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Kinetic modeling of electrostatic ion thrusters

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The development of optimized electrostatic ion thrusters for space propulsion is until now a trial-and-error procedure. The need for expensive prototypes, extensive testing and iterative improvements is non-optimal in terms of time and costs. In other fields of research modeling is used to minimize the number of iterations, replacing real prototypes by virtual prototypes tested in numerical test environments. A typical example for this is car industry and the development of new car models, where numerical wind tunnels replace more and more real tests. Based on integrated models, combining self-consistent kinetic plasma models with plasma-wall interaction modules a new quality in the description of electrostatic thrusters can be reached. These open the perspective for modeling in this field. This will be discussed for the example of the HEMP (High Efficiency Multistage Plasma) thruster patented by Thales Electron Devices. HEMP thrusters represent a new type of grid less ion thrusters with a particular magnetic confinement of the plasma electrons. In the HEMP thrusters the specific magnetic field topology provided by a sequential arrangement of magnetic stages with cusps efficiently confines the plasma electrons and minimizes plasma-wall contact. Electron movement towards the thruster anode is strongly impeded by this magnetic field topology to form steep electrical field gradients for effective ion acceleration. As a consequence, the HEMP thruster concept allows for a high thermal efficiency due to both minimal heat dissipation and high acceleration efficiency, and for a wide range of operational parameters.

Primary author: Mrs DURAS, Julia (Nuremberg Institute of Technology)

Co-authors: Mr KAHNFELD, Daniel (University of Greifswald); Mr BANDELOW, Gunnar (University of Greifswald); Mr LÜSKOW, Karl (University of Greifswald); Mr MATYASH, Konstantin (University of Greifswald); Mr KOCH, Norbert (Nuremberg Institute of Technology); Mr MATTHIAS, Paul (University of Greifswald); Mr SCHNIEDER, Ralf (University of Greifswald); Mr KEMNITZ, Stefan (University of Rostock)

Presenter: Mrs DURAS, Julia (Nuremberg Institute of Technology)

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