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STARS CAN'T SHINE WITHOUT ~~DARKNESS~~ HYDROGEN AND NUCLEAR FUSION.

About the utilization of stars scientific knowledge to refine the process of achieving cheap energy sources.

As humans living in the 21st century, we have got used to many facilities that make our life luxurious. We cannot imagine our existence without illumination guiding us on dark nights, electricity to powering most of the homeware equipment, or without internet to keep us in touch with the rest of the world. Neither living without air conditioning saving us on hot and humid summer days or heating on cold snowy winter nights. Our lives would look very differently without efficient cars or fast connecting flights to every little corner in the planet.
The human being needs a large amount of energy to cover his needs for lighting, health care, transportation, air conditioning, industrial production, among other services. Furthermore, the amount of energy required enhances each year as our living standards increase. The solution for growing energy demand relies on the diversification of resources, giving preference to those abundant, environmentally friendly and economically affordable.
Today, fossil fuels still are the main sources of energy, because of their low cost and known technology; however, these natural resources have been massively exploded over the past centuries, and their depletion is inevitable. It is also noteworthy that the combustion processes by which we obtain energy from fossils are far from being efficient and environmentally friendly, mainly because of the incomplete combustion and the release of greenhouse gases. Therefore, as a generation we are obliged to innovate, by setting new technologies based on alternative energy sources with reduced environmental impact. Indeed, a variety of renewable energy sources are already in use or are currently going through a stage of development, where the main focus is on high efficiency and low cost of massive production.
In this essay we invite to admire the stars, not because of their beauty, but because of their natural wisdom allowing them to glow very intensely for such a long time. It is very poetic to say that stars cannot shine without darkness, but in fact, they cannot shine without the presence of light nuclides like hydrogen and without nuclear fusion. During the process of nuclear fusion, two light nuclei merge forming a single yet heavier nucleus with simultaneous release of the great amounts of energy. If we could control and optimize the process of nuclear fusion, getting required amounts of energy for its commercialization, we would provide a solution for energy problem for at least several future generations. Energy from nuclear fusion would be cheap, produced from abundant and easily obtained resources and would not harm the environment. Further, we discuss the aftermath of nuclear fusion within the context of energy production.

Advantages and challenges related with the use of nuclear fusion for energy production.

The most important advantages of nuclear fusion are sufficiently high abundance of nuclides of light elements in nature and enormous amount of energy released during nuclear reaction. The two nuclides of primary interest are deuterium and lithium-6. On Earth, deuterium is present in the molecules of water where it substitutes the lighter isotope of hydrogen at the rate of 34 grams of deuterium per ton of water. Fusion of two deuterium nuclei yields helium nucleus with the release of kinetic energy of 5MeV per one atom of deuterium. Therefore, the energy content of the oceans is at least one million times higher than that contained in all fossil fuel resources [1]. According to researchers of the Institute of Nuclear Fusion (IFN) of the Polytechnical University of Madrid (UPM), the total extractable energy from one cubic meter of water by nuclear fusion of deuterium would be approximately equivalent to the combustion of about 200 tons of petroleum[1].
Lithium is not directly used as a fuel in nuclear fusion, but when bombarded with neutrons, it is converted to tritium, a radioactive isotope of hydrogen practically absent in nature. In turn, lithium can be found in oceans at the rate of 0.7 grams per ton of water, and its abundance in the earth's crust is even higher (up to 20 parts per million) [1]. The interest in tritium in the context of energy production arises because its fusion with deuterium releases about 17.6 MeV of energy, which is much more than energy obtained from two deuterium nuclei. Looking closer at the reaction of tritium and deuterium, we notice that deuterium is a stable non-radioactive nuclide and tritium is beta emitter with short radioactive half-life. Hence, lithium-6 acts as an in-situ precursor of and the only radioactivity produced will be in the process by which neutrons created in fusion activate the apparatus structural material. This effect can be significantly reduced by designing and optimizing technological equipment. Specific issues involve the selection of materials that would minimize the generation of radioactive isotopes in their structure and would not allow the escape of any of them into the atmosphere. Some

representative materials that are already in use can be mentioned, such as steels produced as iron and chromium alloys, vanadium alloys or composite materials based on silicon carbide and/or carbon. Investigation of other nuclides of potential utility in nuclear fusion yet without producing radioactivity and without neutron release should also be mentioned; such is the case of proton fusion with boron-11 nucleus, which is achieved in boron plasma under laser irradiation and produce helium-4 together with energy.
As mentioned before that we like to obtain lots of energy at low cost. Therefore, the next advantage of nuclear fusion is that light nuclides costs are much lower than the cost of fossil fuels per unit of energy produced. Besides, if you like politics, you would notice that the global distribution of light nuclides is much more even than fossil fuels, which leads us to less nations hoarding on energy sources. Finally, safety of nuclear fusion should be emphasized. Since this process is quite difficult to maintain, nuclear explosion would not occur; also the reaction product is helium-4, which is a very stable and safe gas.

Beside obvious benefits offered by nuclear fusion, there are also many difficulties that need to be addressed. The first obstacle is electrostatic repulsion between two positively charged nuclei; in order to overpower this effect, heating is necessary until kinetic energy of nuclei becomes greater than their repulsion. This process is called thermonuclear fusion and the corresponding temperature is called ignition point; in the case of deuterium-tritium fusion, ignition temperature rises to 50 million Celsius degrees whereas for other nuclides, temperature required is much higher. Other issue is to ensure that nuclei collisions result in their fusion and for this purpose, high temperatures mentioned above should be maintained until a sufficient amount of fusions are produced, and the total obtained energy exceeds the input energy to continue the process. In this regard, magnetic or inertial confinement of plasma allows more efficient fusion. Despite understanding the physicochemical bases of nuclear fusion and awareness of its high potential as the future energy source, there are many technological issues that still need to be solved. These include, plasma formation and confinement, strict control of temperature, scaling to massive production, selection of the most suitable fuels, selection of the materials and design of apparatus, minimizing environmental impact, among many others.

Once nuclear fusion becomes well established, affordable and easy to operate energy source, I would like to have my own miniature constellation of traditionally glowing stars to decorate the ceiling of my daughter's bedroom.

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