science news OF THE WEEK

Atomic energy from fusion plus fission

'Thermonuclear fission' of boron may be a power source for the future

The world's future energy needs will be solved mainly by release and utilization of the binding energy of atomic nuclei or they are likely not to be solved at all. The energy can be released either by the fission of heavy elements (uranium, plutonium), which is already an operative possibility, or by the fusion of light ones. Fusion is still in the future, but the cycles on which most research is being done are deuterium fusing with deuterium or deuterium fusing with tritium.

Now a new fuel and a new cycle are proposed, which partake of the nature of both fusion and fission. It involves the fission of the common element boron and has been dubbed "thermonuclear fission." The proposal was presented last week at the meeting of the American Physical Society's Plasma Physics Division at Philadelphia by Thomas A. Weaver of the Lawrence Livermore Laboratory.

The new reaction is a fundamental departure from conventional concepts of fusion and fission. Generally the balance of energy within atomic nuclei is such that only fission of heavy nuclei and fusion of light ones yields energy. Fission of lightweight nuclei is generally difficult to achieve and costs energy. But there is an exception for nuclei that can divide themselves evenly into an integral number of helium nuclei (also called alpha particles).

The helium nucleus is a particularly tightly bound entity that appears as a kind of building block of heavier nuclei. When these helium building blocks are present in integral numbers with nothing left over, the fission of the larger nucleus can yield energy. It is this exception that Weaver and his collaborators suggest using.

The way to go about it is first to fuse nuclei of hydrogen and of boron-11, the most common form of boron. Lasers would be used to irradiate from all sides a small pellet containing a mixture of the two elements. The laser light would cause heating and an implosion in which the two elements would fuse. The fusion yields boron-12. The boron-12 would then fission, 99.9 percent of the time dividing evenly into three helium-4 nuclei. For the past year and a half physicists at LLL and the California Institute of Technology have been studying the characteristics of the reaction, using boron-11 samples and protons from an accelerator. Others in the work besides Weaver are Lowell L. Wood, who first proposed the use of this reaction, and G. B. Zimmerman, H. F. Lutz, I. D. Proctor and W. Bartolini at LLL and T. A. Tombrello and M. Dwarkanth at Caltech.

The proton fission of boron would be extremely clean of radioactive by-products, much cleaner than any other fission or fusion cycle now in use or proposed. Another advantage is that the energy is carried off by charged particles, making conversion to electric energy easier than for most other cycles, which tend to yield energetic neutrons.

The energy of the boron fission could be converted directly into electric currents by collecting the charged helium nuclei at electrodes or by magnetohydrodynamic (MHD) methods. The MHD method being considered would use a pulse of energy from the boron reaction to expand a preexisting magnetic field across an electrical conductor. The change in the field would cause a current to flow in the conductor. Energetic neutrons have to be trapped in a substance, which they heat. The heat is used to boil water to make electricity in a steam turbine.

There are other elements that are one proton shy of having an integral number of helium nuclei. They include nitrogen-15 (four heliums), lithium-7 (two heliums) and fluorine-19 (five heliums). But boron-11 was found to produce the highest net energy under reactor conditions.

It is likely to be many years before a boron reactor is operating. Weaver stresses the extreme technological difficulties involved in bringing the idea to fruition. One of the worst of them is the extremely high temperature necessary, 3 billion degrees, and the requirement of lasers 10 times as energetic (100,000 joules) as those now contemplated for fusion reactors using other cycles. Thus the boron cycle is likely to come into use later than the other proposed fusion cycles. But the cleanliness of the reaction and the abundance of its fuel (boron is plentiful in the oceans and in dry lake beds) may make it a desirable future alternative to them.

Lasers measure moon distances to 6 inches

"How high the moon?" asks a romantic song. Whatever the answer may mean to lovers, the exact height of the moon is a datum of great importance to science. The exact distance to the moon can be used to study continental drift, polar wandering, phenomena inside the earth and the mass distribution in the interior of the moon.

Now work with laser beams reflected off devices on the moon has succeeded in measuring variations in the earth-moon distance to an accuracy of 6 inches—the most accurate measurement ever. Work in the next year or so is expected to narrow the figure to about 1 inch. The measurements are the work of the Lunar Ranging Experiment (LURE) team, a group of scientists headed by James Faller of the National Bureau of Standards' Boulder laboratories.

The men in the moon, specifically those of Apollo 11, 14 and 15, placed arrays of corner reflectors at various points on the moon's surface. (Corner reflectors are shaped like cubes cut in half along the diagonal; they send light back in the direction it came.) Pulses of laser light sent through a telescope from earth are reflected back, and their flight is precisely timed. Since the roughly 235,000-mile distance to the moon varies, the experiment must be done repeatedly for a long time to gain a statistically significant picture of the moon's motions.

The pulses take about one and a quarter seconds to get to the moon. When the light beam arrives, it has spread to a diameter of two miles. By the time it gets back to earth it has spread to 10 miles. Only a billion-billionth of the light sent out comes back to the detector on earth, yet it is enough, but just barely, to activate a photoelectric mechanism that stops the clock. ☐

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