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The Linear Fusion Reactor Linrec

(in abbreviated form)

CTF will rescue Earth

More than half a century minds of people excites possibility of receiving the electric power by means of the controlled thermonuclear fusion (CTF). For today it is represented the most probable solution of such scandalous problems of survival of mankind, as global warming on a planet, atmosphere and hydrosphere pollution, an energy crisis at the termination of stocks of naphtha and natural gas. The world in which the mankind receives energy at the expense of almost inexhaustible pollution-free thermonuclear fuel (deuterium) in comparison with present much seems paradise on the earth.

However, long-term researches in this direction yet did not yield actual result. Most the CTF perspective direction — Tokamak installations — is today at a stage of check of actual effectiveness. The ITER project (International Thermonuclear Experimental Reactor) plans to receive the first plasma by 2020, while it is possible to guess results of this experimental reactor only (www.iter.org). Other CTF directions, such as a laser fusion, yet did not overcome the keyest difficulties of achievement of positive energy balance.

In this article the CTF new method — the Linear Fusion Reactor on colliding plasma beams of high energy, (in abbreviated form Linrec), is offered in essence. This reactor was calculated by the author as a first approximation in 2012, and these calculations show that today Linrec is not a fantasy, but lies somewhere on the verge of existing technologies and for actual work demands the creative solution of several engineering tasks.

Linrec's principle

The common principle of the linear fusion reactor on colliding plasma beams Linrec consists that the nucleus before the delay and before a departure out of beam in the reactor has to react with a counter nucleus with rather high probability (unreacted nuclei carry away for nothing the energy spent for their acceleration). In other words, a nucleus, moving with a plasma beam with a speed, sufficient for nuclear reaction, has to meet other nucleus moving towards, in the nuclear cross section of reaction with probability, sufficient for the positive energy balance.

Speed of a beam is defined from reaction characteristics (for deuterium-tritium reaction optimum speed correspond to energy of a nucleus about 80 Kiloelectronvolts, thus nuclear cross section is maximally and makes 5 barns). The probability of reaction of one nucleus is defined by a formula **p=1-1/e^(x/l)**, where x — the path passed before delay, l — the special reference length which is determined by a formula **l=1/(s*n)**, where s — the cross section of reaction, n — concentration of nuclei in colliding beam. (There is author's mathematical proof of this formula in the Linear Fusion Reactor CNEWS forum, http://live.cnews.ru/forum/index.php?showtopic=79853). For probability of reaction (1-1/e) ~63% at the reference length 1 kilometer required concentration is n=2*10^18 nuclei in cubic centimeter. Thus the pulse length has to be equal 300 microseconds (approximately). In receiving a plasma beam with such characteristics the problem consists for today. Though theoretically plasma accelerators are capable to generate similar beams, practically for today I did not find actual model with such parameters. Probably, it was simply not necessary till this time. The

theory allows to construct the similar plasma accelerator, and Linrec's some features allow to soften requirements to parameters of a plasma beam and facilitate creation of the corresponding accelerator. Author have some ideas to obtain required plasma beams.

That occurs in Linrec

The theory as a first approximation gives such picture of processes in Linrec. At a meeting of beams of plasma in the center of the reactor, a nuclei are braked on counter electrons apart about a centimeter (maximum). Energy of nuclei is transferred to counter electrons. In the center the fixed cylinder of plasma with the energy of electrons approximately equal to initial energy of nuclei is formed. Through this layer flying nuclei pass already without the essential power loss (symbolically), the fixed cylinder of high energy plasma is extended with a speed about a half of initial velocity of beam to one the direction and with the same speed to another. Radial dispersal of a beam thus is defined by the magnetic field intensity in Linrec. Particles in a transversal projection move on a circle r=mv/qB radius, at B=5 Teslas for deuterons this radius is not greater then centimeter (approximately), for electrons — about tenth share of millimeter (maximum). Nuclei which did not react in the fixed cylinder, expand this cylinder while its length will not reach a limit (about 2l, on such way react about 87% of nuclei).

Certainly, this picture is very approximate. The computer model can clear a situation to some extent. But also it can strikingly differ from results of the subsequent experiment.

It is important that the energy spent for dispersal of nuclei, even in the stopped plasma turns into energy of thermal motion and gives the chance of further thermonuclear reactions similar to that happen in a tokamak, but to the very increased density of plasma. It is the main reason for positive energy balance of Linrec.

Why Linrec

The reason for which Linrec is energetically more perspective, than a tokamak, is that given energy in a tokamak is spent for the radial speed which, except the useful function for reaction, washes away a plasma beam and by that reduces time of its keeping and an energy efficiency. In Linrec all energy of acceleration is spent for the longitudinal speed which does not disperse a beam but only gives the chance of reaction. Beam degradation in Linrec is secondary harmful effect which can be reduced in the different ways, increasing an energy output.

There is a question, whether it is possible to curtail Linrec into some rings and to reduce its length, that is whether Linrec's principle in a tokamak with counter injection of two high-energy plasma beams will work. For this time answer - No. Problem is that high-speed particles in a tokamak will move not on an ideal circle, but on a spiral, with each round increasing radius by size about $(\sqrt{2})\ \pi$*mv/qB so, having curtailed kilometer Linrec into a ring 30 meters long, we will receive average degradation of a beam with the parameters stated above about a meter. It is absolutely unacceptable, as for power reasons the admissible diameter of the specified beam about a several centimeters. At increase in diameter of a beam the expense and an energy output will exceed reasonable possible limits. So, the beam with a diameter of 1 centimeter with a length of 1 kilometer with concentration 2*10^18 nuclei in cubic centimeter with energy of a nucleus of 100 kiloelectronvolts demands for acceleration ~1,6*10^28 electronvolts (without losses), or ~2,5*10^9 joules, and this energy has to be emitted for time of 300 microseconds. With a frequency of 1 an impulse per 10 seconds necessary power input on one plasma accelerator is more than 250 megawatts. Terminating power output at such parameters of a beam, reaction of 50% of nuclei and efficiency of the subsequent production of the electric power of 30% is about 6,6 gigawatts. Respectively, 1 impulse per 1000 seconds is necessary for a beam with a diameter of 10 centimeters at the same parameters of power. In this case energy brought in an impulse is equal to ~2,5*10^11 joules, and energy emitted for time at reaction of 50% of nuclei will be about 20 terajoules (for comparison: explosion of a nuclear bomb over Hiroshima — about 71 terajoules). So for today the actual diameter of a plasma beam in Linrec is about a centimeter.

Not single exit

Linrec will rescue a planet Earth from ecological and power crises or not — the author estimates these probabilities as 50%:50%. Too many surprises are laid up at the nature as long-term researches CTF in tokamaks showed it.

But even if the effective controlled thermonuclear reaction at all does not become reality, the pollution-free power engineering has one more path of development which is in essence new. At survival of mankind it at any stage will go on this path. But this method of obtaining energy is interfaced to larger expenses and more high level of technologies, than Linrec, therefore for today it looks more as a fantasy. Its description can be found in my book "Gate of Future Life", available on http://a9414495.eu5.org/ (in Russian).

Why this article

Even if Linrec does not come to level of the positive energy balance, researches in this direction will be necessary for the people, especially for the subsequent generations.

This book does not set a task to establish any framework in development of models and versions of the linear thermonuclear reactor. Here the principle of its work is formulated, Linrec's key diagram is described, the recent trend of CTF is offered and is shown that Linrec is already today not a fantasy, but the project on an edge of the modern advanced technologies.

This article is reduction of the mini-book of Anatolij I. Kharchenco with the same name. The complete text of this work with parts "Calculation of parameters of Linrec", "Linrec with a deuterium-tritium cycle", "The positive energy balance", "The key diagram of the linear thermonuclear reactor (Linrec)", "A power key diagram of the linear thermonuclear reactor (Linrec)" it is possible to receive via mail y9414495@gmail.com.

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