighter atomic ions, N^+ and O^+ seem to fall through a greater potential than that of either Xe^+ or N_2^+ , a result that is yet unexplained, and attributed to fluctuations in axial potential.

Advanced diagnostics of plasmas and reacting flows pertinent to the aerospace-related studies.

To some extent, this Special Issue made a survey of state-of-the-art reviewing the most aspects of plasma employment in emerging aerospace applications. The editors greatly appreciate the authors for their excellent contributions!

<https://iopscience.iop.org/journal/0022-3727/page/special-issue-on-electrical-discharges-for-aerospace-applications>

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