On the solution of problem of nuclear fusion on base of ball lightning

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A number of problems, such as the anomalous transport of plasma on the walls, the necessity of using a superconducting magnetic system and the unresolved problem of the first wall of the tokamak give reason to believe that the demonstration reactor cannot appear in the coming years. The possibility of long-term exploitation of the first wall of fusion reactor at a temperature $T = 10^9 K$ in stationary operating conditions and superconducting magnetic system at presence of intense fluxes of radiation also raises to significant doubts [1]. It is therefore necessary to look for simpler and more efficient methods for solving the problem of nuclear fusion. For the first time nuclear reactions were carried out in [2,3] using a strong electric field. In the first experiments on the reactions of nuclear fusion a protons accelerated by the electric field with the help of an electrostatic accelerator interacted with a target from lithium. Because of the absence of high-intensity sources of ions the method did not find application for solution the problem of nuclear fusion in that time. Further development of new methods allows to find solution the problem of nuclear fusion. It is also known that there is an accelerating mechanism in plasma which allows producing deuterons with energies which exceed value of the Coulomb potential barrier and is enough for the nuclear fusion. The mechanism of charged particles acceleration in plasma is associated with electrical domains. They appear in the plasma due to the inequality of flows of directional drift of ions and electrons. The origin of electric domain is accompanied by the generation of a transverse electromagnetic wave. The charged particles in the field of electromagnetic wave acquire an energy, that is significantly higher than the value that corresponds to the applied voltage [4].

In experiments with a ball lightning on the installation "Prometheus" has been found that the axled and azimuthal component of the energy of ball lightning in the area of its generation, respectively equal to 100 keV and 1 MeV [5,6]. These values of ions energy are sufficient to overcome the Coulomb potential barrier. The elements of ball lightning consist from ions of gas in environment where it was obtained. High values of the ions energy and a considerable amount of charges give possibility to create a nuclear fusion reactor with a positive energy yield. The phenomenon of passage of ball lightning through a very thick

absorbing filter and the observation of dark spherical formation are connected with presence of very strong field inside of a ball lightning. Charged particles also acquire a big value of energy in the non-neutral external spherical layer of ball lightning. In this area of ball lightning an orientation of own electric and magnetic fields is similar to orientation of the fields in the accelerator type of cyclotron.
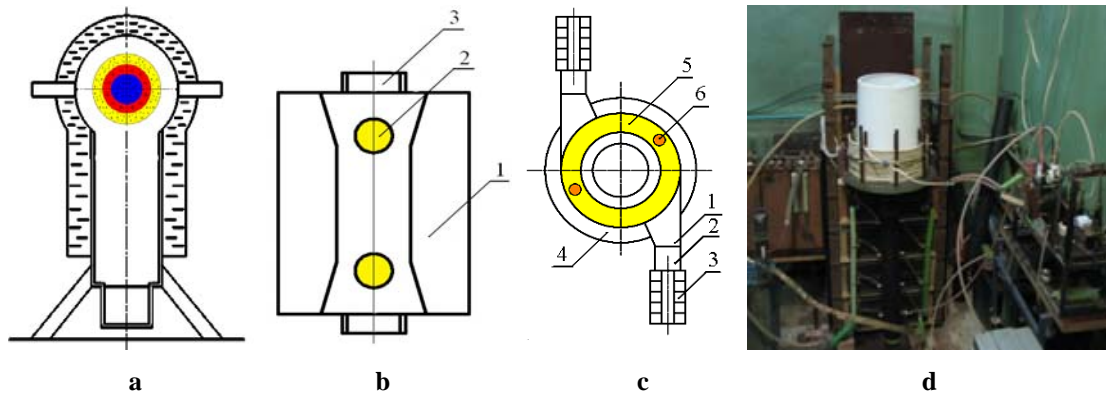

| a | b | c | d |

Figure 1. The scheme of nuclear fusion reactor based on ball lightning – (a); the scheme of nuclear fusion reactor which is based on two opposing ball lightnings – (b); the scheme of reactor of nuclear fusion on base of ball lightnings which inject in the chamber on tangentially – (c) and prototype of source of ball lightning on base of Marx generator as energy storage –(d). Designations in (b): 1 – blanket with lithium; 2- ball lightning; 3- discharge cell. Designations in (c):1- branch pipe; 2- discharge cell; 3- storage condenser; 4- blanket with lithium; 5- toroidal chamber; 6- ball lightning.

There were many attempts to produce ball lightning, which is located at the fixed height or slowly drifting in space tracking potential distribution following [7]. Unfortunately, there was no success in receiving of such ball lightning due to a high values of its energy (including heat energy) in a zone of generation. It can be assumed that ball lightning in Nature passes a significant distance from place of its origin to the place of its observation. During the passage of ball lightning occurs a reducing the axial component of the energy. In principle it is very hard to obtain a ball lightning, which has zero vertical component of energy for subsequent usage as the active zone of the spheromak type reactor. Spheromak that uses structure of ball lightning type requires the presence of weak external fields to stabilize the active zone in the center of the reactor. Reactor of nuclear fusion based on ball lightning has been proposed in [8] and its scheme is shown in Figure 1 (a). Unfortunately, for practical implementation the reactor, shown in Figure 1(a) should have lengthy cylindrical part. As a result of the collision of two ball lightnings could be created a stable long-living ball lightning. On Figure 1(b,c) are given only a few possible schemes of reactors for realization the reaction of nuclear fusion. The discharge cell of the opposite type which consisted of two discharge cells has been created. Zone of generation of each discharge cell were direc-

ted towards each other. In this case the lifetime of ball lightning was less than 1 second. This discharge cell is an analogue of discharge cell that plan to use in the reactor the scheme which is shown in Figure 1 (b). It is possible that the further development of this design will allow to receive a ball lightning with lifetime of a few seconds.

Discharge cells developed by the author allow obtaining the intense flows of fast ions and electrons. The presence of an intense flow of ions with energy above 100 keV during the passage of zone of generation of ball lightning allows proposing following method of nuclear fusion. In the proposed method, an intense flow of fast deuterons of ball lightning interacts with the atomic deuterium or mixture of deuterium and tritium which placed in chamber of cylinder shape. The flow of neutrons which are the result of the fusion reaction is determined by the number of reactions per second. The neutron flow is proportional to the product of number of bombarding particles or the current of fast ions $i(t)$ on the yield value of a nuclear reaction $Y(E)$, i.e. $N(E,t) = i(t) \cdot Y(E)$ [9]. The reaction yield is equal to the product of the reaction cross section $\sigma(E)$ on the path length x of an ion in the gas and on their density n, i.e. $Y = \sigma(E)xn$. To obtain a significant neutrons flow it is necessary that accelerated ions are fully inhibited at interaction with atoms in the gas medium. In this case the reaction will occur over the entire range of energy of fast ions - from E_{max} to 0. Thick target from gas can be regarded as a set of thin targets. For a thin layer of thickness dx the reaction yield in the thick target is $dY = n\sigma(E)dx$. The total yield of neutrons in the fusion reaction in the case of thick target counting on one interacting ion can be determined by integrating on the path length of an ion in the gas from 0 to x: $Y_0 = \int_0^x n\sigma(x)dx$. As a result, the transition to energy integration under the assumption of constancy of the gas density on the path length it's possible to obtain $Y(E) = n\int_0^E \frac{\sigma(E)}{-dE/dx}dE$.

Assessments that were carried out in [8] show that the ratio of the energy released in one cycle to the consumed energy is more than 4. The calculation was carried out for D-D cycle. In case of using the D-T cycle, the ratio of released energy to consumed energy will be 22. And this is with the assumption that only 1/10 of the ions interacts. Even higher values of the ratio of the released energy to input can be obtained by using other cycles. Note that the calculations was carried out under the most stringent assumptions. Using of Marx generator allows to enclose 80-90 percent of the energy that is available in the storage

to a ball lightning. The received value presents a practical interest. The experiment on interaction of a ball lightning with absorbing filter which was installed under angle allows to create the reactor of nuclear fusion on base of two or more ball lightnings which are injected in the chamber on tangentially. The scheme of such reactor is given in Figure 1 (c). The lifetime of ball lightning in a closed toroidal chamber is sufficient for effective interaction of deutrons of ball lightning with not ionized deuterium and the implementation of the fusion reaction with positively output. Also presents interest an experimental study of the neutron yield in a reactor in which creating in a gaseous deuterium environment the ball lightning bombards a tritium target. The proposed method of nuclear fusion and devices has a number of significant advantages compared to existing [8]. It should be noted that the interaction cross section of a fast deuteron with a neutral atom of deuterium is much higher than the cross section of interaction of two hot deuterons. The method is based on real data obtained by the author in the experiments on generation of ball lightnings. The suggested method of solution of the problem fusion requires an experimental validation. The cost of creating reactor of nuclear fusion on base of ball lightning is a few thousand times smaller than cost on creating of fusion reactors with magnetic or inertial confinement.

References

[1] G. J. Linhart, Quo vadis fusion?, Nukleonika, vol. 54, no. 4, 2009, pp. 305-310.

[2] M. Oliphant, S. Kinsey, E. Rutherford, The transmutation of Lithium by Protons and by Ions of Heavy Isotope of Hydrogen, Proc. Royal Society, Series A, vol.141, pp.722-733, 1933.

[3] J.D.Cockcroft, and E.T.S. Walton, Experiments with High Velocity Positive Ions, Proc. Royal Society, Series A, vol. 137, pp. 229-242, 1932.

[4] A.G.Oreshko, The acceleration of charged particles in plasma at the separation of charges, 39th EPS Conf. and 16th Int. Congress on Plasma Physics. Proc. ECA Vol.36. P1.100. 3 p. Stockholm, Sweden, 2-6 Jule 2012.

[5] A.G. Oreshko, Ball lightning generation research. – Unconventional Electomagnetics and Plasmas (UEP), 2011, v.3, N 1-2, pp. 77-81.

[6] A.G. Oreshko, The effect of anomalous passage of ball lightning through thick absorbing filters and observation of dark spherical formation. - Int. Journ. of Innovations in Electrical Power Systems, 2012, v.4, N 2, pp. 141-153.

[7] J.J.Lowke, A theory of ball lightning as an electric discharge, J.Phys. D: Appl.Phys, vol.5, pp. 1237-1244, 1996.

[8] A.G. Oreshko, Possibility ball lightning application for nuclear fusion, 35th EPS Conference on Plasma Phys. Hersonissos, 9 – 13 June 2008 ECA, vol.32D, D-5.005, 2008

[9] G.I. Kiryanov, Generators of fast neutrons (Russian), Moscow: Energoatomizdat, 1990.