Center for Environmental & Applied Fluid Mechanics

"Towards Physics-Aware Design of Next-Generation Space Systems"

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Abstract: Plasma science becomes paramount to designing next-generation space and hypersonic systems owing to its high-energy density nature. Progress in the field, however, has been bottlenecked due to the need for more understanding of fundamental physics on plasma-matter interactions and connection to real-life design applications. This leads to significant uncertainty residing even to date when space systems encounter extreme environments and corresponding space situational awareness. Mainly, plasma-solid-electromagnetic wave interactions are inevitable for most space and defense systems, while almost no research has addressed physics-aware computational modeling of them. Similarly, ground tests also suffer due to the lack of reliable predictive models, often critical to convert measured signals to desired quantity of interest.

In this talk, I will unveil how my group's research leverages the synergy of uncertainty quantification and scalable multi-physics coupled algorithms to overcome these limitations and push the boundaries of computational modeling of plasmas around space and hypersonic systems. By integrating the first-principle plasma reaction dynamics and stochastic inference into a novel reduced-order modeling closure, my work reveals major quantity of interest of hypersonic shock layers with unprecedented fidelity. More importantly, I will demonstrate how these distinct physical modalities can converge to deliver multi-physics coupled insights into the extreme phenomena around space and defense systems, empowering engineers to achieve non-intrusive, efficient, and highly accurate interpretation of ground measurements, ultimately designing next-generation space and defense systems. Join me as we explore a future where strong foundation on plasma physics combined with scalable computational algorithm drives the next frontier of space exploration mission designs.

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