Have we found a breakthrough on potential catastrophes?

~ How nuclear fusion holds promise for our future

Ryoji Furui

In this essay, I propose how to put nuclear fusion to practical use by introducing a "technology", so it is the description of a revolution in energy, which I strongly believe will come.

Nuclear Fusion

First, what is nuclear fusion? Nuclear fusion is the opposite of nuclear fission, which has been used as an energy source for over 50 years. As the name implies, nuclear fusion has some properties opposite to those of nuclear fission, although both are nuclear reactions. As a result, nuclear fusion is safer and cheaper and is envisioned as the next-generation main energy source for humanity. There is no need to worry about radioactive pollution or waste, which could linger for tens of thousands of years. It is also said that because its fuels like deuterium are inexhaustible sources, its cost performance would be much greater than that of fission. Therefore, it could help lower regional gaps in energy supply. Furthermore, like nuclear fission, nuclear fusion would not produce carbon dioxide.

No worry about nuclear pollution, very cheap and no carbon dioxide; it sounds like a fantasy, but generating electricity would be almost the first step in using nuclear fusion. In the future, it would be applied to the propulsion of aircrafts or space rockets or to engines downsized to the micro scale and functioning semi-permanently. It is not easy to imagine how human civilization would change with nuclear fusion in the long run like over hundreds of years, but it would keep contributing to our prosperity and could be a theme for future contests.

Nanotechnology

So what "technology" would make nuclear fusion possible? It is a well-known technology in recent years called "nanotechnology". Here, we focus on carbon nanotubes (Figure 1), which are widely used and are formed by carbons arrayed in a hexagonal net. The idea is simply using this material as an additive in the fuel for nuclear fusion.

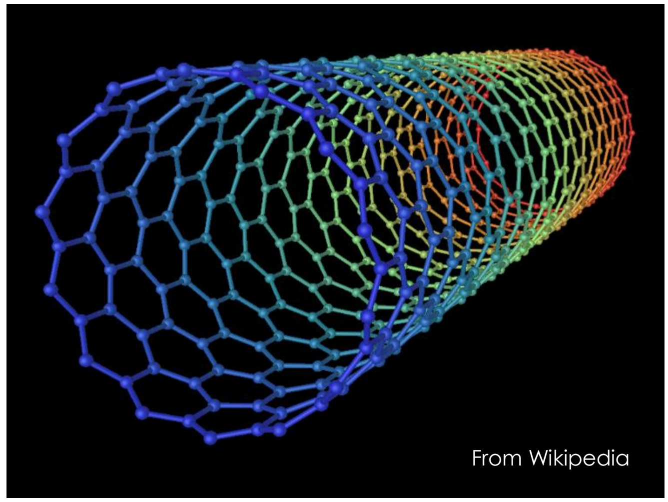

FIGURE 1: MOLECULAR MODEL OF CARBON NANOTUBE

My earliest idea about this nanotechnology was submitted in a short letter to the journal Nuclear Fusion in 2006 (1). This was a short manuscript at that time. After that, I spent more time to build a theory (as we shall discuss later), rather than work out the technical aspects of this idea. This was so that the basic idea could fit into this paper.

Before we move on, I would like the reader to excuse this essay if it contains some theoretical or technical descriptions different from those not published. Such information may often take time to be published, so there may be a difference between them.

Graphene

I still remember being surprised in late autumn of 2010 when hearing the news that Andre Geim and Konstantin Novoselov had won the Nobel Prize in physics for their achievement of generating graphene. Graphene (FIGURE 2) is a kind of carbon nanotube, and its shape is not like a tube but a flat sheet. It has a very simple structure and therefore can have a very strong frame with very light weight and various useful properties. Graphene is one of the materials attracting rising attention in various industries as a new-frontier technology.

In 2012, a paper by Fei et al. was published in *Nature Online* magazine (2) that confirmed the existence of plasmons on a graphene surface. A plasmon is formed in cool plasma, the state in which electrons move freely in the material but atomic nuclei are fixed. When Fei et al. made a cool plasma on the graphene surface, they confirmed moving electrons are controlled by the graphene structure, and electrons are energetically excited on each hexagonal net. Plasmons were already a common physical phenomenon observed in various materials, not only graphene. However, plasmons can be interpreted theoretically as being where quantum mechanics (modern physics) meets classical physics. This means quantum mechanics can be applied to plasmons, but plasmons are currently theorized using classical physics. Therefore, I believe this phenomenon is the last unexplained area of modern physics. Therefore, we are watching the unification of classical physics represented by gravity and modern physics represented by quantum mechanics through a real phenomenon in nanotechnology. Again I believe this fact would carry forward the practical use of nuclear fusion.

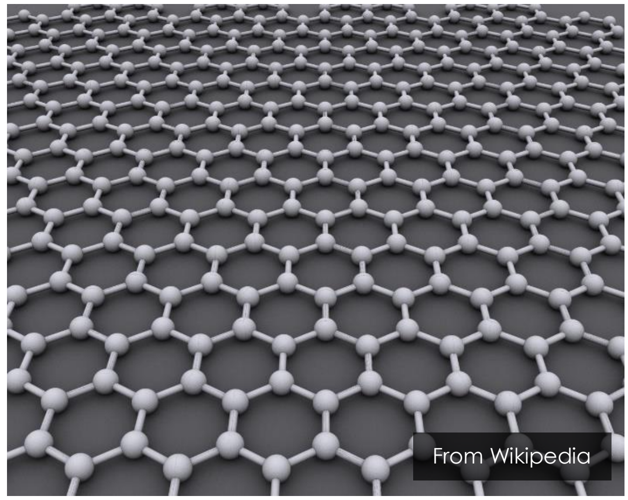

FIGURE 2: MOLECULAR MODEL OF GRAPHENE

Now, we try to learn a little more about nuclear fusion. Nuclear fusion is observed as a phenomenon of plasma. This time, it is not cool plasma but hot plasma that is the state in which atomic nuclei move freely along with electrons. Its temperature is said to be about 100 million degrees Celsius. In this state, atomic nuclei sometimes hit each other and become different nuclei with emitted energy (if the nuclei are lighter than steel). This is the simple process of nuclear fusion. The common natural object in which we observe nuclear fusion is the sun. Large stars like the sun have strong gravity, and material objects attract each other very strongly. This strong gravity induces the hot plasma state through nuclear fusion. You may already understand that the difficulty in nuclear fusion is how to duplicate solar conditions on the earth. Before we make a hot plasma in a nuclear reactor, we need to duplicate the state of the sun. It is not difficult to know how it consumes energy. The consumption of energy has always been greater so that nuclear fusion has not been in practical use until now.

Now we come back to how my idea would work. One of the most important points of my idea is that the temperature of hot plasma is a different order of magnitude from that of cool plasma, so that graphene would lose any control in the hot plasma. Actually, graphene will crash itself in the hot plasma; however, we should not forget graphene maintains its state over a certain temperature range before the transition to hot plasma. The initial condition of nuclear fusion can be set to lower temperature, where graphene can hold nuclei, and it means nuclei can start moving in a certain direction or along a limited range and would no longer be free. Thus, this makes nuclear collisions more frequent with less effort to produce sun-like conditions in the reactor.

Theorizing

Which model or theory better explains this phenomenon? In 2012, *Nature Online* published an article about the experimental confirmation of a paper written by Masanao Ozawa in 2003. Ozawa's paper was about modifying quantum mechanics to include the effects of noise or experimental devices, with the result that quantum mechanics loses its probability under certain conditions (3). This may be an acceptable explanation from the standpoint of quantum mechanics. However, its equation contains external events and therefore no longer describes a physical event in an isolated system. This means it does not describe the law of the event itself. This paper concludes this fact of quantum mechanics by improving the accuracy of its description.

As described before, I personally believe this area is where we can discuss the unification of physics theories. I have intended to model this unification for many years, and I believe that my thesis can be applied to some quantum mechanical probabilities of interactions (4). Its main idea is to define gravitons and their properties through classical extensions of Einstein's special theory of relativity.

Reactor Designs

I have two simple ideas for using graphene in nuclear reactors, shown as a hybrid model in the picture below (Figure 3). The first one is shown in the upper half of the picture; fuel and graphene powder are mixed in the reactor, and the graphene helps to boost fusion reactions. This effect can be considered similar to that of dust explosions. The other idea is shown in the lower half of the picture; rod-shaped graphene soaked in the fuel is inserted to a point where a high-energy field is generated by lasers. The graphene may contribute to the high-energy field, thus we would need less laser power. This design is still far from a quantitative model; however, I believe it is possible with a certain balanced arrangement or inclusion of additional components.

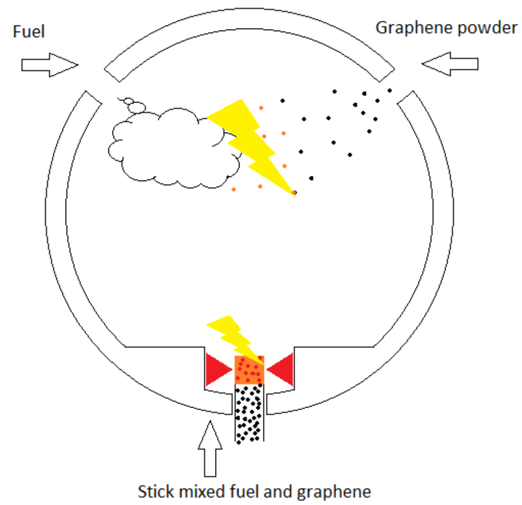

FIGURE 3: NUCLEAR FUSION REACTOR WITH GRAPHENE ADDITIVES

Risk behind Fruit

It is well known that nuclear fission can derive power from enriched fuels. In nuclear fusion, fuel can be enriched by soaking graphene layers in a crystalized solid state at very low temperature. As we get more energy output, we certainly receive more benefit. However, we may need to make some regulations for future nuclear deals, because the gain may exceed the current maximum output with easier handling.

Nuclear fusion would dramatically reduce energy costs; therefore it would reduce the risk of social instabilities caused by interstate conflicts or economic disparities. However, we need to put more effort into keeping the social state stable through a global organization formed with global consensus. I further think this effort should never end, just as humanity has kept believing in religions or ethics or whatever has worked and kept respecting their growth beside the development of science. I believe we would never lose them as humanity continues to create new technology.

References

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