Electrohydrodynamic modeling of electrospray thrusters

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Small spacecraft require compact, less than 1U, and energy-efficient (5–100 W) propulsion systems. A promising solution is electrospray thrusters [1], which operate on the principle of emitting droplets and/or ions from the ionic liquid (IL) meniscus surface in an electric field, and followed by ion acceleration by electric field. A combined model, integrating analytical and numerical methods, is used to calculate electrospray thruster integral parameters. This study presents a numerical module that calculates the electrostatic field, the shape of the meniscus and droplets, and the velocities of the particles. The following values are supplied to input: thruster geometry, properties of the emitter material and IL, and voltage between cathodes. The formation of the Taylor cone and the subsequent droplet/ion mode at the emitter needle is calculated using a 2D axisymmetric electrohydrodynamic leaky dielectric model [2]. The electrostatic field is calculated from Poisson's equation, and the charge conservation law is solved alongside the Navier-Stokes equation for flow field and charge distribution. The Volume-of-Fluid (VOF) method is used to capture the interface between liquid and vacuum. The hydrodynamic equations are solved in OpenFOAM using the finite volume method, while Poisson's equation is solved in MFEM using the finite element method. To verify and validate the model, the meniscus shape was computed and compared with the data underlying the study [3]. The module will be further expanded and improved by incorporating particle motion to predict the divergence angle and the extractor surface impingement rate.

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[2] Saville D A 1997 *Annual Review of Fluid Mechanics* **29** 27–64

[3] Petro E M, Gallud X, Hampl S K, Schroeder M, Geiger C and Lozano P C 2022 *J. Appl. Phys.* **131** 193301