



Fusion Power Breakthrough: New Method for Eliminating Damaging Heat Bursts in Toroidal Tokamaks

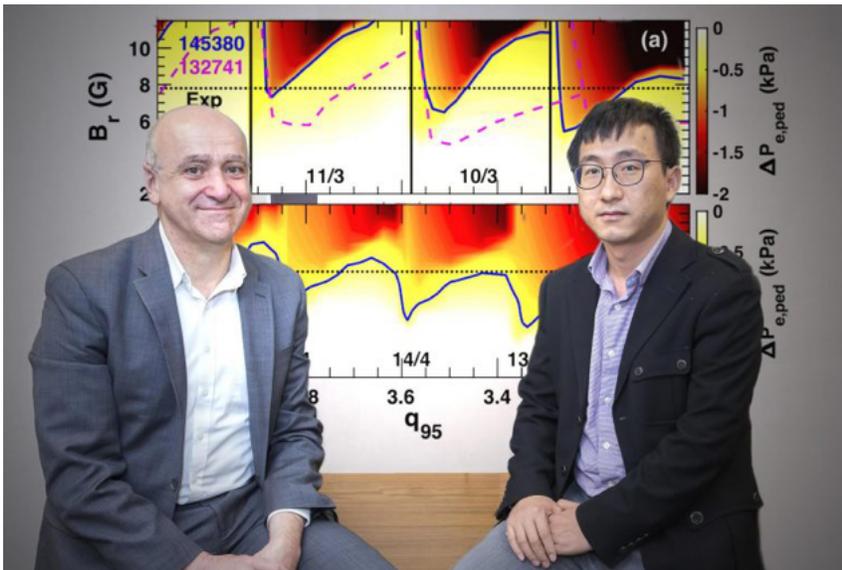
TOPICS: DOE Fusion Energy Popular

Princeton Plasma Physics Laboratory

By PRINCETON PLASMA PHYSICS LABORATORY AUGUST 28, 2020

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Physicists Raffi Nazikian and Qiming Hu with figure from research behind them. Credit: Elle Starkman/PPPL Office of Communications

Picture an airplane that can only climb to one or two altitudes after taking off. That limitation would be similar to the plight facing scientists who seek to avoid instabilities that restrict the path to clean, safe, and abundant fusion energy in doughnut-shaped tokamak facilities. Researchers at the U.S. Department of Energy’s (DOE) Princeton Plasma Physics Laboratory (PPPL) and General Atomics (GA) have now published a breakthrough explanation of this tokamak restriction and how it may be overcome.

Toroidal, or doughnut-shaped, tokamaks are prone to intense bursts of heat and particles, called edge localized modes (ELMs). These ELMs can damage the reactor walls and must be controlled to develop reliable fusion power. Fortunately, scientists have learned to tame these ELMs by applying spiraling rippled magnetic fields to the surface of the plasma that fuels fusion reactions. However, the taming of ELMs requires very specific conditions that limit the

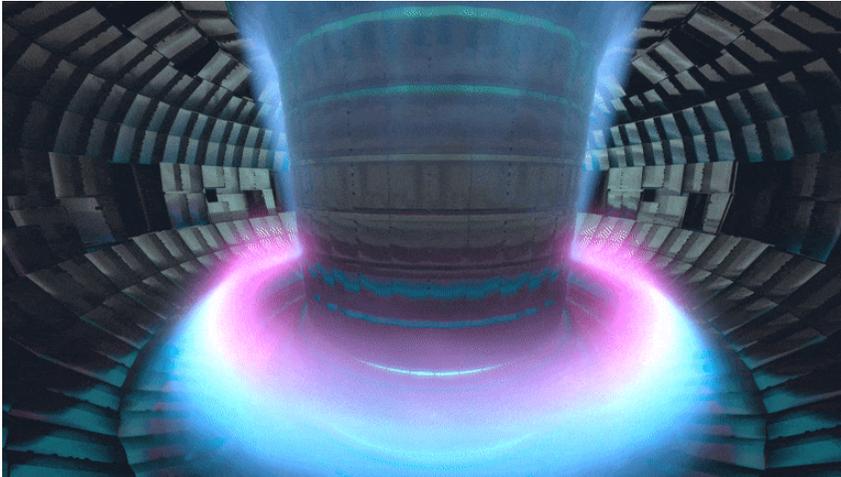


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operational flexibility of tokamak reactors.



In a fusion reactor, the hydrogen is heated until it becomes a cloud-like ionized plasma. Credit: ITER

ELM suppression

Now, researchers at PPPL and GA have developed a model that, for the first time, accurately reproduces the conditions for ELM suppression in the DIII-D National Fusion Facility that GA operates for DOE. The model predicts the conditions under which ELM suppression should extend over a wider range of operating conditions in the tokamak than previously thought possible. The work presents important predictions for how to optimize the effectiveness of ELM suppression in ITER, the massive international fusion device under construction in the south of France to demonstrate the feasibility of fusion power.

Fusion, the power that drives the sun and stars, combines light elements in the form of plasma — the hot, charged state of matter composed of free electrons and atomic nuclei that makes up 99 percent of the visible universe — to generate massive amounts of energy. Tokamaks are the most

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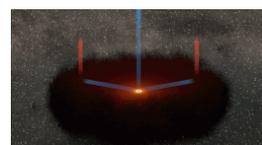
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widely used devices by scientists seeking to replicate fusion as a renewable, carbon-free source of virtually limitless energy for generating electricity.

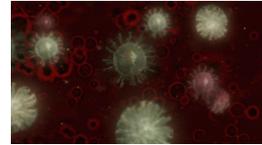
PPPL physicists Qiming Hu and Raffi Nazikian are the lead authors of a paper describing the model in *Physical Review Letters*. They note that under normal conditions the rippled magnetic field can only suppress ELMs for very precise values of the plasma current that produces the magnetic fields that confine the plasma. This creates a problem because tokamak reactors must operate over a wide range of plasma current to explore and optimize the conditions required to generate fusion power.

Modifying magnetic ripples

The authors show how, by modifying the structure of the helical magnetic ripples applied to the plasma, ELMs should be eliminated over a wider range of plasma current with improved generation of fusion power. Hu said he believes the findings could provide ITER with the wide operational flexibility it will need to demonstrate the practicality of fusion energy. “This model could have significant implications for suppressing ELMs in ITER,” he said.

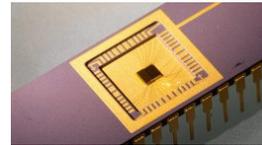
Indeed, “What we have done is to accurately predict when we can achieve ELM suppression over wider ranges of the plasma current,” said Nazikian, who oversees PPPL research on tokamaks. “By trying to understand some strange results we saw on DIII-D, we figured out the key physics that controls the range of ELM suppression that can be achieved using these helically rippled magnetic fields. We then went back and figured out a method that could produce wider operational windows of ELM

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suppression more routinely in DIII-D and ITER.”

Enhanced tokamak operation

The findings open the door to enhanced tokamak operation. “This work describes a path to expand the operational space for controlling edge instability in tokamaks by modifying the structure of the ripples,” said Carlos Paz-Soldan, a GA scientist and a co-author of the paper. “We look forward to testing these predictions with our upgraded field coils that are planned for DIII-D in a few years’ time.”

Returning to the aircraft analogy, “If you could fly at only one or two different altitudes, travel would be very limited,” said PPPL physicist Brian Grierson, a co-author of the paper. “Fixing the restriction would enable the plane to fly over a wide range of altitudes in order to optimize its flight path and fulfill its mission.” In the same way, the present paper lays out an approach that is predicted to expand the capabilities of fusion reactors to operate free from ELMs that can damage the facilities and hinder the development of tokamaks for fusion energy.

Reference: “Wide Operational Windows of Edge-Localized Mode Suppression by Resonant Magnetic Perturbations in the DIII-D Tokamak” by Q. M. Hu, R. Nazikian, B. A. Grierson, N. C. Logan, D. M. Orlov, C. Paz-Soldan and Q. Yu, 23 July 2020, *Physical Review Letters*.

DOI: [10.1103/PhysRevLett.125.045001](https://doi.org/10.1103/PhysRevLett.125.045001)

Support for this research comes from the DOE Office of Science. Collaborators include researchers at the University of California, San Diego, and the Max Planck Institute for Plasma Physics. Part of the data

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analysis was performed using the OMFIT integrated modeling framework developed by GA scientists.



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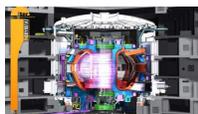
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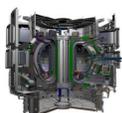
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ON "FUSION POWER BREAKTHROUGH: NEW METHOD FOR ELIMINATING DAMAGING HEAT BURSTS IN TOROIDAL TOKAMAKS"



David | August 28, 2020 at 7:16 pm |
Reply

You watch

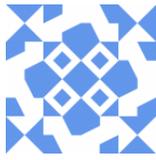
This type of energy system will become archaic and obsolete.

There is an energy system coming very soon that will put every sort of energy system to shame,



rassalas | August 29, 2020 at
6:48 am | Reply

Yes, Its called Fusion. Read a book or two please, improve your reading comprehension, spare us the pontifications.



Giuseppe Aprile | August 28, 2020 at 10:37 pm | Reply

Io mi sono fatto una ragione che nel 2025 ci sarà l'ala prima accensione



Aliyu | August 29, 2020 at 12:40 am | Reply

Gradual inadequate energy would become history.



Richard M France | August 29, 2020 at 1:40 am | Reply

For each & every complex FUSION problem; there's an equal Solution when thinking outside the box. Reality is that box.



rassalas | August 29, 2020 at 6:50 am | Reply

The word is spelled Fusion. Your education was a box, and you spent too much time outside of the box.



dan | August 29, 2020 at 7:43 am | Reply

“too much time”

u speld 'two' rong; fiks dat plees.



David's brother | August 29, 2020 at 3:27 am | Reply

David is about to introduce an energy system fuelled by his farts. Watch out, world



David's brothers mate | August 29, 2020 at 6:06 am | Reply

👏👏👏 David's brother hit the nail on the head! 🌊🌊🌊🌊🌊



dan | August 29, 2020 at 7:51 am | Reply

If there is a solution to the fusion conundrum, it will come a whole lot faster if they build geometrically and magnetically *reconfigurable* tokamaks, and pair them up with (exascale) supercomputers that can model phenomena and adjust the machine and test again:

test, model, reconfigure, test, model... etc.

It sounds like the sort of project that Elon

Musk would jump into. They can't keep building tokomak after tokomak, each one fixed in design, just to address problems in a piecemeal fashion. They should drop the ITER project and re-start along the lines I've just outlined.



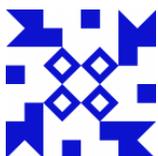
James | August 30, 2020 at 1:10 am | Reply

You have no idea how complex these machines and the physics involved are. You can't just reconfigure this. You could use computer models for it, but the actual reactor is such a precise piece of equipment that it's impossible with current technology.



dTony | August 29, 2020 at 11:35 am | Reply

Might MIT apply this to their ARC-SParc design tokomak?



Vernon Brechin | August 29, 2020 at 5:12 pm | Reply

This article, along with most popular articles

regarding fusion energy breakthroughs, was primarily promotional in nature. The journalist made no effort to include any input from those who have skepticism regarding the positive proclamations. The decision, to go ahead in building the enormously expensive ITER was made well before numerous plasma instabilities problems had been addressed. Any researcher can find references to plasma instability breakthroughs that go back for many decades. In the National Ignition Facility (NIF) its instability problems were never resolved and it is now expected to never achieve a break-even fusion reaction. Most fans of fusion power production have never encountered the following critical analysis.

ITER is a showcase ... for the drawbacks of fusion energy

<https://thebulletin.org/2018/02/iter-is-a-showcase-for-the-drawbacks-of-fusion-energy>



Gary Hill | August 29, 2020 at 9:31 pm
| Reply

The emperor has no clothes. Or, to spell it out, 2.71 MeV neutrons that you somehow siphon out of your magnetic confinement, and slam into a Li blanket that absorbs

them, then heats the substrate so you can transfer heat into water/steam pipes and spin turbines to then generate electricity, ain't gonna be clean, and has significant technical developments beyond the vaunted physics of plasma energy pumping and confinement to work out if it's ever gonna work. Basically, if you ask me, all of the proponents are charlatans selling you a shell game.



John Wass | August 29, 2020 at 11:27 pm | Reply

If fusion power is ever achieved it will be too expensive because of the high building cost. Much cheaper to have wind and solar backed up by energy storage.



xABBAAA | August 30, 2020 at 1:42 am | Reply

... Cool, how long to the happy outcome?



Andrew | August 30, 2020 at 6:19 am | Reply

Check out the laser containment system that

the University of New South Wales / Physics department have created that can contain a plasma reaction without the need for ridiculous strong magnetic fields and expensive tokomak reactors. Lasers are the way forward for fusion power and Australian talent has proved this works!



Roy Felix | August 30, 2020 at 8:24 am
| Reply

Perhaps the ELM's are a natural result of fusion. In the natural fusion reactor (sun), perhaps they are evidenced as mass coronal ejections, or just sun spots. That might infer a serious obstacle to taming the process.



Nathan | August 30, 2020 at 7:24 pm |
Reply

Use this tech and make it using nanoparticles so it's mini. I'm noob but it sounds like a good idea. Nonphysicist signing off.



Robert Alexander Drummond IV |
August 31, 2020 at 3:37 am | Reply

The media campaign against Bill Gates is not coincidental. There are literally 100's of conspiracy theories against Bill Gates, ranging from

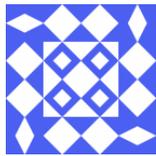
“His wife is Satan worshiper who eat's children” to “Gates Foundation vaccines aims to depopulate the planet by killing off the people who take them.”

These conspiracies were orchestrated and propagated by the Trump Administration and the NSA, so people would be so disgusted with Gates that they would not be interested in how his advanced wave reactor technology could eliminate America's Dependency on fossil fuels by 75%. In addition to demonizing Gates by the NSA, Trump launched a public “all-out” (phony) trade war with China to stop Gates from successfully completing a reactor on Chinese soil, proving his reactor technology works.

The USD is also known around the world as the “Petrol Dollar”, more the 50% of the value of the greenback comes from fossil fuel related industries. Gates wave reactor technology directly poses a substantial threat to the fossil fuel industry(s). His technology would cause the U.S. Dollar to plummet, causing a severe National Security Threat to the United States and a worldwide economic catastrophe.

The Netflix documentary, “Inside Bill's

Brain” was released to the public on 20SEPT2019. Bill Gates discussed his “TerraPower” Project that can create energy from depleted uranium. The world has enough depleted uranium to supply the entire globe with power for the next 50-75 years, without the risk of a “melt-down”. Gate’s TerraPower project was purposely sabotaged by the global strategic effort. After China learned why Trump was escalating tensions, they were in panic mode because their economy is also heavily tied to fossil fuels, then COVID-19 conveniently was released.



Glen | August 31, 2020 at 6:54 am | Reply

Now combine the twisting magnetic fields with twisting harmonics. Should work alright. Getting there people’s.



Bill Simpson | September 3, 2020 at 10:09 am | Reply

Even if they can make fusion work continuously, which is a big if, I doubt the electricity will be cheap enough to ever afford. Even a huge amount of extremely expensive electricity is useless. See a lot of

fission plants being built today? Those suckers are powerful.

Solar and wind are the way to go. Use them to produce hydrogen and electricity. Use the electricity in real time, and the surplus during the day and windy periods to make hydrogen for fuel cells.

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