Researchers generate fusion at 100 million Kelvin for 20 seconds

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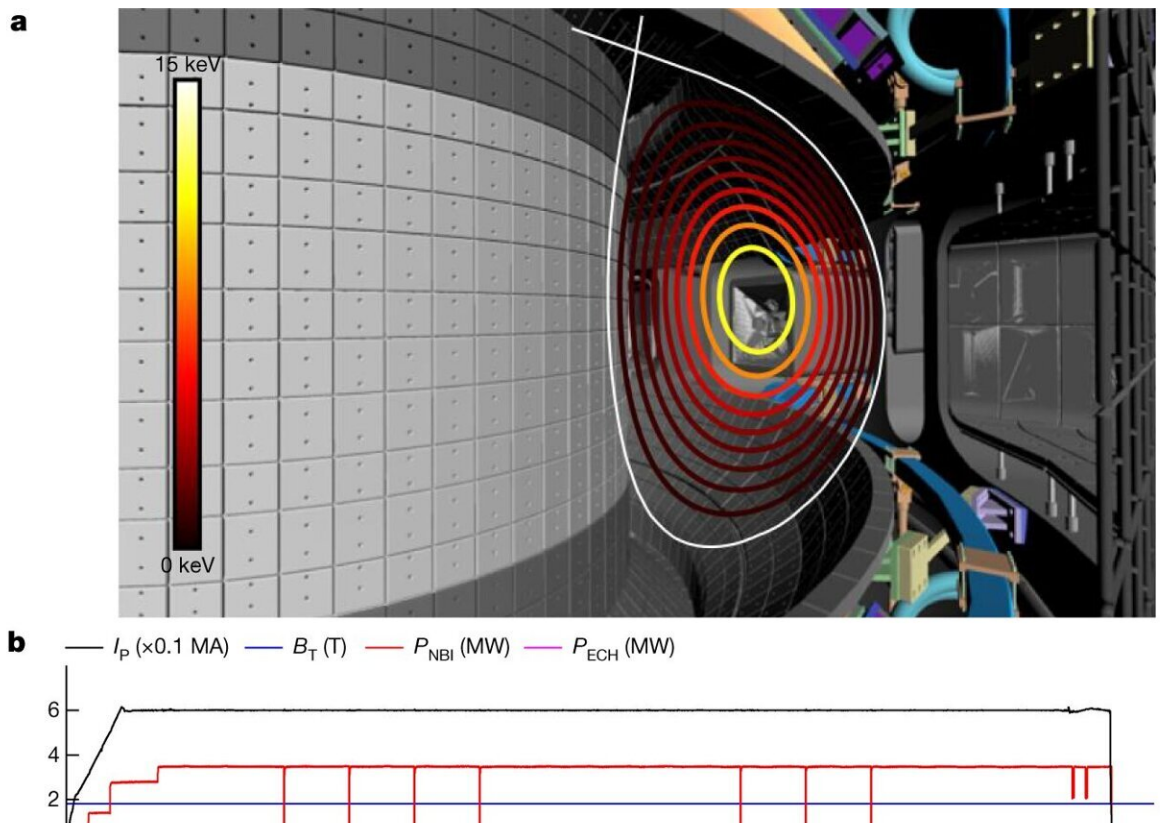

Tokamak geometry and the parameter evolution of a FIRE mode. a, The plasma configuration of a FIRE mode in KSTAR. The colour of the lines indicates the ion temperature in kiloelectronvolts, with 10 keV corresponding to ≈120 million kelvin. b–i, The time evolution of main physics and engineering parameters (shot 25860). b, The plasma current (I_p), toroidal magnetic field strength at the magnetic axis (BT), neutral beam injection power (P_{NBI}) and electron cyclotron resonance heating power (PECH). c, The energy confinement enhancement factors relative to the ITER89P and the IPB98(y,2) scaling law (H_{89} and H_{98y2})

and stored plasma energy (W_{MHD}). d, The line-averaged electron density (n_e) and line-averaged fast-ion density from NUBEAM calculations (n_{fast}). e, The central ion and electron temperature ($T_{i,0}$ and $T_{e,0}$). f, The D_α emission intensity. g, The loop voltage. h, The internal inductance (l_i), normalized beta (β_N) and the magnetic fluctuations detected by Mirnov coils. i, The carbon line radiation intensity from $C^{2+\rightarrow3+}$. Credit: *Nature* (2022). DOI: 10.1038/s41586-022-05008-1

A team of researchers affiliated with multiple institutions in South Korea working with two colleagues from Princeton University and one from Columbia University has achieved a new milestone in the development of fusion as an energy source—they generated a reaction that produced temperatures of 100 million Kelvin and lasted for 20 seconds. In their paper published in journal *Nature*, the group describes their work and where they plan to take it in the next few years.

For the past several years, scientists have been trying to create sustainable fusion reactions inside power plants as a means of generating heat for conversion to electricity. Despite significant progress, the main goal has still not been met. Scientists working on the problem have found it difficult to control fusion reactions—the slightest deviations lead to instabilities that prevent the reaction from continuing. The biggest problem is dealing with the heat that is generated, which is in the millions of degrees. Materials could not hold plasma that hot, of course, so it is levitated with magnets.

Two approaches have been devised: One is called an edge-transport barrier—it shapes the plasma in a way that prevents it from escaping. The other approach is called an internal transport barrier, and it is the kind used by the researchers working at Korea's Superconducting Tokamak Advanced Research Center, the site of the new research. It works by creating an area of high pressure near the center of the plasma to keep it under control.

The researchers note that use of the internal transport barrier results in much denser plasma than the other approach, and that is why they chose to use it. A higher density, they note, makes it easier to generate higher temperatures near the core. It also leads to lower temperatures near the edges of the plasma, which is easier on the equipment used for containment.

In this latest test at the facility, the team was able to generate heat up to 100 million Kelvin and to keep the reaction going for 20 seconds. Other teams have either generated similar temperatures or have kept their reactions going for a similar amount of time, but this is the first time both have been achieved in one reaction.

The researchers next plan to retrofit their facility to make use of what they learned over the past several years of research, replacing some components, such as carbon elements on the chamber walls with new ones made of tungsten, for example.

More information: H. Han et al, A sustained high-temperature fusion plasma regime facilitated by fast ions, *Nature* (2022). DOI: 10.1038/s41586-022-05008-1