Can nuclear fusion save us from energy shortages?

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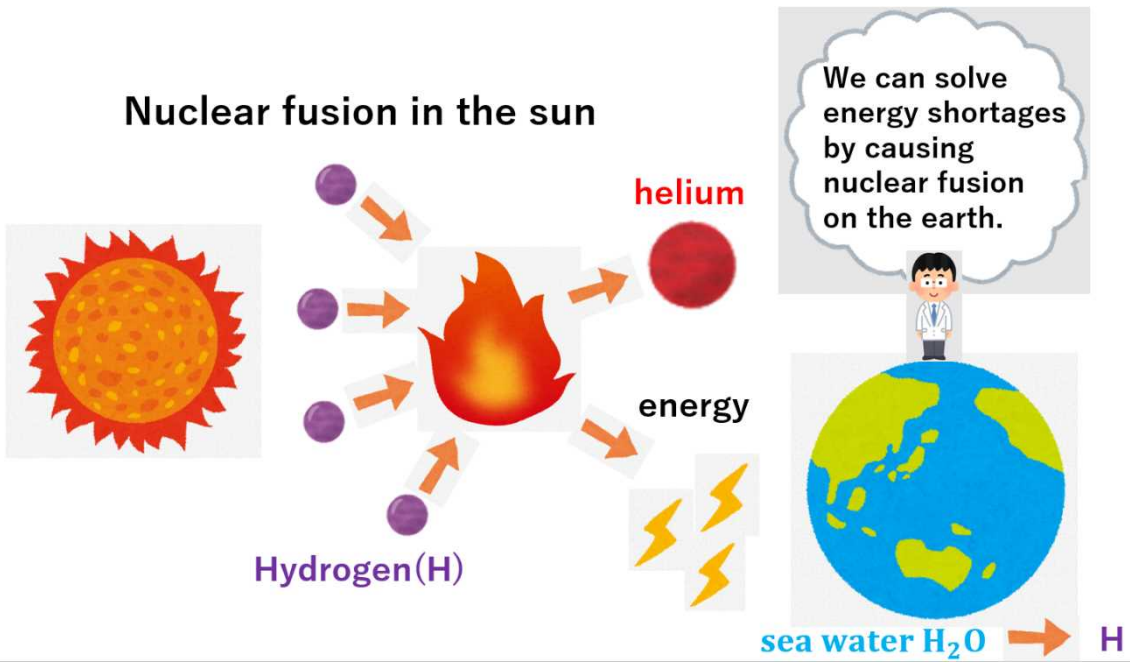

I introduce the nuclear fusion as a solution of the energy shortage problem.

Now, we are using fossil fuel as the most important energy source, but the depletion of the fossil fuel may bring the serious energy shortage in the near future. It is also said that fossil fuel may be exhausted only in tens of years. If so, we will not be able to use electricity everyday life and factories which make all things necessary for our life will also stop. And global warming due to the thermal power generation has caused major environmental problems such as sea level rise and the extinction of animals and plants. So, all people around the world are calling for an alternative energy source which is both sustainable and environmentally friendly.

Some scientists have found a clue to solve the energy shortage problem in the energy generation mechanism of the sun. The sun is producing huge energy continuously by nuclear

fusion reaction. In the nuclear fusion reaction, hydrogens are burned and heliums are created. Unlike the combustion of fossil fuel, which burns carbons, the nuclear fusion doesn't generate carbon dioxide. So, this process is environmentally friendly. Moreover, hydrogen as fuel is abundant in the sea. We can obtain hydrogens (H) from water (H_2O) made of hydrogen (H) and oxygen (O). So, nuclear fusion can also be expected as a sustainable energy source. Some scientists are actually working on research creating nuclear fusion reactors which is so to speak "suns" on the earth.

Then, what would be being needed to realize the nuclear fusion reactors on the earth? To cause nuclear fusion, we must confine hot and dense hydrogens. But hot hydrogens do vigorous thermal motion in a reactor as if water molecules move vigorously in a microwave oven. So, the confinement of hydrogens is becoming the next most important subject to the realization of high temperature. In the center of the sun, hydrogens are confined by strong gravitational force due to the sun's large mass about 10^{30}kg. Unfortunately, we can't create the same gravity as the one that the sun makes on the earth. Instead, we can use the magnetic force to confine hydrogens. Compass directs to the north by the magnetic force due to the earth magnetism. In a hot environment of a reactor, hydrogens become ions which are charged with electricity and behave as magnets in the magnetism. So, ions' motion always directs to magnetism. By applying magnetism in the reactor, we can control the hydrogens' thermal motion so as to confine hydrogens. Research to confine hydrogens by the strong magnetism are being carried out hard now.

What we must take into account in considering confinement of hydrogens is random flow called turbulence. In general, turbulence is generated in the environment where hot ions exist. Turbulence stirs hydrogen ions confined by magnetism and causes net heat flow from the center of the reactor with high temperature to the surrounding wall of the reactor with low

temperature. This lowers the temperature in the center of the reactor which must be sustained high to cause nuclear fusion reaction. So, it has been considered that suppressing the turbulence is important.

However, in a recent experiment [1] of the nuclear fusion which achieved as high temperature as one in the center of the sun, it has been found that turbulence can be used to cause nuclear fusion safely and effectively by controlling it. There were two big discoveries in this experiment. The first one is that creating small turbulence near the center of the reactor and large turbulence near the surrounding wall can lower only the wall's temperature. This can reduce thermal load applied to the wall. The second one is that controlling turbulence can mix deuterium and tritium (Deuterium and tritium are kinds of hydrogen.) which trigger the nuclear fusion.

The research of turbulence is being carried out by experiments using actual reactors and numerical simulations [2]. Further understanding of the properties of turbulence including advantage as well as disadvantage for nuclear fusion may lead a breakthrough toward energy supply by the nuclear fusion.

In this essay, I introduced the nuclear fusion as a solution of the energy shortage problem.

So far, various scientific discoveries have supported the advance of technology. As mentioned above, the idea of the nuclear fusion was obtained from the sun. The nuclear fusion may become a good example in which research of the universe promotes the advance of technology outstandingly. Confinement of the ions and turbulence which work in the nuclear fusion reactor are also ubiquitous phenomena in the universe where hot ions and strong magnetism exist. In fact, the research of the nuclear fusion is being propelled by collaboration with astronomical scientists. The era when the understanding of the universe makes our lives convenient more than ever would come.

If energy supply by nuclear fusion is realized, we can solve two major problems in our society, the problem of sustainable energy supply and the environmental problems caused by global warming simultaneously. Nuclear fusion reactors also called "the suns" on the earth may lead to brighter tomorrow.

Reference

[1] Ohtani et al. Nucl. Fusion 61 (2021) 034002 (6pp)

[2] Nunami et al. Physics of Plasmas 27, 052501 (2020)