PLASMA THRUSTERS FOR SPACE APPLICATION, MATHEMATICAL MODELING

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In this lecture we confine our attention to Hall Effect Thrusters (HET) only. Their applications include control of the orientation and position of orbiting satellites. They are also used as a main propulsion engines in space missions. HET is a type of ion thruster in which the propellant is accelerated by an axial electric field, which is perpendicular to a radial magnetic field. As a result electrons are magnetized, so they are subject to Hall effect, i.e. the main direction of electron movement is perpendicular to both the magnetic and electric fields. In this way, the axial electron current is strongly reduced (to zero if there were no collisions), which allows the ions to be accelerated. Ions are practically not affected by the magnetic field due to their much larger masses. Starting from the equations for three fluids, i.e. fluid of neutral particles, electron fluid and fluid consisting of "cold" ions, we construct a system of equations that describes the operation of such an engine. Experimental data and numerical simulations reveal emerging instabilities and oscillations in HET plasma discharge. The most distinctive are the low-frequency breathing mode oscillations, which have the character of oscillations appearing in predator-prey systems. The role of predators is played by electrons, while neutral atoms play the role of prey - atoms are ionized (killed) in collisions with electrons. At high operating voltages, the oscillations become so violent that they can break the plasma discharge. In this case their elimination or mitigation becomes a key issue. We derive simplified equations that allow us to better understand the conditions under which these instabilities appear.

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