Measurements and kinetic simulations of the Alternative Low Power Hybrid ion Engine (alphie)

L. Conde[1], J. Gonzalez[2], J. M. Donoso[1], J. L. Domenech-Garret[1], M. A. Castillo[3]

[1] Departamento de Física Aplicada. Escuela Técnica Superior de Ingeniería Aeronáutica y del Espacio. Universidad Politécnica de Madrid, 28040 Madrid. Spain.

[2] DIFFER Dutch Institute for Fundamental Energy Research. De Zaale 20, 5612 AJ Eindoven. The Netherlands.

[3] Aernnova Aerospace SAU. Avenida de Manoteras 20, 28050 Madrid. Spain.

The Alternative Low Power Hybrid Ion Engine (*alphie*) is a new gridded plasma thruster introduced in reference [1] that been the subject of two recently granted patents [2, 3]. This new concept is intended to provide high specific impulses to small (100 − 500 kg) satellites, where electrical power available is typically below 300 W. Its envisaged applications are the station keeping, flight formation and/or end-of-life disposal maneuvers. This new disruptive technology presents an unique counter-flow of charges through its two grids system operating only with one external cathode with a twofold function: to neutralize the accelerated outgoing ions and to provide the electrons for the ionization of propellant gas (Argon, Xenon). These electrons are accelerated to high energies by the potential drop between the two grids and then are trapped by the magnetic field inside the ionization chamber. Additionally to ionizing the neutral gas, electrons exchange an important amount of energy with the neutrals, leading to high temperature distributions of exhausted ions [1]. In this work, a series of experimental data and simulations performed during the ongoing development of *alphie* are presented. The dynamics in the plasma plume are measured by means of a RPA retarded field energy analyzer (RFEA) along the axial and radial directions. The relevant collision processes taking care place in the plume and leading to the two-peaked distributions are analysed by means of a new fully kinetic particle-in-cell code named *fpakc*. Moreover, the counter-flow of charges is simulated and similar exhausts velocities are obtained (in the order of 40-50 km/s) as in the experiments [4].

[1] Conde, L., et al., J. Appl. Phys., 131.2 (2022): 023302.
[2] Conde, L., et al., 2019. US Patent No. 10,172,227 B2.
[3] Conde, L., et al., 2015. European Patent EP3369294B1.
[4] Gonzalez, J., et al., Phys. Plasmas, Vol. 26, No. 4, 2019, p. 043505.