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Thin films and thermonuclear synthesis problem

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Abtract

An idea of inertial thermonuclear synthesis consists in accumulation of energy and subsequent almost instantaneous transformation of that energy into heat within a small milligram –scale dt-capsule (a mixture of deuterium and tritium in solid freezed state).

One can, however, go another way by accumulating the kinetic energy in dt-capsule itself by accelerating it. The velocities needed are of the order of one million meters per second, corresponding to optimal temperature of the thermonuclear reaction ~ 10-20 keV, if that energy can be transformed into heat by striking the target within the reactor or by collision with a similar oncoming capsule. It is important to note that in this case an opportunity appears to deliver the fuel into reactor still hot after previous micro-blow. Obviously, the ignition of thermonuclear reaction can be achieved by bombardment of dt-target by solid body. The outlined idea of solid-state macroparticle acceleration for solving thermonuclear problem was proposed almost fifty years ago. An investigation into various methods of macroparticle acceleration demonstrated that to implement the idea accelerators of enormous size are necessary, which made its practical application quite conjectural. However, even today it is technologically feasible to create the required macroparticle accelerators of the order of 100-1000 meter long in case part of the macroparticle is made of super-thin superconducting films or ionic superconductor.

In the beginning of 50s of the last century for many physicists of that (faked-alas!) generation, it was seemingly no obstacles for realization of controlled thermonuclear reactions and the way to inexhaustible source of energy for mankind seems to be almost open.

By now, the problem of constructing a commercial thermonuclear electric power station is nowhere near its solution. Moreover, the lines of attack on the problem on the basis of inertial thermonuclear fusion being developed at present [1] are not quite a fortunate choice, and it is not only from the viewpoint of difficulties in obtaining plasma satisfying Lawson criterion. Such methods as laser heating up of solid-state dt-target or its heating up by an ion beam, or use of lag z-pinch effect with the intended substitution of the whole current-carrying system within the reactor after each microexplosion, though capable of providing a single thermonuclear fusion burst are difficult to use for constructing a commercial electric power station. It is evident that the frequency of thermonuclear explosions repetition within the reactor proportional to the released power should be sufficiently large. For instance, for an electric power station with the power of the order of one GW, the frequency of microexplosions repetition should be tens of cycles per second. Under these conditions, it is not easy to provide for focusing laser radiation or ionic emission of a large number of sources into the given point of the reactor and placing a target into this point subject to the fact that in the one hundredth fractions of a second before this, within the reactor, there had been a microexplosion equivalent to the explosion of tens of kilograms of trotyl. At present, there is no answer to the question what minimum time, in technological terms, is required to provide for replacement of the target within the reactor, and it is not evident whether these are hours, minutes, or seconds. For instance, within the framework of the NIF project [2], it takes 24 hours to replace the target. The problem of overcoming optical elements degradation under the effect of ionizing radiation is still unsolved. In its turn, an opportunity to provide for fast replacement of the current-carrying system destroyed by a microexplosion within the reactor by a new one by way of using inertial z-pinch effect is in doubt. Though the idea of solid-state macroparticle acceleration for solving the thermonuclear problem is not new, and an estimation of opportunities to use various acceleration mechanisms [3] has been made, no acceptable, from the economic point of view, technological solutions have been found. The calculations showed that the required macroparticle accelerator size is enormous (as a rule, of the order of 10^5m and higher). The task of this paper is to prove that, in principle, there exist technological solutions to the thermonuclear problem, with relatively small-size accelerators being used.

For clarification of the possible mechanism of acceleration you are invited to see Fig.1., where the current source is depicted (the magnitude of the current is "I"), which is shortened by the plate (sliding contact) placed on the two parallel current-feed bars with distance "d" in-between. The plate is placed perpendicular to the bars and the surfaces of the bars in contact with the plate are positioned in one horizontal plane (for example). The magnetic field **B** is directed normal to the plate.

The force acting onto the plate is F=BId, and, if ignore for a moment the friction force and the force of air resistance, this force will provide the acceleration a=BId/m and velocity reached after time t will be V=(BId/m) "t", where t is acceleration time and "m" is the mass of the plate. The length of the current-carrying bars will then be

$$L=1/2\ (mV^2)/(IBd) \qquad (1)$$

For example, for B= 10 T, $V=10^6$m/s, $I=10^5$A, $m=10^{-6}$ kg, d=2.5 10^{-3} m, we will have L=200 m, t=4.10^{-4} s. It is seen that dimensions of accelerating system is quite acceptable for practical realization. The fabrication of pulsed current source for $I=10^5$ A is also quite feasible. In many physical experiments pulsed current sources are used in which current values are orders of magnitude higher. Generation of magnetic fields of the order of 10 T is a common place. In order to reduce two opposing forces the whole system must be evacuated. To reduce or even completely eliminate the friction force one can use an additional magnetic field $\mathbf{B_1}$ directed along the moving contact (See Fig.1).

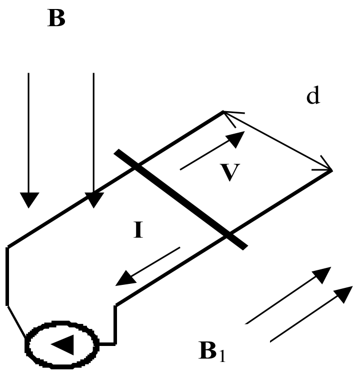

Fig.1. Method of acceleration of solid bodies.

In that case an additional force appear acting on the plate and directed up-word that can be used to compensate the plate weight and to reduce the friction force, which is proportional to this weight.

To eliminate the friction force of sliding contact one can also use the vertical arrangement of the bars-railways. In that case one must apply additional magnetic field to press the plate to the rails. Since very high current can easily burn the minute plate it is advisable to make the rails and plate from superconductive materials. It goes without saying that our plate can be used as a container for delivery of fuel to the thermonuclear reactor.

Assuming that I_s is the critical current density in superconducting shot-circuiting plate, ρ is its density, S is its cross area and m=ρSd, and taking into account that current through rails and plate is $I=I_sS$ one can obtain the minimal dimensions of accelerating system:

$$L=L_{min}=\tfrac{1}{2}\ (\rho V^2)/(I_sB) \quad (2)$$

At liquid helium temperatures (T = 4.2 K) for Nb-Ti alloy with ρ=6.5 10^3 kg/m^3, $V=10^6$ m/s, $I_s=5.10^9 A/m^2$, and magnetic field of 5 T (B=5 T), we have L_{min}=1.3 10^5m. Approximately the same length of accelerating system is obtained for B=6 T, if Nb_3Sn is used. Data for critical current densities in magnetic field were extracted from [4]. For accelerating system of minimal size ($L \approx L_{min}$) the only option available is to use the shot-circuiting plate as a bullet to strike dt-target in the reactor. Obviously, the ignition of thermonuclear reaction can be achieved by bombardment of dt-target by solid body. For $L>L_{min}$, however, the sliding contact-plate can be used as a container for delivery of thermonuclear fuel into reactor.

And, if the achievement of very high efficiency in transforming the current source energy into energy of dt-target, is not of concern it is not necessary to make $L>>L_{min}$. From practical point of view (since the cost of accelerator construction is directly proportional to its length) it is quite sufficient to increase its length up to 1.5-3 times of L_{min}.

The explained method of acceleration of macroscopic particles is known for a long time. See, for example [3].

Since the contact method of macroparticle acceleration has evident disadvantages, it makes sense to apply another simple technique of macroparticle acceleration by constructing an analog of linear resonance charged particle accelerator (resonance linac). The accelerating system of this accelerator is made of a multitude of solenoids, analogs of drift tubes with common axis Z. In this case, even solenoids are powered with a. c. in the opposite phase with the odd ones. The superconductor which is preliminarily charged by a sufficiently large magnetic moment producing a magnetic field the maximum size of which is times more than the external magnetic field of solenoids enters the accelerating system. Let us consider the superconductor with current circulating in its body, in-between two accelerating solenoids. And let the current in the back solenoid is circulating in the opposite direction with respect to the current in superconductor, whereas the current in front solenoid is in the same direction. Roughly speaking, the superconductor is pushed off from the back solenoid and is attracted to the front one. The superconductor orients its magnetic moment along the field and is forced to go to the axis of solenoid. As soon as the superconductor transits by inertia the front solenoid the field in it is switched to the opposite. And the process of acceleration is repeated. It might seem that in order to move the superconductor by inertia within the solenoid without noticeable deceleration it is required to provide for a significant excess of the solenoid length above its diameter. But it is wrong since it follows from the calculations that the value of the magnetic field derivative along the axis within the solenoids reverse its sign with insignificant mean value in comparison with the mean value of this quantity with commensurate size of the diameter and solenoid length.

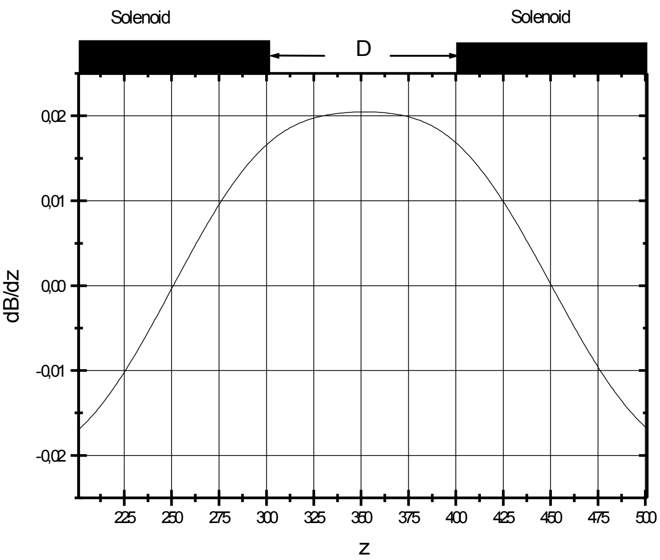

Fig. 2. Dependence of the magnetic field derivative along the axis for two similar solenoids having a common axis and allocated from one another at a distance equal to the solenoid length with the opposite direction of the magnetic field of one solenoid relative to the other with double excess of each solenoid's diameter above its length (in relative units)

Let the accelerating body is in the form of a cylinder. For the cylinder with diameter d, height h, and density ρ, we will have for the magnetic moment (distance between accelerating coils D with current I_s) $M= 1/3\ \pi I_s h(d/2)^3$. And for the mass $m= \pi\ \rho\ hd^2/4$, the force will be $F= M\ dB/dZ \approx 2B\ M/D$, corresponding to acceleration of $a \approx 2B\ M/Dm=1/3\ BI_s d\ /\ (D\ \rho\ )$, where B is magnitude of the magnetic field in accelerating solenoids averaged over a period. For a ring of diameter d we obtain $a \approx 1/2\ BI_s d\ /\ (D\ \rho\ )$, that is, in order to increase acceleration it is necessary to decrease the average distance between solenoids. That is why for decreasing the accelerator size it makes sense to increase the a. c. frequency as a particle is accelerated or to use a large number of current sources operating at different frequencies. Since, in the acceleration method discussed, the macroparticle is not accelerated during approximately half the time, with the similar acceleration rate of macroparticles the size of the non-contact accelerator will be larger than with the contact acceleration. For approximate size equality of non-contact and contact accelerators it is necessary that $d/\ 4D \approx 1$ (D is the average distance between solenoids) with the equality of current density values and mean values of magnetic fields quantities.

The accelerating system could be implemented in a different way, that is, in such a manner when in all solenoids placed behind the body being accelerated the current flows in the opposite direction in comparison with the solenoids placed in front of the body being accelerated, or when the current is delivered only to the adjacent solenoids, with the body being accelerated placed between them.

DISCUSSING PROCEDURES FOR REDUCING THE ACCELERATOR SIZES BY ORDERS OF MAGNITUDE

Note that the accelerator size is proportional to ρ/BI_s. Whence it follows that for solving the thermonuclear problem superconducting materials capable of transmitting large superconducting current densities with large magnetic fields are necessary; in this case the current density values or/ and magnetic strength should exceed manifold the corresponding values of superconductors in existence today. The question now arises how to manufacture such materials. The answer to this question is similar to answering the question how to reduce the accelerator size. Plausible alternatives for solving the problem are given below.

1. As is known, a magnetic field can annihilate superconductivity or, in other words, destroy Cooper pairs of electrons in superconductors, which is a limitation for creating strong magnetic field sources. Ionic superconductors do not have Cooper pairs and their analogs – objects for destroying under various mechanisms of interaction of these charge carriers with other particles or quasi-particles in solid body. As charge carriers, ions of lithium isotope which are bosons are used. The calculated temperature value of Bose-condensation for lithium isotope ions owing to the smallness of its effective mass value can exceed the value of the order of 10^4 K [5,6]. If, for instance, the real generated ionic superconductors temperature value of Bose-condensation for lithium isotope ions will appear only 10 K higher, then the concentration of superconducting ions of lithium isotopes under the temperatures of liquid helium would exceed, by orders, the Cooper pairs density in traditional superconductors under the same conditions since Cooper pairs are generated by only a small part of electrons which have energy close to Fermi energy whereas in the ionic superconductors under comparatively small Bose-condensation temperature excess above the medium temperature in the fundamental state, the number of bosons appear comparable by the order of magnitude with their general number. That is why there is hope that the problem can be solved by creating ionic superconductors which could be used as part of macroparticle whereas in this case the macroparticle can be given an extremely high magnetic moment. Ionic superconductors can also be used when generating sources of large alternating magnetic fields required for non-contact macroparticle acceleration. To realize materials with ionic superconductivity in practice the use of molecular beam epitaxy is proposed for the formation of heterostructures from thin and thick layers of thoughtfully-chosen composition [5,6].

2. It is known that in films stable superconductivity is observed in the fields parallel to the film surface exceeding by hundreds of times the critical field for massive superconductor of the same material. In this case, the critical current is still determined by the critical field value in massive superconductor. Let us show this in the Londons theory approximation [7]. Let the thickness of the film be equal to $2a<<\lambda$ and the film be placed in the B_f value field parallel to its surface. For the field in the film we have $B= B_f \, ch(x/\lambda)/ch(a/\lambda)$, with x=0 corresponding to the coordinate in the center of the film. More precisely B there is an induction of a magnetic field. The value of a maximal (critical) field in film is approximately equal $B_f \approx 6^{1/2} \lambda/a \, B_c$, where B_c a critical field for a massive superconductor. Since with the maximum field $B(a)- B(0) \approx (6^{1/2}/2) B_c \, a/\lambda \approx B_c \, a/\lambda$ the density of current induced by external magnetic field is equal to $I_s= B_c/ (\mu_0 \lambda)$. It is evident that with x>0 the direction of current in the film is opposite to the case when x>0, that is, when a superconducting film is placed in the magnetic field, the current starts circulating in the film, the current density being obtained from the theorem on magnetic field circulation. These relations also can be received from Ginzburg-Landau of the equations ($I_s \approx B_c/ (1.84\mu_0 \lambda)$). For $\lambda=5 \; 10^{-8}$m, $a=5^{-10}$ m, B_c=0.1T, we obtain $I_s \approx 2.10^{12}$A/m^2, B_f= 24 T. The parameters used for calculation approximately correspond to such materials as Nb or Pb and the product value of I_sB for Nb or Pb for films with the thickness of the order of 10 angstrom exceeds the corresponding value of the Nb-Ti alloy by more than 10^3 times. If the films possessed sufficient mechanical strength we would have at least 10^3 times reduction of the accelerator size. And here we were dealing with meter-long accelerators for solving thermonuclear problem. It is necessary to make a mechanically strong structure of films, that is, it is possible to imagine a structure containing a multitude of superconducting films of niobium or lead with layers of non-superconducting material placed between them.

If the mass of the structure exceeds the total mass of superconducting films by N times ($N \approx < 10^3$), then the accelerator size could be reduced by 10^3 /N times in comparison with acceleration of Nb-Ti particles of the same mass. With the non-contact acceleration, layers and films are formed on the side surface of the cylinder. ith the non-contact acceleration, layers and films are formed on the side surface of the cylinder. For example, the cylinder can be fulfilled from a low-melting material, which is substituted after deleting partially or completely by mixture of a deuterium and tritium. One should take into account that the total thickness should not exceed the $10\lambda^2/a$ order of magnitude since otherwise the value of current critical density decreases. Indeed, let the current flow in the film set up a magnetic field on its surface approximately equal to the ½ $a/\lambda \, B_c$ order of magnitude, which, as was shown, is possible. If there are n similar parallel films with the current flowing along each of these, the magnetic field will increase n times. From the condition of equality $B_f = ½\ n\ a/\lambda\ B_c = 6^{1/2}\ \lambda/a\ B_c$ let us obtain the maximum total film thickness $S=2na= 96^{1/2}\lambda^2/a \approx 10\lambda^2/a$, $n= 24^{1/2} (\lambda/a)^2$.

By way of example, let us estimate the length of such accelerator. Let us derive the minimum accelerator size from (2)

$$L_{min}= ½ (\rho V^2)/(I_s B)= ½ (\rho V^2)/(6^{1/2} B_c^2/ a\mu_0)$$

If B_c=0.1T,V=10^6m/s, ρ=10^4 kg/m^3, a=5. 10^{-10}m, then $L_{min}\approx$100 m

In this case, the minimum non-contact accelerator size is times larger.

As the critical density of a current in rails is much less than in a film, the contact between rails and sliding contact should be fulfilled on enough large area. This circumstance determines the geometrical form of sliding contact in main. The optimal geometrical form of a film is an isosceles trapezoid (see fig.3). Moreover it is necessary to provide constant area of contact at moving sliding contact. Therefore contact method of acceleration of macroscopic particles is very difficult for practical realization.

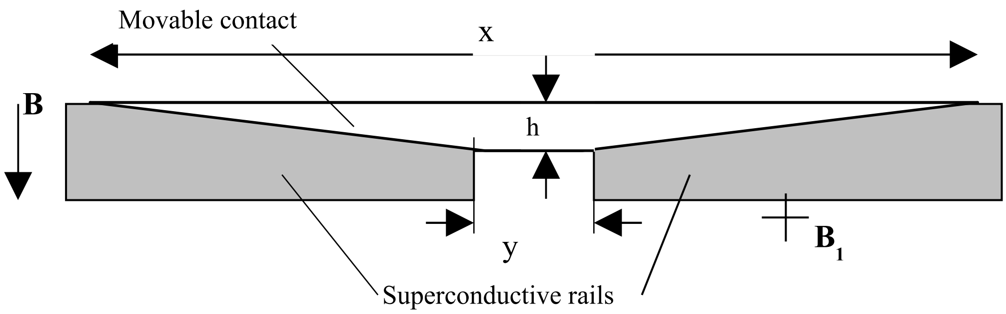

Fig.3. An example of accelerating system, when the critical density of a current of a movable contact much greater critical densities of a current a rails.

Distance between the parallel sides of a trapezoid is equal h. Length of the greater side of a trapezoid is equal x, length of the upper side of a trapezoid (y) is equal to distance between rails, besides x >> y, x >> h. Current density in sliding contact is more than current density in rails approximately in S x/h of times. The planar technology for manufacture of films can be applied. Though there is no clearness about possibility of application of standard technologies to creation of necessary structures. The ultimate strength of a dt-capsule is equal to pressure 5.10^{5}Pa. To prevent a damage of dt capsule at acceleration, it is necessary to place it inside a strong substrate [3]. The macroparticle apparently contains one or two movable contacts, on which surface the substrate is placed, and inside a substrate the mixture of a deuterium and tritium is placed. As the ignition of thermonuclear reaction can be achieved by bombardment of dt-target by solid body, the macroparticle apparently can contain one or two movable contacts and the solid body with a mass ~ 5 -10 milligrams. If not to take into account compression, the minimum linear size dt- capsule is equal approximately 2 mm. The mass of a cylindrical dt-capsule with sizes of a diameter and height of 2 mm is equal approximately about one milligram. Approximately one milligram weighs a film by width 10 microns and density 10 g/cm^3 fulfilled on a lateral area of the evocative cylinder. The minimum width of films on visible can not exceed a constant of a crystal lattice (r_c) of a material from which she is fulfilled. The ultimate strength of a dt-capsule is equal to pressure 5.10^{5}Pa. To prevent a damage of dt capsule at acceleration, it is necessary to place it inside a strong substrate [3]. The macroparticle apparently contains one or two movable contacts, on which surface the substrate is placed, and inside a substrate the mixture of a deuterium and tritium is placed. Numerical values of all relevant parameters are collected in Table 1. Density (ρ) and ultimate strength (P_c) can be found in [9].

Table 1. Numerical of parameters .

Material	r_c (Å)	ρ (kg/m^3)	B_c(T)	P_c(GPa)
Pb	4.95	11.34 10^3	0.08	7. 10^{-2}
Nb	3.3	8.58 10^3	0.2	1.1
DT-mixture (T=4.2 K)		0.22 10^3		5.10^{-4}
SiC		3.21 10^3		21-37
Al_2O_3		3.960 10^3		28-42
V	3.03	5.96 10^3	0.142	0.6

A cylindrical symmetry of a macroparticles shown in Fig.4, intended for non-contact acceleration.

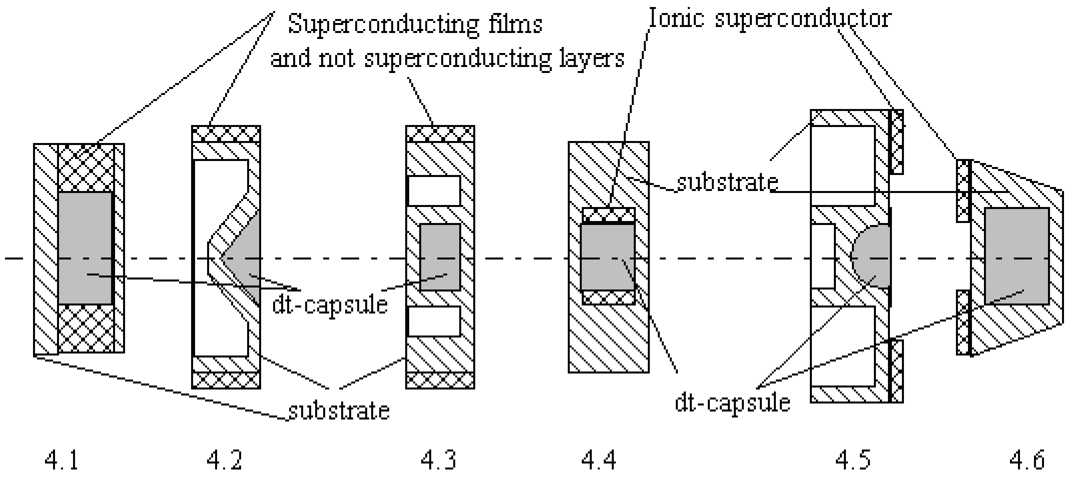

Fig.4. Configuration of macroparticles intended for non-contact acceleration.

Creating mechanically strong structures with the use of super-thin films of superconducting materials allows solving the thermonuclear problem with macroparticle accelerator size acceptable for practical implementation, though in terms of manufacturing it is not easy to form an accelerated macroparticle, in particular, for non-contact acceleration. For creation of macroscopic particles (see fig.4.1-4,4), applicable for acceleration in accelerators having small sizes it is necessary to improve of the technology of thin films formation. Most likely, the speech goes about modernization of MBE and CVD or ALD technologies. At application of the ALD- technology (Atomic Layer Deposition – technology) it is possible to make of a film on a surface of any geometrical form.

Besides of it is necessary to form a macroparticle from components (for example substrate, dt-capsule, films) by an automatic way. It is necessary to create also mechanical strong substrates with the least weight. The limiting factor is the value of acceleration, at which there is destruction of a macroparticle. Let accelerator has length equal to 1000 meters (L=1000 m). Let mass of a cubic dt-capsule (m) is equal 2 milligram. At acceleration of dt-capsule the pressure value (P) on a substrate is approximately equal 0.5 GPa (if $L=10^3$m,$V=10^6$m/s, then $t=L/V=10^{-3}$s, a=V/t, P=ma/s. If m=2 10^{-6} kg, $s=l^2$ ~ 4 mm^2, then P=0.5 10^9Pa). This pressure is more than ultimate strength of many solid-state materials. Let substrate and mixture of deuterium and tritium are contacting in five planes. As $P=mV^2/(Ll^2)$, on a substrate the force by the value ~ mV^2/L operates. The force exerts pressure on opposite edges of a substrate. Let l_s there is a width of a substrate, l ~ 2mm there is a characteristic linear size dt-capsule. Therefore minimum width of a substrate (l_s) is defined approximately by equality $mV^2/L=P_s\, l\, l_s$. Here P_s is a ultimate strength of a material, from which substrate is made. A minimum mass of a substrate (m_s) will be defined by approximated equality $m_s= 5\rho l^2 l_s= 5\rho\, l\, mV^2/ L P_s$. Here ρ is a density of a substrate. From calculations it follows, that for the strongest materials (P_s~25 10^9Pa, for Al_2O_3 or SiC) the minimum width of a substrate is equal approximately 40 microns, and the minimum mass is approximately equal 2.5-3 milligrams (if L ~ 1000m, then m_s ~ m). The macroparticles with massive substrates are necessary for small accelerators (if L < 1000 m, then m_s > m). This is the reason for the increase of energy costs. For increase of efficiency of obtaining of energy it is possible to magnify a mass of dt-mixture. As the ignition of thermonuclear reaction can be achieved by bombardment of dt-target by solid body, the macroparticle with a mass ~ 10-20 milligrams can be fulfilled without substrate and dt-capsule. The second limiting factor is the long time of superconducting films and layers of non-superconducting material (if a ≈10 Å, then n ~ 10^4) creation. It is difficult to create cost effective technologies for manufacture of macroparticles with the necessary productivity (>10 macroparticle/s).

It is probable that simpler solutions, in terms of manufacturing, could be expected as a result of producing ionic superconductors. In this case, the cost planar technology can be applied. Likely macroparticle creation may require a small amount of ion superconducting material. See fig. 4.5-4.6.

In order to compare the method described above with alternatives presently available, I think that one example is sufficient. Based on 25 years of experience in laser-driven thermonuclear synthesis in USA the NIF (National Ignition Facility) program is acting from the middle of 90's, aimed at achievement of thermonuclear ignition [2]. According to numerical calculations single shot experiments on this laser system are expected to provide generated power 5-7 times that of laser power with overall efficiency some fraction of percent. The output energy of laser pulse will be ~1,8 MJ and will be achieved by step-by-step amplification of the initial pulse (~0,1J) in 192 parallel channels. In NIF experiments both targets are planned to be used –direct action and X-ray. The cost of the project is estimated to be about 4 billions $ and full deployment was expected in 2007-2008. This example illustrates how complicated is a route already traversed (and even more so lying ahead) in the way to the thermonuclear station. In the opinion of the present author any interested reader is able to evaluate himself the expediency of going to the ambitious goal of solving the thermonuclear problem by the route proposed here or remain on the old track.

Acknowledgments

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Addition

More correct approximate calculations.

Let B_f=0.5 $6^{1/2}$ λ/a B_c , $I_s \approx B_c/$ (1.84 μ_0 λ). Indeed, let the current flow in the film set up a magnetic field on its surface approximately equal to the 1/4 a/λ B_c order of magnitude, that corresponds to a current density little bit less critical value. If there are n similar parallel films with the current flowing along each of these, the magnetic field will increase n times. From the condition of equality B_f+ 0.25 n a/λ B_c=$6^{1/2}$ λ/a B_c let us obtain the maximum total film thickness S=2na= $96^{1/2}\lambda^2/a \approx 10\lambda^2/a$, n≈ $5(\lambda/a)^2$.

Superconducting current density in strong magnetic fields is limited. (At liquid helium temperature (T = 4.2 K) in external fields 5T for the alloy Nb-Ti Is = 5.10^5 A/cm^2.)

To create a mechanically stable film's structure it is necessary to ensure the interleaving of thin superconducting films with nonsuperconducting layers. The number of superconducting films in such a structure is less than $24^{1/2}$ $(\lambda/a)^2$. Otherwise, the magnetic field produced by the films during the flow the maximum current through them density exceeds the critical magnetic field for the film. For λ = 5 10^{-8}m, a = 5 10^{-10}m, n ~ 50 000. Is it possible today to produce such structures? Since we need to produce pellets with great intensity, and the formation of tens of thousand of films is a long process, it is necessary to form a films with large areas. It seems, that MOCVD or ALD technology are preferred. Unfortunately, I do not know about the formation of very thin films of Pb, V, Nb using these technologies, but this does not mean that it is impossible to do. For aluminum and indium films, the critical temperature is much higher than the corresponding critical temperature of bulk materials and the temperature of liquid helium (4.2 K). Therefore, aluminum and indium may be prepared in the form of thin superconducting films. The technology of producing such films (ALD technology) are known.

The most simple technical solution consists in gunning by the accelerated rigid body of a thermonuclear target located in a reactor. Though the realization of this version requires padding power expenditures. The mechanical strong not massive shell (substrate) for thermonuclear fuel in this case is not necessary. Manufacture of a strong not massive substrate to realize not simply.

Than large length there is an accelerator, the easier is to make a substrate (canister) for mixture of a deuterium and tritium. Therefore usage of the accelerator having length 3-5 kilometers, can appear more acceptable from behind economic reasons, than usage of rather small accelerators.