Physics-based and data-driven models of partially ionized gases

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MAE Seminar Series

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Ionized gases (plasmas) play an important role in various engineering applications, including spacecraft electric propulsion, hypersonic flow, space weather, and microelectronic fabrication. The goal for computational plasma models is to predict dynamic behavior of complex systems, e.g., transport, reactions, energy heating and loss mechanisms, plasma-material interaction, etc. In this talk, I will present an overview of the theoretical and computational models for weakly ionized plasmas, with a particular focus on partially magnetized plasmas that are used in cross-field discharges such as Hall effect thrusters. First, I will discuss various kinetic models, such as particle-in-cell (PIC), Monte Carlo collision (MCC), and grid-based direct kinetic (DK) models, to investigate the effects of kinetic instabilities on anomalous plasma transport. Next, I will introduce the development of the full fluid moment (FFM) model, which is a new type of hydrodynamic model for low-temperature plasmas that capture electron inertia effects. Finally, I will present a data assimilation technique using extended Kalman filter (EKF) for plasma dynamics, which allows one to infer hidden states and parameters that are difficult to be measured.

Ken Hara is an Assistant Professor of Aeronautics and Astronautics at Stanford University. He received a Ph.D. in Aerospace Engineering and a Graduate Certificate in Plasma Science and Engineering from the University of Michigan (2015), and B.S. and M.S. in Aeronautics and Astronautics from the University of Tokyo (2008/2010). Prior to joining Stanford, he was a postdoc at Princeton Plasma Physics Laboratory and an assistant professor in the Department of Aerospace Engineering at Texas A&M University. He is a recipient of several awards, including AFOSR Young Investigator Program, DOE Early Career Research Program, Kuriki Award from Electric Rocket Propulsion Society, ONR Young Investigator Program, Noah Herskhowitz Early Career Award from Plasma Sources Science and Technology, and IEEE NPSS Early Achievement Award. His research interests include electric propulsion, low temperature plasmas, plasma-wall interactions, kinetic and fluid instabilities, data-driven modeling, rarefied gas flows, and computational fluid and plasma dynamics.

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