New Nuclear Fusion for Our Second Generations

Ho-Jin Choi*
Koan-Sik Joo**

In this short report (before the authors would like to introduce an important application for one of the techniques of complex angular momentunm, say, Regge Pole approach, to nuclear fusion reaction for Light-ions: it will be reported in forthcoming papers) , two kinds of thermalnuclear **fusion** reaction sources are introduced and discussed (A) the case of fusion: the production of **neutron** and target of **Deuteron** and (B) the case of fusion: the production of **proton** and target of **Deuteron**. Nuclear **fusion** reactions for Light-ions , such as the thermalnuclear energy sources and fuel cycles, are already well known. **Fusion** reactions are widely known as being extremly important and nationally vital (in point of view of nuclear **weapons** : we must reconsider seriously developement and building of such dangerous **weapons**) for our next generations in the future. This paper (a topics in review) is concerned with a simple introduction about a new nuclear fusion reaction of the above case of (B) for the second generation.

Typical thermalnuclear **fusion** reactions which result in the release of huge amount of energy are nuclear stripping reactions :
i.e.,
(A) . for (H^2, n) reaction

i. $H^2+H^3 \rightarrow n+He^4+Q$ (=17.6 Mev) or $D+T \rightarrow n+He^4+Q$

ii. $H^2+H^2 \rightarrow n+He^3+Q$ (3.27Mev) or $D+D \rightarrow n+He^3+Q$

where H^1=proper Hydrogen atom, H^2(or D) =Deuteron, H^3(or T) =Triton, n=neutron, He^4=Helium-4, He^3=Helium-3, and Q=a released energy during the fusion process.

*Adelphi University · **Myongji University

Consider the element of Hydrogen atoms . There are three kinds of Hydrogen atoms: the symbol H^1 is a proper Hrdrogen atom, the symbol H^2 is called Deuteron (or Deuterium) , and the symbol H^3 is called Triton (or Tritrium) . As we can see H^2 and H^3 in the above two reactions (i and ii) , these are isotopes. Actually occuring water, H_2O, contains 99.987 % of H^1 and 0.013% of H^2, this H^2 is available everywhere this Earth. The amount of the Hydrogen atoms, as the energy source, is in fact infinite.

"Hrdrogen bombs" are concerned with the stripping reaction of the case of (A) : everyone is familiar with such a terminology, atomic and nuclear bombs. In the nuclear fission reaction (for instance, the $n+U^{235}$ and $n+Pu^{239}$ reactions) , energy released during the fission process is around 0.51 Mev/particle. Comparing the Q-values of the case of (A) with 0.51 Mev/particle of the fission energy, the resulting fusion energy is much larger than the fission energy. Although the fusion energy is a define energy source, fusion reactions really scare us. We are concerned with Hydrogen Bombs and its huge Bursts. The fusion reaction will take place, when we supply tremendous high temperatures to , for instance, D+T reaction system. On the other hand, the fission reaction (for example, $n+U^{235}$) requires to use a "Critical mass" for U^{235}. Since we focus on the topics of the fusion reaction, the fission reaction will not be discussed here.

It is noted that for a nuclear burst the number of the released neutrons is around 10^{24} neutron/burst . This amount of the neutron is extremely large; we can not control such a huge amount of energy. In particular, the "Pulse Duration" is very short, around 0.1 microsecond. During this short period, people will loose their precious lives by such a tremendous amount of the neutron (i.e. ,strong neutron radiation) and at the same time by its nuclear storm and strong shock-waves which follow from nuclear explosion.

It has been reported 20 years ago that the cost of 10kg of Deuterium (H^2) , in US dollars, would be \$ 75,000,000-80,000,000: 1 ton of H^2 would be \$ 7,500,000,000-8,000,000,000. Today, 1 ton of Gold is roughly equivalent to \$ 100,000,000 ! Tritrium (H^3) is much more expensive than the price of H^2. These H^2 and H^3 are extracted from water. From n+Li reaction, H^3 can be produced.

In this paper, we are interested in the following reactions for our second generation in the future :

(B). the (H^2. p) fusion reactions

i. $H^2+H^2 \rightarrow p^+ + H^3 + Q$ (4.03 MeV)
ii. $H^2+He^3 \rightarrow p^+ + He^4 + Q$ (18.4 Mev)
iii. $H^2+ Li^6 \rightarrow p^+ + Li^7 + Q$ (5.OMfV)
iv. $H^2+ C^{12} \rightarrow p^+ + C^{13} + Q$ (2.72 Mev)

where the symbol "p" is the positively charged proton, the symbol He^3 is an isotope of the Helium He^4, the symbol Li^6 is the Lithium and Li^7 is an isotope of Li^6, and the symbol C^{12} is the Carbon and C^{13} is an isotope of C^{12}.

This reaction (the case (B)) can/could be used as a new kind of "Hhrdrogen Bombs". In 1950, the USA tested the "Hrdrogen Bomt" which is same as one of the case of (A) . The authors believe that in 1953 the Soviet Union tested a Hydrogen Bomb related to H^2 + Li^6 reaction in the case of (B) , although this information may not be reliable. It should be emphasized now that the fusion reactions of the case of (B) is in fact available now and in the near future.

As we can see the reactions of the case of (B) , all the fusion reactions show the positively charged particles p′ s and the charged and produced particles H^3, He^4, Li^7, and C^{13}. We can take an advantage of especially designing and constructing the the thermalnuclear fusion reactors and power plants in the future.
On the other hand, in the case of (A) , it is extremely difficult for us to control the neutron beam, since the neutron n has no charge .

Now, consider the case of (B) in detail : For the reaction (B-i) , H^3 is produced. This H^3 can burn up through H^2 + H^3 in the reaction of the case of (B).

This reaction (B-i) has a useful breeding feature. It is considered as a good fuel recycle .

In the reaction (B-ii) , He^3 is an interesting element: He^3 can be produced from the reaction (A-ii) . Although the reaction (B-ii) has no breeding feature, it releases the most powerful fusion energy of all reactions (B) , that is, Q=18.4 Mev. This reaction can be an alternative to the reaction (B-i), H^2 + $H^2 \rightarrow$ p + H^3.
The reaction (B-iii) releases a huge amount of energy. However, it is noted that the Li elements (which is a soft metal and should be prevented from interaction with Oxygen atoms or molecules) are rare and expensive. This Li metal is availabLe in South American and the U.S. The reaction (B-iv) is the most interesting reaction, since the Carbon elements are some of the cheapest substances known and available anywhere. We can produce the Carbon easily. As we carl see this reaction, the produced particles are both charged particles p and C^{13}. Therefore they can be handled easily. This report is an introduction and a simple review of

the new energy sources for the second generation . The authors have written a number of the research notes concerned with useful applications for Regge Pole method to the case of the fusion reactions (B).
These versions are available now.

Reference

1. Abulafflo C and Peres 1975 " A Phase Shift Analysis of nD,· DD, TT, HeD and HeD Cross Section in Nuclear Cross Section and Technology Proceeding of a Conference" ed. by Schrack RAand Bowman N.B.S. Special Publications 425.
2. Blatt J M and Weiskopf V F 1952 Theoretical Nuclear physics Wiley New York.
3. Butler S T and Hittmair 0 H 1956 Nuclear Stripping Reactions John Wiley and Sons New York.
4. Mott N F and Massey H S W 1965 Theory of Atomic Collisions, 3rd ed., Calarendon Press Oxford.
5. Enge H 1966 Introduction to Nuclear Physics Addison-Wesley Publishing Company Reading, Massachusetts Palo Alto London Don Mills, Ontario .
6. Jackson DF 1970 Nuclear Reactions Hethuen and Co LTD London, England.
7. Choi H J Regge Pole Method and Nuclear Fusion Reaction Amplitude for Light-ions : unpublished. This contains a number of the versions .
8. Choi H f Regge Pole method and Nuclear Fusion Reaction Amplitude for Heavy-ions : unpublished. This version contains a number of the versions .