On the Role of Nuclear Binding Energy in Understanding Cold Nuclear Fusion

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Abstract: Following the concept of strong interaction, theoretically, fusion of proton seems to increase the binding energy of final atom by 8.8 MeV. Due to Coulombic repulsion, asymmetry effect, pairing effect and other nuclear effects, final atom is forced to choose a little bit of binding energy less than 8.8 MeV and thus it is able to release left over binding energy in the form of internal kinetic energy or external thermal energy. Thus, in cold fusion, heat release to occur, binding energy difference of final atom and base atom seems to be less than 8.8 MeV. Qualitatively, energy released during cold fusion seems to be approximately equal to 8.8 MeV minus the difference of binding energy of final and base atoms. Based on this idea, under normal conditions, for the case of $_2He^4$, fusion of four protons can liberate (35.2-28.3)=6.9 MeV and it is 3.5 times less than the current estimates. Point to be understood is that, lesser the binding energy of final atom, higher the liberated thermal energy and vice versa. With a suitable catalyst and sufficient hydrogen under suitable pressure, if reactor's temperature is maintained at (1000 to 1500) ^{0}C, there seems a lot of scope for a chain reaction of cold fusion in which light isotopes transform to their next stage with increased proton number or mass number and liberate safe and clean heat energy continuously. By arranging 4 to 6 reactors and charging them periodically in tandem, required thermal energy can be produced continuously. In this new direction, by carefully selecting the base isotope and its corresponding catalyst, experiments can be conducted and ground reality of cold fusion can be understood at various temperature and pressure conditions.

Keywords: cold nuclear fusion, maximum binding energy per nucleon, nuclear experiment;

1. Introduction

Since 1989, many scientists and engineers are seriously working on cold nuclear fusion experiments that produce 'excess' heat with no hazardous nuclear radiation [1-4]. Here it is very important to emphasize that, energy liberated in cold nuclear fusion is approximately one million times higher than the energy released in burning of ordinary fossil fuels. It clearly indicates the less consumption rate of cold fusion fuel in milligram/sec compared with more consumption of fossil fuels in liter/sec. Point to be noted is that, as the name it suggests, 'cold nuclear fusion can be visualized as a peculiar exothermic nuclear physical phenomenon associated with fusion of atoms at low temperatures of the order 300 to 1000 degree Kelvin against currently believed fusion of atoms associated with a temperature of the order of million degree Kelvin. Cold fusion experiments can be classified into two categories'. First one is 'Electrolytic Cold Fusion' associated with 'Electrolysis of Deuterium' and second one is 'Hydrated Cold Fusion' associated with 'preheating of hydrated metals in a pressurized reactor'. Due to 'failure' of experimental repeatability and 'lack' of proper physical theoretical models, cold nuclear fusion experimental results could not be published in mainstream journals for the past 30 years. It will be a very bad remark to modern science history. We would like to emphasize the point that, if it is strongly believed that, "science is meant for mankind development and nature protection", new and strange experimental results and scientific thoughts should not be ignored at their budding stage. After all, modern science is having hardly 150 years of strong experimental career and it is 'nothing' in front of the cosmological time evolution of mankind.

One should not forget the historical fact that, even though 'Quantum theory' of light and 'Superconductivity' were the best outputs of well conducted experiments, it took very long time to believe and understand. It is surprising and shocking to note that, even though Einstein had been honored with the prestigious Nobel prize for 'Photoelectric effect' that successfully demonstrated the nature of energy quantum, he strongly suspected the independent nature of quantum mechanics against gravity.

In a theoretical perceptive, for any scientist, it is imperative to explain the possibility of low temperature nuclear fusion of atoms against hot fusion and the dominating nuclear Coulombic repulsive forces. As there was a failure in explanation, in many cases, mainstream scientists criticized other scientists working on cold nuclear fusion. In this context, important point to be noted is that, increasing mass number of nucleus can be considered as a representation of increasing strong nuclear attraction. Based on this point, it can be understood as - fusion of two hydrogen ions/atoms under hot nuclear fusion scheme seems to be different from fusion of a heavy atom that constitutes 50+ nucleons and one hydrogen atom under cold nuclear fusion scheme.

Based on the repeatable nature of hydrated cold fusion experiments conducted by S. Focardi, Andrea Rossi, A.G. Parkhomov, E.O. Belousova Yu.N. Bazhutov, A.I. Gerasimova, V.P. Koretskiy, Yasuhiro Iwamura, Tadahiko Mizuno, Jed Rothwell, Prahlada Ramarao, N.S. Varaprasad, P. Shyam Sunder and Shashank G Dath and other eminent scientists [5-22], it seems compulsory to review the basics of cold nuclear fusion positively. In this paper, we propose a theoretical mechanism for understanding the excess heat generated in hydrated cold fusion experiments. It needs further study with respect to authors proposed unified nuclear binding energy scheme (that ignores nuclear Coulombic repulsions) and other available theoretical cold nuclear fusion models [6-10, 22-29].

2. Current encouraging progress and upcoming mega project funds

As the main objective of cold nuclear fusion is to produce clean thermal energy, from 2015 onwards, 'Goggle' team put lot of efforts in understanding and generating excess heat via all known experimental cold nuclear techniques with advanced and more sophisticated measuring tools. Even though it was a failure, in 2019-20, Google team members published a seminal paper in the prestigious journal 'Nature' and expressed their strong encouragement for conducting future experiments [30,31]. Another interesting point to be noted is that, right from the beginning, NASA team has shown lot of interest in cold fusion techniques and in 2020, published two very important papers [32,33] in the prestigious journal 'Physical Review C' paving a way for accomplishment of cold nuclear fusion with 'deuterated' Erbium atoms by a new technique called 'lattice confinement'. Following these points and considering the main objective of generating clean energy, in 2020 last quarter, European Union funded 10 million Euros for two cold nuclear fusion projects for a period of 4 years.

3. Basic mechanism of Hydrated cold nuclear fusion

Considering 'Hydrated cold nuclear fusion' experiments, we propose the following points.

1) Evacuated and sealed reactor is loaded with small quantity of very fine Nickel like powder and large quantity of hydrogen gas under certain pressure.
2) As the reactor is slowly heated by external electric power, reactor temperature and pressure, both, slowly increase and hydrogen atoms start making to and fro forced oscillations in the reactor.
3) At certain controllable temperature and pressure conditions, hydrogen atoms, start entering the nuclear core of the Nickel atoms triggering nuclear fusion reactions.
4) Within the nuclear core of Nickel atom, due to weak nuclear interaction [7], hydrogen atom immediately transforms to a neutron and by strong attractive nuclear force, new neutron joins with nuclear core and increases Nickel mass by one unit.
5) Sometimes, within a short span, due to weak nuclear force, newly formed neutron transforms to proton, electron and neutrino.
6) Due to strong nuclear attractive force, new proton joins with Nickel's nuclear core and increases the nuclear proton number by one unit.
7) New electron joins with Nickel's electronic orbits and increases Nickel's electron number by one unit.
8) In this way, within the nuclear reactor, as time is progressing, Nickel mass number increases slowly and some times, Nickel transforms to its next level new atoms. This concept can be compared with the observed cold fusion nuclear transmutations.

9) Based on the currently believed nuclear binding energy scheme, maximum binding energy per nucleon is around 8.8 MeV [34,35].
10) Considering the fusion of one hydrogen atom in hydrated cold fusion, energy acquired by the final nucleus during the fusion of hydrogen atom seems to be 8.8 MeV. This can be considered as the origin of 'missing energy' or 'excess energy' in cold nuclear fusion.
11) In the absence of increase in internal kinetic energy, there is a scope for liberation of excess energy in the form of safe thermal energy. This can be considered as the basic information missing in mainstream nuclear physics.
12) Due to Coulombic repulsion, asymmetry effect, pairing effect and other nuclear effects, final atom is forced to choose a little bit of binding energy less than 8.8 MeV and thus it is able to release left over binding energy in the form of internal kinetic energy or external thermal energy. Thus, in hydrated cold fusion, heat release to occur, binding energy difference of final atom and base atom seems to be less than 8.8 MeV.
13) Qualitatively, energy released during hydrated cold fusion seems to be approximately equal to 8.8 MeV minus the difference of binding energy of final and base atoms.
14) Based on this idea, under normal conditions, for the case of $_2He^4$, fusion of four protons can liberate (35.2-28.3)=6.9 MeV and it is 3.5 times less than the current estimates.
15) Point to be understood is that, lesser the binding energy of final atom, higher the liberated thermal energy and vice versa.
16) Reactor input charge can be chosen to constitute, less abundant, stable and heavy mass numbers of light Z in large proportion so that, after fusing with hydrogen, output becomes more abundant, light and stable mass numbers of Z+1.Thus difference in binding energy of (Z+1, A+1) and (Z, A) is on lower side and less than 8.8 MeV.
17) Considering $_{28}Ni^{62}$ and $_{29}Cu^{63}$ isotopes, liberated thermal energy can be around {8.8–(550.0–544.4)} = 3.2 MeV.
18) Considering the case of fusion of two Deuterium atoms, liberated thermal energy can be around, {(4*8.8)–[28.3–(2*2.22)]}=11.3 MeV. Clearly speaking, fusion of two deuterium atoms can be considered as a representation of fusion of 4 nucleons. Binding energy of $_2He^4$ is 28.3 MeV and binding energy of deuterium is 2.22 MeV.
19) With a suitable catalyst and sufficient hydrogen under suitable pressure, if reactor's temperature is maintained at (1000 to 1500) ^{0}C, there seems a lot of scope for a chain reaction of cold fusion in which light isotopes transform to their next stage with increased proton number or mass number and liberate safe and clean heat energy continuously.
20) By arranging 4 to 6 reactors and charging them periodically in tandem, required thermal energy can be produced continuously. In this new direction, by carefully selecting the base isotope and its corresponding catalyst, experiments can be conducted and ground reality of cold fusion can be understood at various temperature and pressure conditions.

4. Authors recently proposed unified nuclear binding energy scheme

Aim of proposing our unified nuclear binding energy scheme [36, 37] is to show that, without considering the Coulombic energy term, nuclear binding energy can be modelled with four simple terms having one unique energy coefficient. Our approximate model relation can be expressed in the following way. Starting from Z=3 to 120,

$$A_s \cong 2Z + 0.0016(2Z)^2 \cong 2Z + 0.0064Z^2$$
$\cong$ Estimated mass number close to proton-neutron mean stability line. (1)

$$BE \cong \left\{ A - A_{fg} - A^{1/3} - \frac{(A_s - A)^2}{A_s} \right\} (B_0 \cong 10.1 \text{ MeV})$$
$\cong$ Estimated nuclear binding energy (2)

Here, we would like to appeal that,

1) A can be considered as a representation of volume term.
2) $A_{fg} \cong \left(1 + 0.0019A\sqrt{ZN}\right)$ can be called as the geometric number of free or unbound nucleons.
3) $A^{1/3}$ can be called as radial factor associated with nucleons.
4) $\frac{(A_s - A)^2}{A_s}$ can be called as isotopic asymmetric term associated with mean stable mass number.
5) Binding energy coefficient, $B_0 \cong \frac{1}{\alpha_s}\left(\frac{e^2}{4\pi\varepsilon_0 R_0}\right) \cong 10.1 \text{ MeV}$ seems to be associated with nuclear radius, strong coupling constant and fine structure ratio.
6) The numbers 0.0016 and 0.0019 seems to be associated with 'weak' interaction. With further

study, coefficient 0.0019 can be replaced with 0.0064.

On a careful observation, from relation (2), it is very clear that, direct role of Coulombic term is negligible in nuclear binding energy scheme.

5. String theory Vs Cold nuclear fusion

Since 50 years, modern scientists are seriously working on multi dimensional string theory [38]. But, till today no single experiment had revealed any new dimension [39]. In addition to that, so far, the intended purpose of string theory is not being served in unifying the four basic interactions. Conceptual point of view, String theory is one of the best ideas in the entire history of theoretical physics and one of the greatest disappointments as it has no single testable prediction. It may be noted that, string theory is failing in understanding strong interaction and failing in estimating the magnitudes of fundamental physical constants. Even then, modern scientists are seriously working on its development and spending millions of dollars. Here we would like to emphasize the point that, 'string theory' is having conceptual beauty and 'cold nuclear fusion' is having experimental beauty. In near future, both the concepts will have a great control over scientific and industrial development and eco friendly environment [40].

6. Conclusion

In section-1, we have clearly explained the issues connected with cold nuclear fusion theory and experiments. In section-2, we have clearly explained the current positive status of cold nuclear fusion experiments with new and upcoming mega funding sources. Mechanism point of view, nuclear extra energy point of view and heat energy liberation point of view, in section-3, we tried our level best in explaining the hydrated cold nuclear fusion. In section-4, we proposed a unified nuclear binding energy scheme by using which nuclear Coulombic repulsive forces that are assumed to have a key role in understating nuclear fusion scheme can be given a second preference. By comparing the current progress of String theory with current cold nuclear fusion experiments, in section-5, we are trying to highlight the significance, importance and need of cold nuclear fusion implementation. Hence forth, by considering the current 'poor status' of workable models of cold nuclear fusion and 'rich stratus' of repeatable hydrated nuclear fusion experiments, our proposed concepts can be recommended for further study and research.

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