Extinguishing a fusion fire in a flash of light

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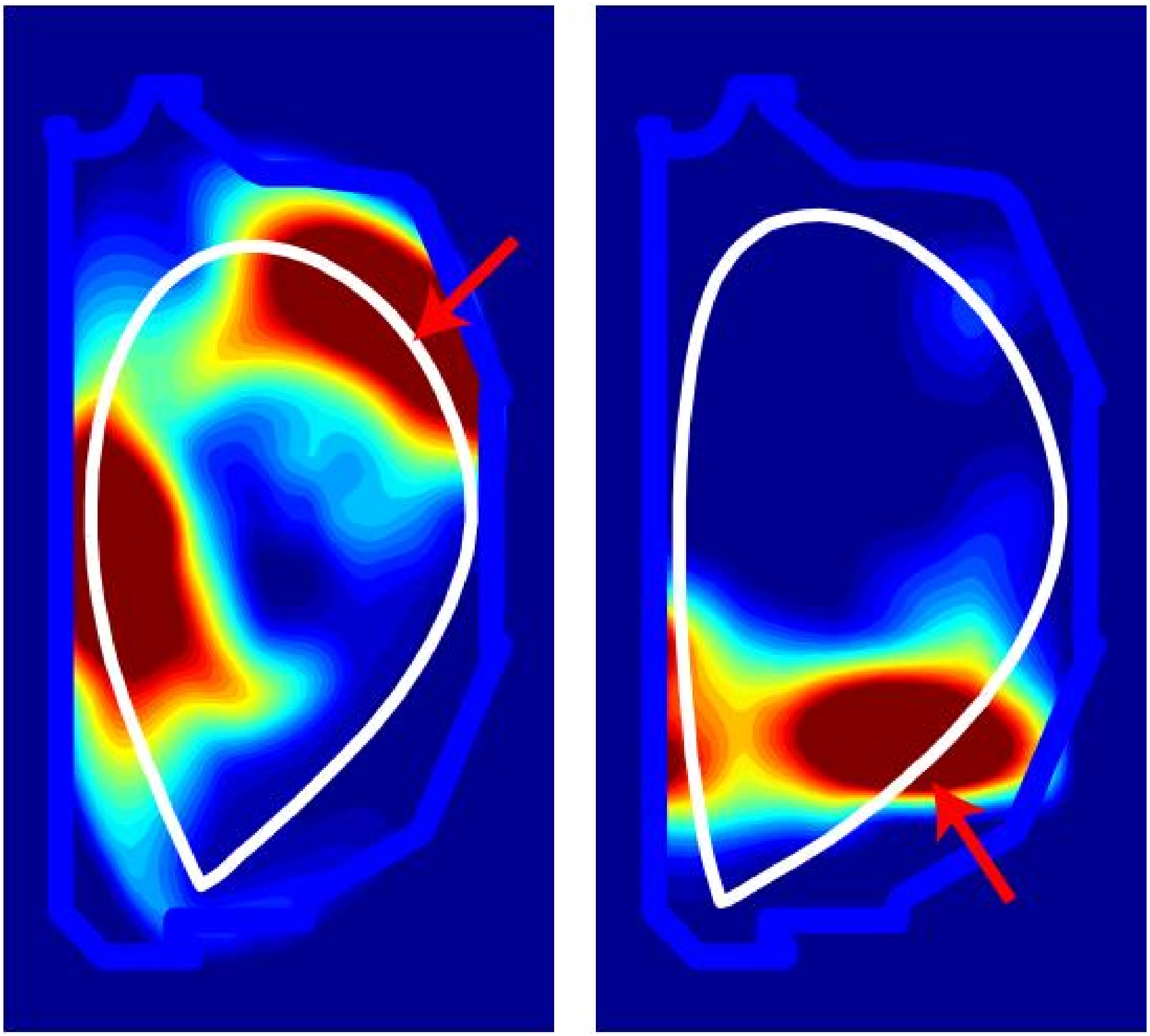

Comparison of experimentally measuredradiated power emission patterns inside theDIII-D tokamak with upper gas injection (left)and lower gas injection (right). Arrowsindicates gas valve locations, the whiteborder represents the plasma boundary, and the light blue border shows the vacuumvessel. Red coloring indicates the strongestemission, blue weakest. Credit: General Atomics

Fusion energy researchers have discovered that they can rapidly extinguish and cool a magnetically confined fusion plasma hotter than the center of the sun by injecting a large quantity of neon gas to prevent damage to fusion-energy devices when there is a loss of plasma equilibrium.

"We have to quickly cool a 100-million degree gas undergoing fusion in roughly 1/1000 of a second," said General Atomics scientist Nicholas Eidietis, "So when you have to shut down a fusion plasma that fast you have to be very careful of where all that energy is going to go."

Extinguishing these fusion fires converts the plasma heat into an intense flash of light. Ideally, this intense flash uniformly illuminates the interior wall of the fusion device to avoid focusing too much energy on any one location, where it could cause damage. It's the difference between a 50-watt light bulb and a 50-watt laser: Both produce the same amount of power, but only one will melt metal and damage the fusion reactor.The complicated physics of how the neon gas is injected from localized valves and spreads around inside the plasma, how the plasma heats the neon, and how the neon sheds the heat as light has recently been modeled by a team working at the DIII-D National Fusion Facility in San Diego.

"This modeling is essential to help us understand what we are seeing in present fusion experiments so that we can confidently predict how a thermal quench will occur in ITER," said Val Izzo of University of California-San Diego (UCSD), who, along with Eidietis, led the team of UCSD and General Atomics researchers. Their results will be presented at the 58th annual conference of the American Physical Society Division of Plasma Physics, Oct. 31-Nov. 4.

The physics models simulate the complex interaction of the fusion plasma and injected neon gas in the DIII-D tokamak experiment. A controlled rapid cooling of the plasma is most likely to be needed if there is a loss of equilibrium caused by the growth of unwanted helical bundles of magnetic field called islands. In DIII-D experiments, pre-existing islands do not appear to impede the overall effectiveness of plasma cooling, but simulations indicate that details of the relative position between the island and the injection location might still affect the spreading of the neon. One of the most important findings of the simulations is that the neon spreading speeds up when the original island breaks up into a series of smaller islands.

In experiments researchers also showed that neon spreads more uniformly when it's introduced near the top of the device (left figure) instead of the bottom (right figure), increasing the desired uniformity of plasma cooling.

These experiments and modeling efforts address a critical issue for protecting machine components from damage when magnetic instabilities arise in future large tokamaks such as ITER, which is now being built in France to demonstrate the feasibility of fusion as a new source of clean and virtually unlimited energy.

More information: meetings.aps.org/Meeting/DPP16/Session/YI2.1

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