Breakthrough in the Inconsistencies to Nuclear Fusion: Nanotechnology Assisted Nuclear Fusion

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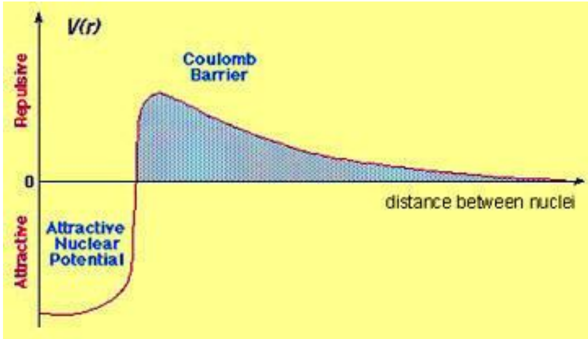
Abstract— At present the usage of electricity is more than it had ever been. So, to meet such high demands of electricity, we need to burn tonnes of coal daily. Scientists, on the other side look forward to the nuclear reactions as a tremendous scope of energy. Nuclear fission and nuclear fusion are two main types of nuclear reactions that produce energy. We talk here about the nuclear fusion reactions. The simple idea behind the nuclear fusion is to fuse the nuclei of elements with atomic numbers lower than iron, to release their binding energy. But, as per the potential energy versus interatomic distance graph, to bring two nuclei closer than the interatomic stable distance, they need to overcome the columbic repulsive forces. This can be made possible only if they have very high kinetic energies. These high kinetic energies are conventionally obtained by increasing the ambient temperature to the order of 106 Kelvin. But to produce such high temperatures and further to maintain them is very costly. So the vast seawater that houses the required hydrogen in plenty remains unused. This paper focuses mainly on the utilization of nanotechnology in performing nuclear fusion reactions. The advancements in nanotechnology provide us with a wide scope to be able to handle processes at the atomic level and even manipulate some of the processes. This advancement in nanotechnology can be used to energise hydrogen nuclei for neutronic; or deuteron and helium nuclei for aneutronic nuclear fusion reaction. This paper discusses the elaborate processes to harness the above discussed goal, its advantages and applications and probable challenges and even their solutions.

Key words: nanotechnology, nuclear fusion, electricity, binding energy

I. INTRODUCTION

The need to obtain nuclear fusion at economical rates is like a challenge at present. The beneficial aspects of nuclear fusion as discussed in [1] and [2] are motivating the scientists across the world to throw some light in this domain of science. The nuclear fusion reactions that occur by the utilization of high temperatures are called thermonuclear fusion reactions. They require high energy to take place. Now according to $e=3/2k_bt$, the entire energy of the gas molecules is in the form of temperature. Though at very high temperatures, the conversion of gaseous matter to plasma takes place, we can approximate the energy to be in the form of energy due to temperature. We are doing it this way because to simplify the elementary calculations. Then, the energy of the neutrons should be very high in order to overcome the coulombic repulsion barrier.



From [3], the coulombic repulsion barrier for deuterium-teuterium fusion is 0.1MeV. So, the temperature turns out to be of the order of mega Kelvin. To produce such high temperatures is very costly. Also, if we produce such high temperatures, it becomes very costly to maintain such high temperatures. Such high temperatures are obtained by laser in plasma confinement by tokamak methods .There are some other methods too-but all of them are much costly to obtain a quasi static nuclear reaction [4].

As discussed in [3], there are alternate methods to high temperature to inculcate nuclear fusion like the sonofusion, which states that acoustical shock waves when burst a bubble or cavity can produce temperatures and pressures required for nuclear fusion. But it is costly to achieve electricity commercially. And we cannot forget the present stalwarts like muon catalysed fusion and beam targeted fusion: both are viewed as potential scopes of producing electricity but presently they are facing limitations stated in [6] and [5] respectively. The main inconsistency to muon catalysed fusion in achieving electricity is the cost to produce the muons and the fact that the muons are quite unstable particles. The same problem of cost effectiveness lies with the beam targeted fusion. Then the tabletop device of Farnsworth – Hirsch fusor, which produces high effective temperatures produced by electrostatic acceleration of ions. But to produce electricity on a large scale using the fusor is not cost effective. We even have Polywell as a non-thermodynamic equilibrium machine that uses electrostatic confinement to accelerate ions into a center where they fuse together. But the same problem of cost effectiveness also applies to it. The antimatter initialized fusion uses small amounts of antimatter to trigger a tiny fusion explosion. But to produce the antimatter and to sustain it for some time is costly. Hence an out of the box idea is required to produce electricity on a large scale. The main purpose the idea should serve is the cost effectiveness.

This brief states that the application of nanotechnology will come in handy where we will manipulate the systems at the nano level. This brief also states that the nano machines like the scanning and tunnelling microscope can be modified to manipulate the circumstances at the nano level such that the coulombic repulsive forces will be overcome by the nuclei and the thermonuclear fusion can take place. This paper discusses how we can achieve our objective. This paper also discusses the need of implementing the method to produce electricity for the current increasing demand of electricity. This paper also discusses the other advantages of implementing this idea to real world problems. This paper also discusses the problems and limitations that can come in the implementation of the idea stated hereby and also throw some light on the solutions to them.

II. THE PRECISION REQUIRED

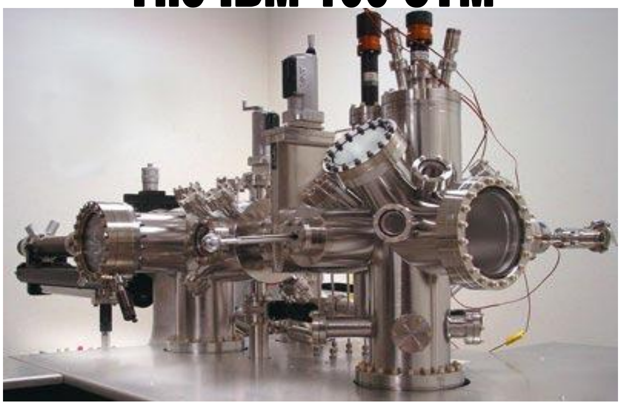
The machine, say as for example the IBM 100 scanning and tunnelling microscope, that will handle the nuclei of hydrogen and its isotopes ,needs to overcome the Heisenberg's uncertainty principle. We look upon it in this manner: the machine goes to pinpoint a certain nucleus. The Heisenberg's uncertainty principle states that the place and momentum of the nucleus cannot be determined simultaneously and accurately. Thus the nuclei have a wavelength $nh/2\pi$, where n is having integral values. But the scanning and tunnelling microscope [15] is indeed very precise .We all know that the logo of the IBM (International Business Machines) was made by arranging individual atoms. Thus the Heisenberg's uncertainty principle is already taken care of by the development in the technology. At least we have become precise enough to catch and hold the nuclei and thereafter placing them in the required places.

Then the question arises that: agreed that the machines are sensitive to pinpoint the atoms, they are even sensitive to catch them. But thereafter how will we throw the nuclei so that they fuse together? Here it should not be forgotten that the things that we are dealing with at present are taking place at the quantum domain. So the probability of head-on collision is very less. But, at nanoscale, it is possible to try millions of collisions per second. Hence the problem posed of proper collision is thus resolved.

III. THE DESCRIPTION OF THE REQUIRED MODIFICATIONS

The scanning and tunnelling microscope holds and places the atoms in order. But for the nuclei to fuse, they require high kinetic energy. Thus, we need to modify the scanning and tunnelling microscope such that it provides proper momentum to the atoms such that they combine. We also need to create an arrangement in which there will take place millions of collisions per second.

The IBM 100 STM



At the same time, the other factors that are expected to be present in the machine are its less electricity consumption, good quality alloy, resistance to corrosion, less volume occupation, etc.

IV. THE PROCESS: REDEFINED NOW

So the nuclei that are thrown are colliding with high kinetic energy by manipulated perfections at the nanoscale level. They collide and release the binding energy.

The hydrogen cycle:

$$H + H \rightarrow {}^{2}D\,(+e^{-}) + \beta^{+} + \nu$$
$${}^{2}D + H \rightarrow {}^{3}He + \gamma$$
$${}^{3}He + {}^{3}He \rightarrow {}^{4}He + 2H$$

net

$$4\,H = {}^{4}He\,(+\,2e^{-}) + 2\beta^{+} + 2\,\gamma + 2\,\nu + 26.7\ MeV$$

The binding energy released is equivalent to the equation $E= \Delta mc^2$. Now we won't be seeing here so as to in which nuclei fusion releases what amount of energy. But we see here how we harness the energy. The energy released is in the form of the kinetic energy of the products. That we need to utilize into electricity. That process can be performed by constructing power plant similar to the schematic construction of nuclear fission plant. The energy released is transferred to the water constantly circulating in the pipes, which transfer it to the generator-turbine system, which converts it into electricity.

V. THE BRIGHT FUTURE

A. Potential Benefits:

- Cost effective method to produce electricity
- No radioactive waste generated
- Success can create "electrical revolution"
- No greenhouse gas emitted
- Long term benefits: install a plant and that will power for theoretically millions of years, because the sea water is the fuel for producing electricity.
- Once successful, we can think of nuclear fusion powered heavy vehicles and of course, space shuttles.
- We can utilize nanotechnology in performing the chemical reactions that do not occur otherwise
- We can even cook the food by using the nanotechnology assisted nuclear fusion , just we need is to modify the machine properly
- Electronic devices run by nuclear fusion cell

VI. SOME PROBLEMS AND THEIR SOLUTIONS:

The first and foremost question arises is that the huge amount of heat released will damage the materials of devices or not. For that problem, we are fortunate because self-repairing nanotechnology materials are cheap compared to the benefit of the large amount of energy that we obtain from the nuclear fusion. The other question arises of the fuel required: the hydrogen nuclei. The answer: the water that is present in more than 70 percent of the earth surface houses enough hydrogen that can last till essentially millions of years.

We can even think about the particles released in nuclear fusion damaging the apparatus. Again the same concept of self-repairing machines is the answer. The machines can repair themselves at cheaper rates.

VII. Conclusion

We saw the novel application of nanotechnology to produce nuclear fusion. The machines can be modified to produce nuclear fusion. We even saw that the Heisenberg's uncertainty principle is already addressed by the hi-tech machines. We even discussed how the heat energy released by the fusion will be taken care of. The harm caused by the particles emitted can also be addressed. The self-repairing cheap machines can thus be manufactured and the nuclear fusion can be achieved to produce electricity for the commercial usage.

References

[1] http://link.springer.com/article/10.1007%2FBF01063681#page-1
[2] http://www.plasma.inpe.br/LAP_Portal/LAP_Site/Text/Advantages_of_Fusion.htm
[3] https://en.wikipedia.org/wiki/Nuclear_fusion
[4] https://en.wikipedia.org/wiki/Tokamak
[5] www2.warwick.ac.uk/fac/sci/physics/current/teach/.../lecture_icf.ppt
[6] http://www.muoncatalysedfusion.com/limitations.php
[7] http://pugbrtz.egny?u=ydeaQ3DT8JoJ2wzRBIs1kIdV8UJB9TLZi358ArXw9b6xohskx83htkfW%2B1C6HSRhH16qs7vObT80v0xM%2B2KA%2FeweRur25UgdTdWv4FwCerICLZONG5wJ0iyNmeLohjgUkw%3D%3D&b=21
[8] http://metamodern.com/2009/05/04/nanotechnology-and-nuclear-reactions/
[9] http://chemwiki.ucdavis.edu/Physical_Chemistry/Nuclear_Chemistry/Thermodynamic_Stability_of_the_Atomic_Nucleus
[10] http://en.wikipedia.org/wiki/Nuclear_power_plant
[11] http://en.wikipedia.org/wiki/Space_Shuttle_main_engine
[12] https://www.physicsforums.com/threads/producing-fusion-reaction-with-x-rays.622739/
[13] https://www.physicsforums.com/threads/are-gamma-rays-produced-in-fusion-reactions.403064/
[14] http://www.nasa.gov/exploration/home/antimatter_spaceship.html
http://www.coldfusiontechnology.net
[15] http://ibmresearchnews.blogspot.in/2013/05/how-to-move-atom.html

