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Simulation Tools for Plasma Micro-Propulsion

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The talk will present EP2 activities in the development of models and simulation codes for different plasma thrusters. Under several public and industrial programs, EP2 is directly involved in the research of the plasma discharge in Hall-effect thrusters (HET), ECR accelerators (ECRA), and Helicon Plasma Thrusters (HPT), and the optimization of performances and design of these technologies. Beyond the ongoing development of thruster-specific codes, EP2 is aiming ultimately at achieving a unified simulation code for a class of plasma thrusters, namely electromagnetic thrusters operating with weakly collisional plasmas, which, apart from the previous three ones, includes the HEMP. Besides reducing costs in code development, validation, and operation, the unified approach will allow a better and more systematic understanding and comparison of the different technologies.

The thruster code will be 2D (axilsymmetric), based on a hybrid (particle/fluid/wave) formulation, and will consist of several core modules: one for ion transport, one for electron transport, one for the main electric field, and one for the wave-plasma interaction (this last one, only active for RF-based plasma sources). One central study to be carried out with the code is a down-scaling analysis of the above thrusters in order to elucidate their capabilities and constraints for mini- and micro- propulsion, which are not obvious.

Completing the above 2D codes, EP2 is also involved in the development of a hybrid 3D code of the expansion of the energetic rarefied plume emitted by a generic plasma thruster. The code is capable of dealing with both the near plume (which is very dependent on the thruster type) and the far plume (where plume-spacecraft interaction is a subject of major concern). The code is suited for low-power propulsion and multi thruster arrangements. This code will include collisionless plume cooling and some magnetic field effects.

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[3] F. Cichocki, A. Domínguez, M. Merino, E. Ahedo, 'A 3D Hybrid Code to Study Electric Thruster Plumes', in *Space Propulsion 2016*, Rome, May 3-6, paper 312-4968 (2016).

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