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How to build a star on Earth

Physicist Professor Brian Cox has looked at the different strategies now being pursued to make nuclear fusion a reality. His personal assessment is presented on the BBC's Horizon program.

" If a steady stream of mini-stars can be created, then a power station could be constructed "

Prof Brian Cox

" Nuclear fusion is nature's power source. From the Sun to the most distant stars, the energy that lights up the Universe is released by sticking hydrogen nuclei together to make helium.

Since hydrogen is the most abundant element in the Universe, it seems sensible to ask whether we might endeavor to do the same and power ourselves out of our serious energy crisis by building stars on Earth.

The problem of course is that stars are big and hot; the Sun is the size of a million Earths, and burns six hundred million tons of hydrogen fuel every second.

The temperature at its core is 15 million degrees, and this is barely enough to allow fusion to take place at anything other than a snail's pace.

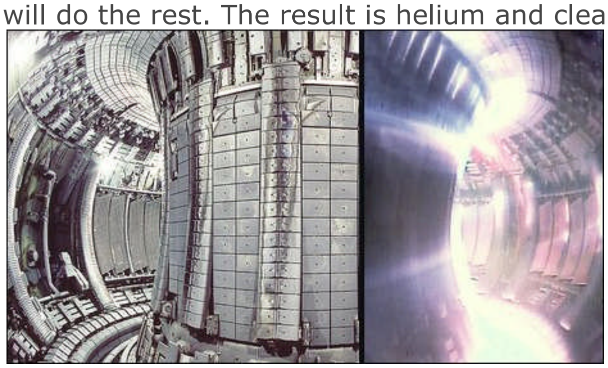
Despite the obvious difficulties, however, the UK has hosted a working nuclear fusion reactor in Oxfordshire for the last three decades.

Jet, the Joint European Torus, routinely heats a cocktail of different forms of hydrogen known as deuterium and tritium to well over one hundred million degrees and initiates nuclear fusion at a rate far in excess of that in the centre of the Sun.

Jet is too small to produce meaningful amounts of electricity, but it is a prototype for a much bigger and potentially commercial design called Iter, now under construction in southern France.

The Jet/Iter approach to fusion is to heat and contain a gas so hot that the electrons are stripped away from the atomic nuclei to form a lively and difficult to control sub-atomic soup known as a plasma.

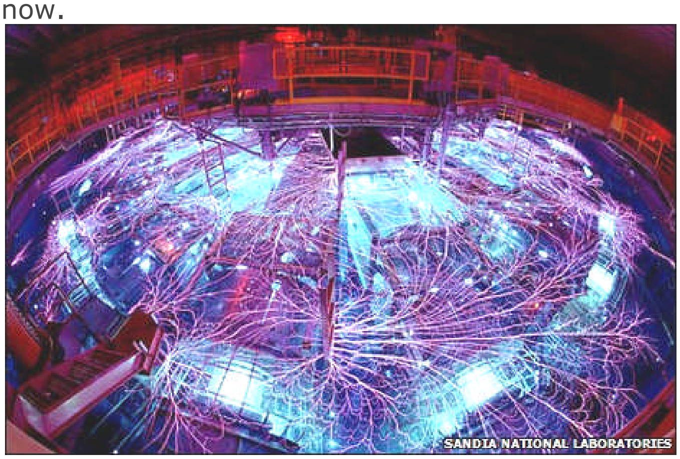
The plasma is held in an intense magnetic bottle so it never touches the walls of the reactor. If enough deuterium-tritium plasma can be held for long enough at a high enough temperature and pressure, Nature will do the rest. The result is helium and clean, abundant energy.



JET has already "bottled" a plasma in its tokomak container

In the US, a different approach known as inertial fusion is being perused at the National Ignition Facility (NIF) in California and the Z-Machine in New Mexico. If Iter is like a conventional power station burning

fuel for days or weeks at a time, the inertial projects share more in common with the combustion engine.
NIF blasts tiny pellets of deuterium-tritium fuel with a single 500-trillion-watt laser beam. This is a big number; about 1,000 times the power consumption of the United States.
This gargantuan short-lived laser pulse causes the fuel pellet to collapse and detonate, producing a mini-star for a fraction of a second.
The Z-machine takes a different approach, channeling half a trillion watts through a spider's web of hair-thin wires surrounding the fuel pellet. The result is much the same: a big crunch known as a Z-pinch and the birth of a star.
If a steady stream of mini-stars can be created, then a power station could be constructed. The Z-machine has already achieved fusion in a test run, and NIF hopes to follow in its footsteps in 2010. The challenge will then be to smooth the rough edges of the technology in order to mass-produce economically viable, reliable power stations.
This is no mean feat, but there seems to be no fundamental reason to doubt that it is possible.
When fusion is mentioned, a common reaction in some circles is to say, "It's always 30 years away, so let's not invest too heavily".
In fact, the fusion engineers of 2009 are speaking of building the final generation of experimental reactors now.



Z-machine: "...half a trillion Watts through a spider's web of hair-thin wires..."

If they succeed, Iter and her sisters should be capable of putting electricity on to the grid sometime in the early 2030s. This long-term and final solution to the energy crisis depends of course on sustained public investment at current or preferably significantly increased levels.
This is a challenge that I believe we must confront now, and not tomorrow. At some point in the future, we will generate our power by nuclear fusion; there is simply no other way to deliver the trillions of watts needed to make life comfortable for all the citizens of our planet.
To this statement nobody objects. The question is therefore not "if" but "when", and it is my view that the "30 years away" argument simply doesn't wash.
John F Kennedy used to tell a story about a French general who asked his gardener to plant a tree. "What's the rush?" replied the gardener. "It will take 30 years to grow."
The general looked him in the eye, and said in an urgent tone: "Thirty years? Then you had better plant it immediately." ”

Professor Brian Cox is affiliated to Manchester University's high energy physics group