

Prospects of 'clean' nuclear fusion

Russian scientists have used a laser technique to induce nuclear fusion, which shows promise of energy without radioactive fallout, says S. Ananthanarayanan

Perhaps the only viable alternative in sight, to replace fossil fuels, is nuclear energy. Several countries, France a leader, have set up large scale nuclear programmes to generate electricity using nuclear fission, or the energy released when heavy atomic nuclei break up into simpler nuclei. But the future is really in the process of nuclear fusion, where two simple nuclei fuse, or join to form a heavier nucleus.

Fission

The classic path is to cause fission of the unstable form of the uranium nucleus. This nucleus breaks up into strontium and xenon + 3 neutrons (electrically neutral particles in the nucleus) or bromine and lanthanum and 2 neutrons and also releases huge energy that is stored in the original, unstable nucleus. This reaction takes place either spontaneously, from time to time, or can be made to occur, practically *on order*, if the nucleus is struck by a neutron. The fact that each fission of uranium, which can be the result of a neutron striking it, produces fresh neutrons is a happy feature that can be used for fissions to generate more fissions and huge energy can be produced through *chain reactions*.

While all the nuclear energy being produced in the world is by this or similar ways, the great problem is that the 'daughter' products are highly radioactive and remain dangerous for thousands of years once they are 'mass produced' in induced nuclear fission.

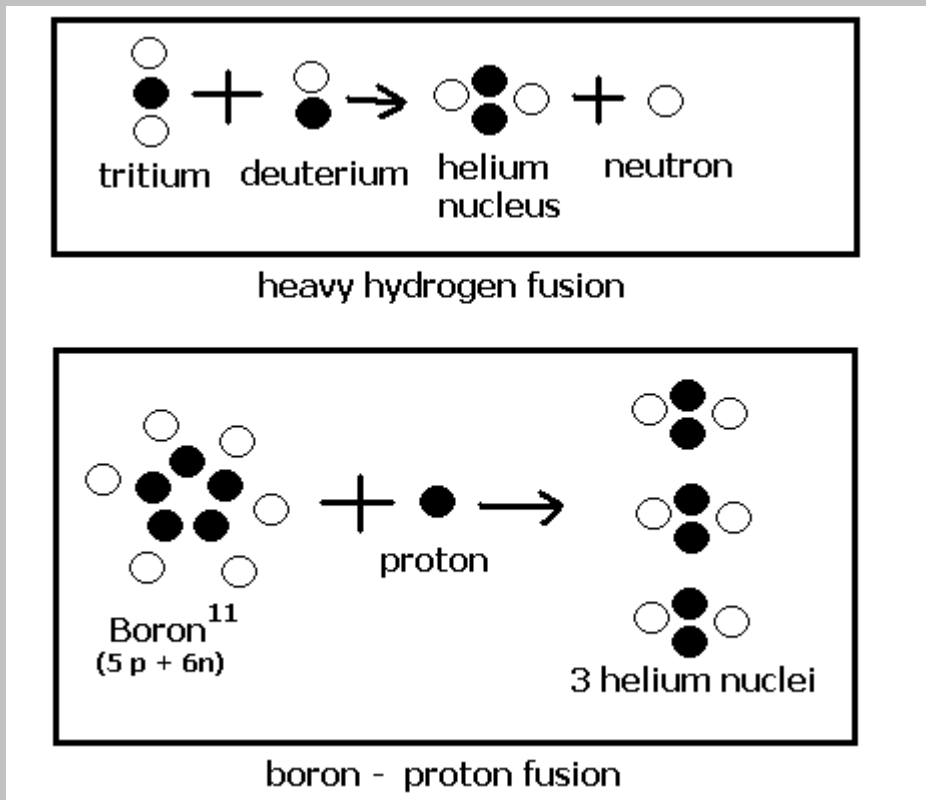
Fusion

An attractive alternative is to seek energy through the *fusion* of two heavy hydrogen nuclei, to form a helium nucleus. The helium nucleus turns out to be a very stable, low energy form of matter and the fusion to create helium is a source of great energy indeed. Heavy hydrogen is a form of hydrogen, which occurs naturally in about 150 parts in a million of ordinary hydrogen. With ample reserves of hydrogen available, in seawater, for instance, this reaction is a virtually inexhaustible energy source.

The problem is that great energy is required to set off the fusion reaction. Once started, the energy output is so large that it can continue on its own, but it still needs to be got going. One way is to use an atom bomb, based on the fission reaction, to start the fusion. This works for the hydrogen bomb, but is not suitable for controlled fusion for generating electricity. The popular method being worked on so far has been to confine fiery plasma, that is, free hydrogen nuclei, with the help of magnetic fields. The mix that works best is with 2 kinds of heavy hydrogen, which give off neutrons as they fuse to form helium nuclei. These neutrons strike the walls of the reactor and, again, create radioactive things

that are a problem in themselves. It is cleaner than fission, but still far from what would be the right thing.

An answer has been found to use not hydrogen nuclei but a mixture of boron nuclei, which have eleven particles and bare protons (these are like neutrons, but positively charged), to split up into 2 helium nuclei.. This reaction is far cleaner but the trouble now is that it needs a great deal more energy to kick off than the heavy hydrogen method. And this kind of energy is not readily there in the magnetic confinement technique.



The Russian method

What the Russian group has done is to use a laser to heat polythene pellets, which contain boron, to the billion-degree temperature that is required. This creates intensely hot plasma that lasts just a trillionth of a second. During this trillionth of a second, protons merge with boron atoms, which then decay into a stream of alpha particles, which are nothing but helium nuclei. It is possible to control the alpha radiation, which are charged particles, so that they do not escape to cause radioactive pollution. Another possibility is to use the stream of alpha particles as an electric current and directly generate electricity. The current method with fission is simply to heat a blanket of water and drive turbines, just like a coal-fired generator.

The Russian achievement of laser driven nuclear fusion is expected to be much easier to sustain than the method of the 'magnetic bottle', where heavy hydrogen nuclei combine to form helium nuclei, and is thought to have opened the door to "an ecologically pure technology of nuclear energy production".
