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Double beam satellite propulsion

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In this talk I present brief review on a dual beam sources used in space propulsion. Dual beam propulsion is currently represented by few innovative concepts being under development. These concepts promise several advantages to the propulsion, such as precise control of the spacecraft potential, reduced background plasma and removal of a dedicated neutralization system that increases general robustness and mass/dimension property. In addition, dual propulsion concepts have great ability to downscale enabling possibility to use efficient propulsion system for a small spacecraft such as CubeSats and nano-sats.
One of the dual beam propulsion concepts is a PEGASES concept (acronym for "plasma propulsion with electronegative gases") where an electronegative plasma discharge is used to create alternated beam packets of positive and negative ions. Efficient broad beam negative ion extraction is possible due to very high plasma electronegativity i.e. ratio between the negative ion and electron density (reaches 5000); under these conditions plasma response is similar to both positive and negative bias since the electron influence on the sheath formation is negligible. By applying square waveform to the gridded ion acceleration system, positive and negative ions are alternately accelerated up to high velocities (>40 km/s) that provide a thrust force in the direction opposite to the ion acceleration. The generated beam is quasi-neutral, and a spacecraft potential can be controlled by changing a duty cycle of the acceleration voltage waveform. Absence of electrons in the generated beam is expected to reduce background plasma formation, and in addition should decrease beam divergence in a presence of weak magnetic field that can be important for the future missions devoted to targeted space debris removal. Use of this source is however limited to very electronegative propellants, typically based on fluorine, iodine or fullerenes.
Another successful dual beam propulsion concept which will be discussed here is based on an ion-electron source with RF acceleration principle. Briefly, this concept assumes using the plasma self-bias effect in the RF-powered gridded system, providing quasi-simultaneous ion-electron acceleration. Heavy ions are accelerated by an averagely dc electric field, while electrons are co-extracted using the same extraction system in a short moments when oscillating plasma potential reaches low values. First proof of concept is already achieved, demonstrating similar efficiency as for traditional gridded ion thrusters. The ion and electron fluxes emitted by the source are equal helping to achieve much better beam neutralization than in traditional system with neutralizer. The experiments demonstrate that emitted flow of electrons is highly directional, thus the thruster plume can be precisely localized. Strong advantage of this concept is significant technology heritage, because of similarity with the already operated ion thrusters.

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Yes

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