An unstructured HPC parallel 3D code for numerical simulations of a Hall effect thruster

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Hall effect thrusters have been used for spatial propulsion since the 1970's. However, complex physical phenomena such as erosion or instabilities which may lower thruster efficiency and lifetime, are not yet fully understood. Unfortunately experiments for the design of Hall thrusters are long and expensive and numerical simulations are now considered to understand and control plasma behavior and predict system efficiency. With the renewed interest for such electric propulsion to supply light satellites, the industry needs accurate numerical solvers.

In this context, CERFACS is developing, in collaboration with the LPP (Laboratoire de Physique des Plasmas), the AVIP code which solves plasma physics in real industrial geometries using an unstructured parallel-efficient 3D fluid/particle methodology. The particle solver uses a Particle-In-Cell (PIC) method to solve the dynamic of ions neutrals and electrons combined with a Monte-Carlo approach for collisions. A Poisson equation is considered for the electric field resolution and the magnetic field is supposed constant. The PIC algorithm has been validated against benchmarks of helium discharges[1]. Similarly to the work of Futtersack[2] and Hakim[3,4], the fluid approach includes a detailed plasma model where species are ruled by a system of Euler equations with source terms representing electric field, ionization or other chemical processes. The fluid part is being validated on different classical benchmarks. Both PIC and fluid solvers are developed in parallel with the idea of building a hybrid solver that will describe the dynamics of ions and neutrals with the PIC solver and electrons with the fluid method.

In this poster, numerical methods and models developed in the AVIP solver will be presented. A particular attention is paid to the choice and validation of the fluid model and numerical schemes. Comparisons of benchmarks between PIC and fluid solvers will be shown. Specifically the influence of the heat flux[4] will be discussed.

References:

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