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Non-classical electron transport in Hall thrusters

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ABSTRACT - Hall effect thrusters (HET) are a plasma-based form of electric thruster commonly used for in-space propulsion. Their high fuel economy compared to more traditional chemical rockets has led to their widespread use on platforms ranging in scope from commercial buses to deep space vehicles. Yet, while HETs continue to grow in maturity and applications, there are aspects of their operation that remain poorly understood. The most critical of these is the so-called problem of electron transport. The HET derives its name from the electron ring current, the "Hall current," that results from the strong E × B fields applied to its axisymmetric, partially-magnetized plasma. The operation of these devices hinges on the ability to maintain this ring current while impeding crossed-field motion. While in principle the rate of depopulation of electrons in the ring current should be low, empirically it has been shown that losses from this region are three orders of magnitude higher than can be explained by classical effects. This talk outlines work at the University of Michigan to investigate this non-classical transport. The first part is an overview of plasma-based propulsion, the role of HETs in space operations, and the practical implications of the lack of understanding of electron transport in these devices. The second part is a discussion of experimental efforts to link the transport to the onset of low-level, high-frequency (MHz) turbulent fluctuations in the Hall direction. The third part focuses on the practical question of how to model this process predictively in an engineering code. Data-driven techniques for calibrating models and closures are presented and validated against experimental results.

Brief Bio

BENJAMIN JORNS is an Assistant Professor of Aerospace Engineering at the University of Michigan where he is co-director of the Plasmadynamics and Electric Propulsion Laboratory (PEPL). His research interests include wear mechanisms and stability in electric propulsion systems, turbulence and nonlinear processes in low temperature plasmas, optically-based

plasma diagnostics, and investigating breakthrough forms of in-space propulsion. Prior to joining the faculty at the University of Michigan in 2017, Prof. Jorns was a technologist in the electric propulsion group at the NASA Jet Propulsion Laboratory and a lecturer at the University of California, Los Angeles. He is a member of AIAA, IEEE, and APS and was a recipient of a 2018 Air Force Office of Scientific Research Young Investigator Program award. Prof. Jorns received a BS in physics from Yale University in 2007 and a PhD in Mechanical and Aerospace Engineering from Princeton University in 2012.