Vortex plasma thruster

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Abstract

The device of a vortex plasma thruster is proposed, in which the collective accelerator mechanism of nuclear fusion reactions is used. It is shown that in the approximation of three nuclei, the threshold value of the potential energy spent on overcoming the Coulomb barrier is several orders of magnitude less than the threshold value of the kinetic energy of paired collisions of nuclei.

The device proposed for discussion relates to the Plasma Propulsion Physics [1] The proposed device differs significantly from cylindrical Hall thrusters [2] and from wall-less Hall thrusters [3], but at the same time it has similarities with them. The main element of a vortex plasma thruster is a conical funnel, in which a gas vortex is formed with the help of a turbine, flying at supersonic speed into a cylindrical chamber of a high-frequency inductor, where it turns into a rotating plasma cylinder with a double electric layer structure. In alternating-constant crossed fields (radial electric and orthogonal magnetic), the plasma rotates as a whole under the action of these fields, and the diameter of the double electric layer of the cylindrical plasma shell is compressed (including due to its own magnetic field) with the frequency of oscillations of the electric field ω_1. At the same time, ion-sound waves are spontaneously formed in the plasma cylinder of the double electric layer due to the nonequilibrium of the plasma caused by its rotation, and when the oscillation frequency of the variable part of the electric field coincides with the oscillation frequency of one of the modes of the standing ion-sound wave, the oscillation amplitude of the ion density of the wave resonantly increases. In addition, the shock wave created by the supersonic plasma flow compresses the plasma cylinder with a ring of shock density of the double electric layer passing through it. It is also expected that the collective-accelerator mechanism of extremely compressed plasma oscillations will create conditions for

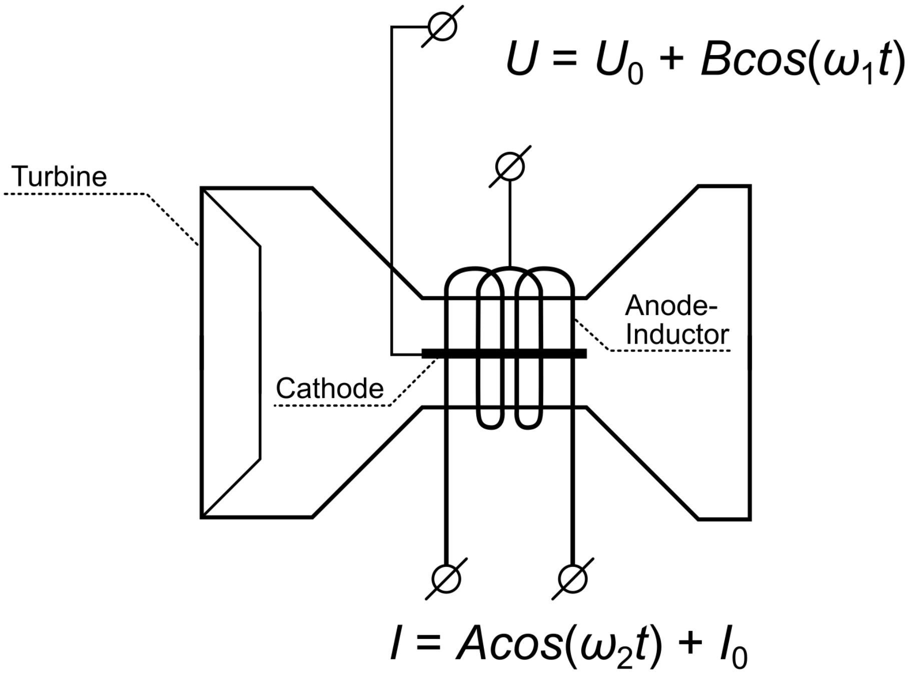

Figure 1: Schematic diagram of a vortex plasma thruster

launching a cold nuclear fusion reaction. In this case, at the outlet of the funnel, we will get not only a faster, but also a hotter gas vortex, which can be returned to the turbine inlet with the help of a pipe branch, turning the jet engine into a motor-generator of thermal and electrical energy. In turn, if we remove the exhaust funnel in our scheme, tightly closing the chamber to the right of the solenoid, then instead of a jet engine, we will get a device that generates an artificial tornado and ball lightning.

Let us now supplement our verbal description with the necessary formulas. Similar to how it is done when deriving a barometric formula [4], from the force balance equation, we obtain the formula for the dependence of the pressure P of the main (background) flow of a rotating plasma on the distance r to the cylinder axis

$$P = P_0 \exp\left(\frac{-MU^2}{RTB^2r^2}\right)$$

where P_0 is the pressure on the chamber wall, U is the voltage between the anode and the cathode, M is the molar mass, B is the magnetic field induction, T is the plasma temperature, R is the universal gas constant, and $P_0 = \rho\frac{\omega^2 r_0^2}{2}$, where ρ is the density of the gas medium, ω is the angular velocity of rotation of the plasma, and r_0 is the radius of the cylindrical chamber. At the same time, the pressure of the external electric field gradient $\nabla E \approx \frac{U}{r^2}$ on the double electric layer of the cylindrical plasma shell having radius r, initial concentration n_0 and width D is equal to

$$P' = \frac{r_0 n_0 U D^2}{r^3}$$

On the other hand, the pressure of the centrifugal force on the double layer of the cylindrical plasma shell rotating with the tangential velocity v_τ, which consists of the drift velocity $\frac{U}{rB}$ and the velocity of the aerodynamic twisting of the gas, is equal to

$$P'' = \frac{n_0 r_0 M v_\tau^2 D}{r^2}$$

In turn, the radius of the double layer of the plasma flow can be calculated from the equality $P' = P''$

$$r = \frac{UD}{M v_\tau^2}$$

and the compression ratio of the cylindrical shell of the double plasma layer

$$\frac{r_0}{r} = \frac{r_0 M v_\tau^2}{UD}$$

Thus, the density and concentration of the cylinder of the double electric layer having a radius of r significantly exceeds the density and concentration of the main (background) plasma at a distance of r from the axis of the cylindrical chamber, and therefore the greatest density of the probability of nuclear fusion is localized in the cylindrical shell of the double plasma layer. In other words, a thin dense shell of a double layer of plasma rotates in a rarefied region of the plasma, and the overcoming of the Coulomb barrier of nuclear fusion reactions occurs mainly due to the collective interaction of nuclei assembled together in the ring of the double layer, and not due to paired collisions, as is the case in high-temperature plasma. Indeed, let the average distance between pairs of neighboring nuclei having a charge q and imaginatively connected in a chain along a circle of radius r be s. Then, in the approximation of three nuclei, the radial force pushing each nucleus of the chain outside the circle by two neighboring nuclei is equal to

$$F_r \approx 2\frac{q^2}{s^2} \cdot \frac{s}{r} = \frac{2q^2}{sr}$$

and the tangential force acting on a nucleus that, relative to neighboring nuclei, has a deviation from the average value of Δs, that is, shifted by a distance of Δs, is equal to

$$F_\tau \approx \frac{q^2}{(s+\Delta s)^2} - \frac{q^2}{(s-\Delta s)^2} \approx \frac{4q^2 \Delta s}{s^3}$$

Imaginary chains of nuclei lie on the positively charged surface of the double layer (or rather, they move chaotically in the thickness of this surface), which is why density waves will propagate along the ring of the double layer, and in the case of resonance with the frequency of forced oscillations of the external electric field, there should be a significant increase in the amplitude of the displacement Δs, and consequently a significant decrease in the distance of convergence of the nucleus $s - \Delta s$, which is responsible for overcoming the Coulomb barrier in nuclear synthesis reactions. Finally, we calculate, in the approximation of three nuclei, the threshold value of the potential energy that must be expended to overcome the Coulomb barrier by the average nucleus, equal to $b = s - \Delta s$

$$U = \frac{2q^2(s-b)^2}{s^3}$$

Then, since the concentration of ions n of the double plasma layer and the average distance between the ions s are related by the formula $n = \frac{1}{s^3}$, we finally have

$$U = 2nq^2(n^{-\frac{1}{3}} - b)^2$$

and, for example, at $b = 10^{-13}\,cm$, $n = 10^{18}\,cm^{-3}$, we get a threshold value of the proton potential energy $U \approx 0.3\,eV$, which is several orders of magnitude less than the threshold value of the kinetic energy of paired collisions approximately equal to $1\,MeV$.

In conclusion, we recognize that our theoretical conclusions require more detailed mathematical modeling and experimental verification. On the other hand, it should also be recognized that the presented mathematical calculations are quite sufficient to initiate R & D. We also draw your attention to the fact that the analysis of the operation of the vortex plasma engine device is based on classical physical concepts, but taking into account a new view of the mechanism of collective interaction of nuclei in the reaction of the so-called cold nuclear fusion.

References

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