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The physics, performance and predictions of the PEGASES ion-ion thruster[1]

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Electric propulsion (EP) is now used systematically in space applications (due to the fuel and lifetime economy) to the extent that EP is now recognized as the next generation space technology. The uses of EP systems have though been limited to attitude control of GEO-stationary satellites and scientific missions. Now, the community envisages the use of EP for a variety of other applications as well; such as orbit transfer maneuvers, satellites in low altitudes, space debris removal, cube-sat control, challenging scientific missions close to and far from earth etc. For this we need a platform of EP systems providing much more variety in performance than what classical Hall and Gridded thrusters can provide alone. PEGASES is a gridded thruster that can be an alternative for some new applications in space, in particular for space debris removal. Unlike classical ion thrusters, here positive and negative ions are alternately accelerated to produce thrust. In this presentation we will look at the fundamental aspects of PEGASES. The emphasis will be put on our current understanding, obtained via analytical models, PIC simulations and experimental measurements, of the alternate extraction and acceleration process. We show that at low grid bias frequencies (10s of kHz), the system can be described as a sequence of negative and positive ions accelerated as packets within a classical DC mode. Here secondary electrons created in the downstream chamber play an important role in the beam space charge compensation. At higher frequencies (100s of kHz) the transit time of the ions in the grid gap becomes comparable to the bias period, leading to an "AC acceleration mode." Here the beam is fully space charge compensated and the ion energy and current are functions of the applied frequency and waveform. A generalization of the Child-Langmuir space charge limited law is developed for pulsed voltages and allows evaluating the optimal parameter space and performance of PEGASES.

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