Helium-3 Fusion

Danny Zaterman
22.012
Professor Molvig
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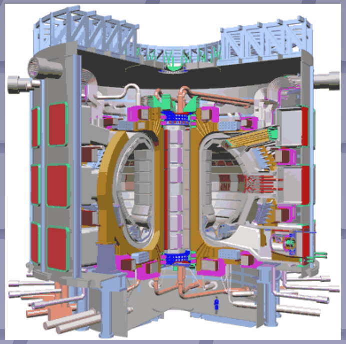
An Introduction to D-He-3 Fusion

The basic goals in Deuterium Helium-3 fusion are to use either a tokamak or inertial electrostatic confinement to control the fusion of D and He-3 to produce an energetically efficient and minimally radioactive fusion reaction as a source of electricity

use



Courtesy of ITER.

or (IEC)

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To produce **$D + {}^3HE \rightarrow p\ (14.7MeV) + {}^4He\ (3.7MeV) + 18.4\ MeV$**

Fundementals of the Reaction

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See Fig. 2 in Lecture 27 by G. L. Kulcinski (1996).
http://fti.neep.wisc.edu/neep602/LEC27/IMAGES/fig2.JPG

- The Combination of nuclei of Deuterium and Helium-3 yields Hydrogen and Helium and an Energy of 18.4 MeV per reaction

Aneutronic Fusion

- The notion of D-T fusion being radioactively benign is a myth as the reaction produces high energy neutrons that activate the materials that compose the reactor, forcing components, especially the inner wall, to need frequent replacement.

- D-He-3 reactions produce no high energy neutrons, and consequently the activation of metals is drastically reduced. (Stray D-D reactions will generate some neutrons)

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Energy Conversion

Another significant benefit of using Deuterium and Helium-3 fuels is that the reaction products, being charged particles, can be manipulated by electric and magnetic fields and can consequently used for direct energy conversion.

Electrical Power

Experiments have demonstrated that a blind like series of water cooled ion collectors can convert a high energy (100 KeV) beam of ions into electrical energy with efficiencies on the order of 60-70 percent. These efficiencies are much greater than with DT fuel or with fission reactors.

Conditions necessary for D-He-3 Fusion

As we have already learned, the amount of energy needed to fuse nuclei is proportional to the number of protons involved in the reaction. Because D-He-3 Fusion involves 3 protons as opposed to 2 with DT fusion, the amount of heat required for good fusion parameters is 100 keV. This is about 10 times greater than the amount needed for DT fusion. At the Naka Fusion Center in Japan, scientists set the world record for the hottest plasma in their advanced tokamak JT-60. This plasma reached 520,000,000 Kelvin, which corresponds to ion energies of 50 keV, showing that the energy requirements for helium-3 fusion are not so farfetched.

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Inertial Electrostatic Confinement

At the University of Wisconsin, researchers have developed a new small scale method of producing fusion. In electrostatic confinement, a small vacuum chamber is filled with gaseous fuel at a low pressure. An outer and inner grid are contained in the chamber and are charged such that there is a potential difference o 100kV between them. Ions oscillate in the center and reach very high energies, enough to force fusion upon collisiding with other nuclei.

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Electrostatic Confinement

Using deuterium and helium-3 fuels, scientists have shown successful fusion and generation of high energy protons on a small scale. The process would need to be greatly refined for energy production but has definitely been effective as a proof of concept.

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Helium-3

Helium-3 is an a one neutron isotope of helium that is formed as cosmic rays bombard Helium-4 that is produced naturally through fusion in the sun. Unfortunately the earth's atmosphere and magnetic field repel helium-3 and consequently there are very minimal quantities in existence on earth. Beside primordial deposits, small quantities of helium-3 can also be attained as products of tritium decay from fission reactors and nuclear weapons.

Although these deposits on earth provide us with a minimal amount of fuel to run small experiments with, another more abundant source of helium-3 would be needed for us to actually use helium-3 for energy

The moon

Without a repulsive atmosphere, the moon has accumulated large amounts of helium-3 on its surface. An interesting statistic is that the amount of energy stored in lunar helium is 10 times the amount of energy stored in all of the fossil fuels on earth. Because the lunar helium-3 exists in concentrations of 13 parts per billion in the lunar soil, a significant amount of refining would need to occur on the moon in order to extract the helium-3 and maximize the amount that could be returned to earth on each trip. When it is considered that the Saturn V rockets used in the Apollo program

could lift off with a payload of 50 tons, the notion of a bringing mining equipment to the moon does not seem completely unrealistic. In fact, the Chinese government has outlined plans to send astronauts to the moon to lay the groundwork for establishing mining colonies for helium-3. The plan is to have astronauts on the moon by 2009 and mining as early as 2015.

Outlook

Helium-3 fusion is definitely a far distance away and should best be considered as a second generation fuel, something that may be exploited after current methods for confinement have been refined to the commercial reactor level. Nevertheless, helium-3's benefits in terms of energy conversion and radioactivity are significant, and should be further explored. Clearly mining the moon is a crazy idea; however, the technology could be developed to make it a possibility. A great deal of capital would be required to get the ball rolling, but the value of helium-3 if it could be used for energy could be great enough to justify the expenditure.

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