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Will Allis Prize for the Study of Ionized Gases Talk: Controlling the Properties of Low Temperature Plasmas: The Role of Modeling in Investigating the Science and Developing the Technology[1]

MARK KUSHNER, University of Michigan

The use of low temperature plasmas (LTPs) in society benefiting technologies has long been the motivation for improving the predictive capabilities of computer models of these systems. The intrinsic non-equilibrium and chemically active nature of LTPs, and their interaction with their boundaries, have required broad inclusive modeling approaches which address electron kinetics at one extreme and plasma surface interactions at the other. One measure of success in addressing this diversity is the increasing adoption of models in development of plasma utilizing technologies. In this talk, a review of one computational approach to this diversity, hybrid models (HMs), will be presented. HMs combine kinetic simulations with hydrodynamic techniques to capture the sometimes subtle roles of electron energy distributions, $f(\varepsilon)$, in the production and transport of reactive species. Two examples of HMs from the extremes of applications of LTPs will be discussed. The first addresses controlling $f(\varepsilon)$ in low pressure inductively and capacitively excited plasmas, as used in materials processing, through frequency, pulse power format, secondary emission and static magnetic fields. These techniques leverage the non-local transport of electrons and the anomalous nature of electromagnetic skin depths to customize $f(\varepsilon)$. The second example addresses the contributions of modeling to the understanding and optimization of plasmas in treating living tissue for therapy and sterilization. Atmospheric pressure plasmas interact with tissue by generating fluxes of radicals, ions and photons onto cell surfaces, the intracellular generation of electric fields and the possible production of plasmas within biological fluids. The current status and challenges for HMs in helping to understand plasma medicine will be reviewed. The critically important past and future role of the DAMOP community in developing the fundamental knowledge base required for these studies will be discussed.

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