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Figuring out the way to make really clean energy

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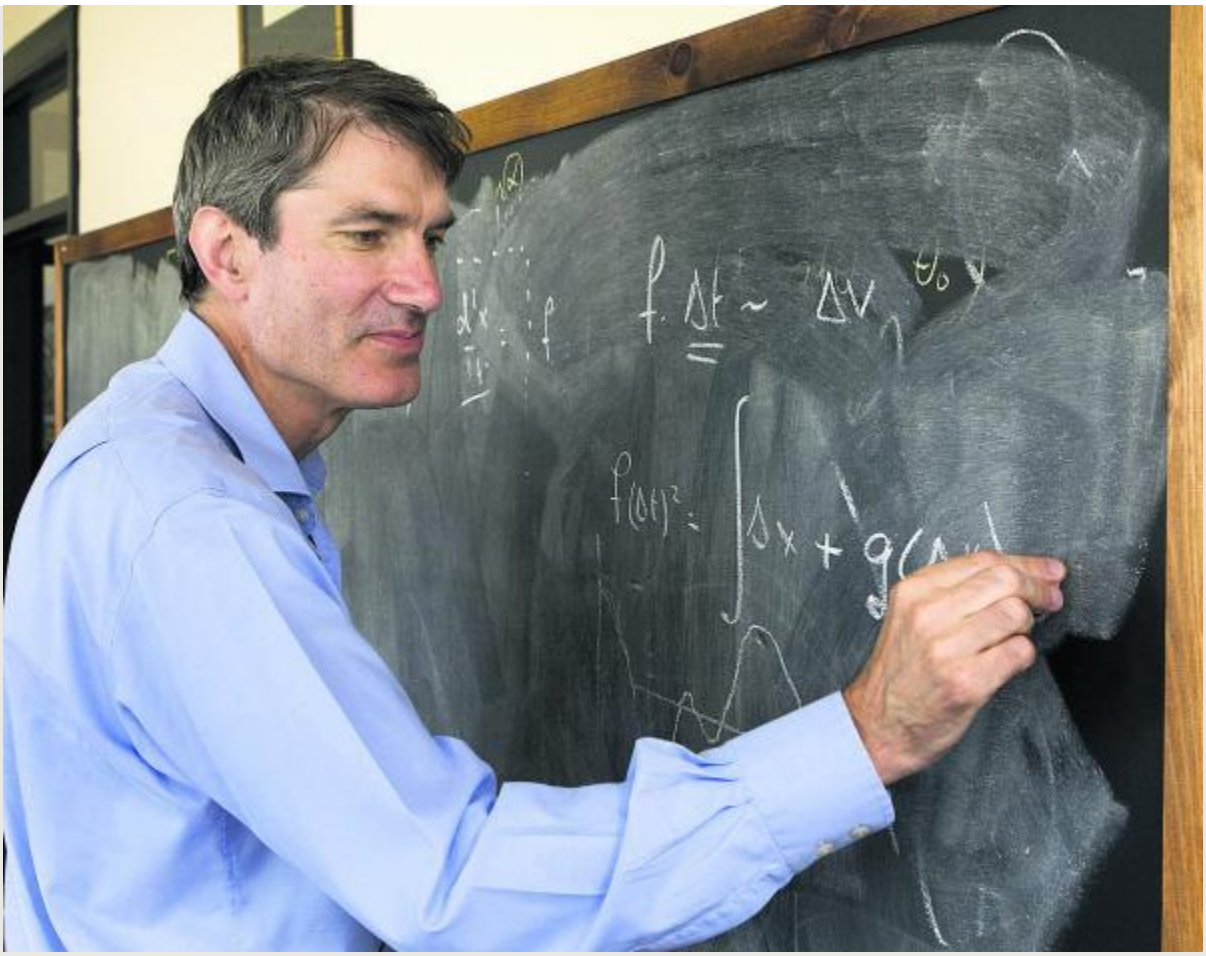


Project chief executive Prof Steve Cowley runs through some of the maths behind nuclear fusion

FOR years, scientists just down the road from Oxford have been quietly working at the forefront of a project that could change the world.

But fusion power is the best invention you have probably never heard of.

That may sound like a bold claim, but Prof Steve Cowley, chief executive officer of the Culham Centre for Fusion Energy, is convinced that it is the only solution to a fast-approacing world energy crisis.

He has been working at the science centre since 2008, but the project – the Joint European Torus (JET) – has been under way since 1982. Its aim: to create the conditions of a star on the Earth, producing clean, cheap energy for us to power our televisions, kettles and lightbulbs.

Prof Cowley said: “At the moment, we do not know how we are going to power the world for the duration of this century. But at Culham we are working on the solution – fusion could solve that problem.”

Work under way on the massive project at Culham in 1980.

By 2050, it is estimated the global population will have reached a staggering nine billion. And that could lead to our energy demands tripling as living standards get better.

This presents a problem, because at the moment most of our energy – 87 per cent in 2012, according to the Worldwatch Institute – comes from burning fossil fuels which produce large amounts of carbon dioxide.

There is now overwhelming scientific consensus that we are polluting the atmosphere and further contributing to man-made global warming. That could destroy wildlife habitats and cause more extreme weather patterns, including storms and flooding.

It is dramatic stuff. Yet Prof Cowley said fusion would be “the perfect way to make energy” and avert disaster at the same time. So why haven’t we done it yet? “Fusion is really hard to do. But that is also why it is so fascinating to work on.”

Some of the most groundbreaking work in the field is being done right in Oxford’s backyard, down at the Culham Science Centre.

But what is fusion? The name is short for “nuclear fusion” and it is the cousin of “nuclear fission”, already carried out in nuclear power plants across the country.

The difference between them is that, although fusion is proving much harder to master than fission, it is to many the Holy Grail in energy production.

Prof Cowley said: “It does not produce any significant waste, has no danger of catastrophic accidents and its fuel source” – the extremely common element hydrogen – “is readily available in sea water.”

Promisingly, scientists know what is required to make a fusion reaction. In fact, you just have to look at the sky to see the most famous fusion reactor in existence: The sun. (And every other star.) The Culham centre houses the world’s largest fusion research facility, the Joint European Torus (JET).

The JET project was first started to prove fusion was possible but now scientists working there are helping to fine-tune the techniques needed for the next stage in development: ITER, an internationally-backed project in France.

At the moment JET’s researchers are operating its reactor in 20-second bursts, about three times every hour.

Fernanda Rimini outside the reactor at Culham.

Morten Lennholm, a senior member of staff who first came to Culham in 1987, works in the control room. He said: “It is all about trying to find the best way to do things.

“That is not just important for JET, but for the future. We also run a lot of experiments for the people working on ITER.

“Various laboratories around Europe will get in touch and ask us to test something if they are unsure about a specific part of the designs and they need to check how it will actually work.”

At the moment it is hoped that ITER, which will be the first proper experimental fusion reactor, could be complete by the 2020s. If it works, it will lead to a full-scale fusion power plant being built in the early 2040s.

Prof Cowley is positive about the future of fusion. He said: “There will be a day when the world is powered by fusion. People here would like it to be during our lifetimes. There are still problems to overcome but none of them are impossible.

“There is no question about whether it is needed, with the problems that are yet to come from global warming. The real question is when we can finally crack it. It’s likely that the current generation will be the first to see fusion work. And when we learn how to do it, that will be something that humanity will then use for millions of years to come.”

- For more, see ccfe.ac.uk

How it works - on the Sun and Earth.

- **How fusion works in the Sun Nuclear fusion is when two hydrogen atoms join together and make a helium atom, releasing a large amount of energy in the process.**

  This is the reaction happening constantly at the heart of the sun, which fuses about 500 million tonnes of hydrogen into helium every second.

  Fusion produces huge amounts of energy, which in the sun's case is turned into light and heat that beams down onto the Earth.

  But to make it happen, you need an environment with a very high temperature and pressure.

  The sun uses its vast size and force of gravity to do this, by compressing all the hydrogen atoms at its core and squeezing them together.

  Its core temperature is 15,000,000C.

- **How fusion will work on Earth**

  On Earth, scientists have to figure out ways of making fusion happen without using too much energy to create the high temperatures and pressures needed.

  This is the main challenge that they face, because maintaining fusion conditions – a temperature of 100 to 200 million degrees Celsius – is difficult.

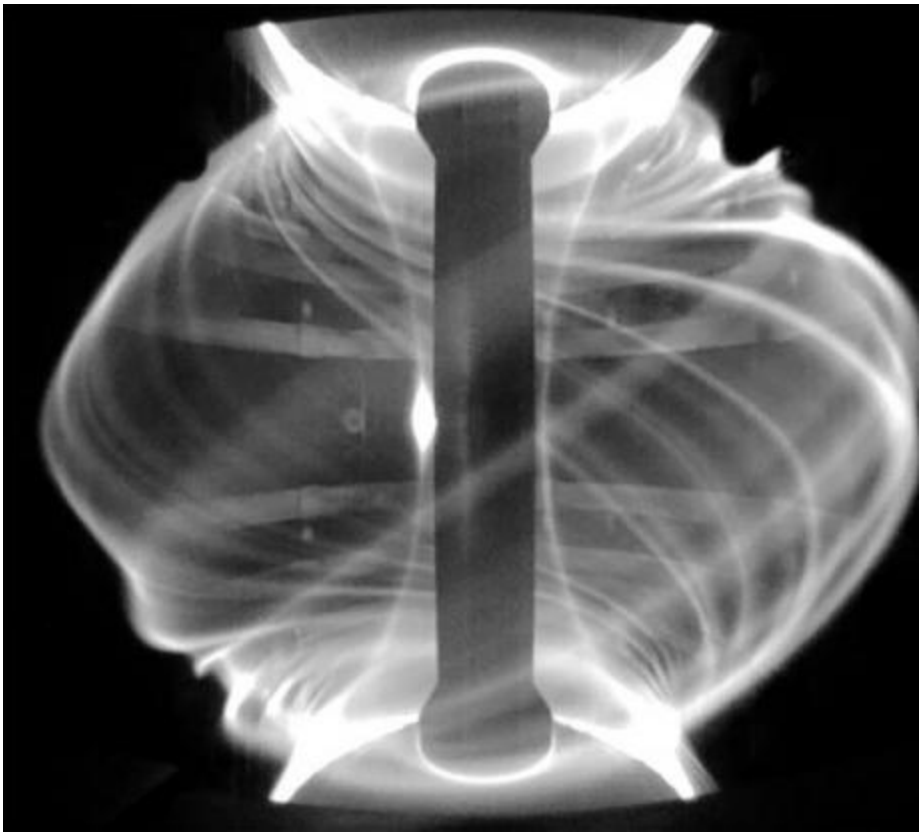
  At Culham, powerful magnets are used to confine the fuel. And different atomic versions of hydrogen, deuterium and tritium, are used because they are more energy-efficient.

  JET is a tokamak design – first built in Soviet Russia during the 1950s – capable of creating a "hot donut" of hydrogen plasma at its core.

  At the moment however, JET uses more energy than it produces.

  But scientists are confident that the ITER experiment in France, the £12bn successor project to JET, will produce 500 megawatts of power for hours at a time – but only need 50 megawatts to function.

That internationally-backed project is due to begin in the early 2020s and, if it works, will lead to a full-size fusion power plant being built in the early 2040s.



The 'donut' of plasma in which temperatures as hot as the sun are reached to create a sustainable, clean form of energy.

- **How does fusion compare?**

THE European Union estimates that to power a city of 100,000 people for a year you would need:

- **400,000 tonnes of coal**
- **250,000 tonnes of oil**
- **0.06 tonnes of fusion fuel**
- **What could we do with fusion power?**

FUSION power "offers the prospect of an almost inexhaustible source of energy for future generations" according to the World Nuclear Association.

Jet chief executive Prof Steve Cowley said: “It would be like another industrial revolution. Cheap energy would allow us to use robots that could help us and cars that can drive anywhere.

“Having more energy means you can generally have a more enjoyable lifestyle.”

Another exciting application of fusion is much more out there. In outer space, to be precise. America’s national space agency, NASA, is looking into using small-scale fusion reactors in its rockets.

It said: “If realised, it would not only enable manned interplanetary space travel, it would allow it to become commonplace.”