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Research Led by PPPL Provides Reassurance That Heat Flux Will Be Manageable in ITER

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Credit: ITER

Fish-eye view of ITER construction with tokamak site in center.

A major issue facing ITER, the international tokamak under construction in France that will be the first magnetic fusion device to produce net energy, is whether the crucial divertor plates that will exhaust waste heat from the device can withstand the high heat flux, or load, that will strike them. Alarming projections extrapolated from existing tokamaks suggest that the heat flux could be so narrow and concentrated as to damage the tungsten divertor plates in the seven-story, 23,000 ton tokamak and require frequent and costly repairs. This flux could be comparable to the heat load experienced by spacecraft re-entering Earth's atmosphere.

New findings of an international team led by physicist C.S. Chang of the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory (PPPL) paint a more positive picture. Results of the collaboration, which has spent two years simulating the heat flux, indicate that the width could be well within the capacity of the divertor plates to tolerate.

Good news for ITER

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"This could be very good news for ITER," Chang said of the findings, published in August in the journal *Nuclear Fusion*. "This indicates that ITER can produce 10 times more power than it consumes, as planned, without damaging the divertor plates prematurely."

At ITER, spokesperson Laban Coblentz, said the simulations were of great interest and highly relevant to the ITER project. He said ITER would be keen to see experimental benchmarking, performed for example by the Joint European Torus (JET) at the Culham Centre for Fusion Energy in the United Kingdom, to strengthen confidence in the simulation results.

Chang's team used the highly sophisticated XGC1 plasma turbulence computer simulation code developed at PPPL to create the new estimate. The simulation projected a width of 6 millimeters for the heat flux in ITER when measured in a standardized way among tokamaks, far greater than the less-than 1 millimeter width projected through use of experimental data.

Deriving projections of narrow width from experimental data were researchers at major worldwide facilities. In the United States, these tokamaks were the National Spherical Torus Experiment before its upgrade at PPPL; the Alcator C-Mod facility at MIT, which ceased operations at the end of 2016; and the DIII-D National Fusion Facility that General Atomics operates for the DOE in San Diego.

Widely different conditions

The discrepancy between the experimental projections and simulation predictions, said Chang, stems from the fact that conditions inside ITER will be too different from those in existing tokamaks for the empirical predictions to be valid. Key differences include the behavior of plasma particles within today's machines compared with the expected behavior of particles in ITER. For example, while ions contribute significantly to the heat width in the three U.S. machines, turbulent electrons will play a greater role in ITER, rendering extrapolations unreliable.

Chang's team used basic physics principles, rather than empirical projections based on the data from existing machines, to derive the simulated wider prediction. The team first tested whether the code could predict the heat flux width produced in experiments on the U.S. tokamaks, and found the predictions to be valid.

Researchers then used the code to project the width of the heat flux in an estimated model of ITER edge plasma. The simulation predicted the greater heat-flux width that will be sustainable within the current ITER design.

Supercomputers enabled simulation

Supercomputers made this simulation possible. Validating the code on the existing tokamaks and producing the findings took some 300 million core hours on Titan and Cori, two of the most powerful U.S. supercomputers, housed at the DOE's Oak Ridge Leadership Computing Facility and the National Energy Research Scientific Computing Center, respectively. A core hour is one processor, or core, running for one hour.

Researchers from eight U.S. and European institutions collaborated on this research. In addition to PPPL, the institutions included ITER, the Culham Centre for Fusion Energy, the Institute of Atomic and Subatomic Physics at the Technical University of Vienna, General Atomics, MIT, Oak Ridge National Laboratory and Lawrence Livermore National Laboratory.

Support for this work comes from the DOE Office of Science Offices of Fusion Energy Sciences and Office of Advanced Scientific Computing Research.

PPPL, on Princeton University's Forrestal Campus in Plainsboro, N.J., is devoted to creating new knowledge about the physics of plasmas — ultra-hot, charged gases — and to developing practical solutions for the creation of fusion energy. The Laboratory is managed by the University for the U.S. Department of Energy's Office of Science, which is the largest single supporter of basic research in the physical sciences in the United States, and is working to address some of the most pressing challenges of our time. For more information, please visit science.energy.gov (http://science.energy.gov/).

Iter (/search/advanced/?search[tag]=Iter), Divertor plate (/search/advanced/?search[tag]=Divertor plate), Heat flux (/search/advanced/?search[tag]=Heat flux), Fusion (/search/advanced/?search[tag]=Fusion), Computer Simulation (/search/advanced/?search[tag]=Computer Simulation)

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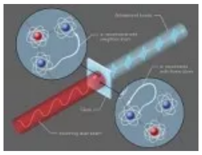

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A Potential New and Easy Way to Make Attosecond Laser Pulses: Focus a Laser on Ordinary Glass (/articles/view/681997/?sc=c57)

Scientists from the Stanford PULSE Institute at the Department of Energy's SLAC National Accelerator Laboratory have found a potential new way to make attosecond laser pulses using ordinary glass - in this case, the cover slip from a microscope slide.

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Small Scale Energy Harvesters Show Large Scale Impact (/articles/view/681917/?sc=c57)

Nano-scale modeling of piezoelectric energy harvester offers a new nano-scale sensor design and demonstrates important design elements for efficient implementation.

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New Study Finds Expected Savings from School Energy Efficiency Upgrade Outpace Actual Returns (/articles/view/681901/?sc=c57)

Students returning to school this Fall may not think much about the significant amount of energy it takes to keep the lights on and their classroom smartboards operating, but principals, superintendents, and building managers are taking note. According to the EPA, schools nationwide spend $8 billion a year on energy - second only to personnel in K-12 operating budgets.

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Turbocharging Engine Design (/articles/view/681097/?sc=c57)

Researchers at the Department of Energy's (DOE) Argonne National Laboratory have moved the development process into the passing lane. For the first time, Argonne's scientists and engineers pinpointed engine designs for a given fuel using the Mira supercomputer at the heart of the Argonne Leadership Computing Facility (ALCF), a DOE Office of Science User Facility.

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Researchers Develop a Way to Better Predict Corrosion from Crude Oil (/articles/view/681744/?sc=c57)

Using X-ray techniques, scientists are developing an analysis tool that can more accurately predict how sulfur compounds in a batch of crude oil might corrode equipment- an important safety issue for the oil industry.

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IceCube Helps Demystify Strange Radio Bursts From Deep Space (/articles/view/681732/?sc=c57)

A University of Wisconsin-Madison physicist and his colleagues are turning IceCube, the world's most sensitive neutrino telescope, to the task of helping demystify powerful pulses of radio energy generated up to billions of light-years from Earth.

Nanoparticle Supersoap Creates 'Bijel' With Potential as Sculptable Fluid (/articles/view/681671/?sc=c57)

A new type of "bijel" created by Berkeley Lab scientists could one day lead to applications in soft robotics, liquid circuitry, and energy conversion.

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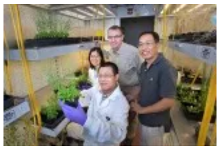

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With Extra Sugar, Leaves Get Fat Too (/articles/view/681684/?sc=c57)

Eat too much without exercising and you'll probably put on a few pounds. As it turns out, plant leaves do something similar. In a new study at the U.S. Department of Energy's Brookhaven National Laboratory, scientists show that retaining sugars in plant leaves can make them get fat too. In plants, this extra fat accumulation could be a good thing.

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High-Speed Movie Aids Scientists Who Design Glowing Molecules (/articles/view/681576/?sc=c57)

In a recent experiment conducted at the Department of Energy's SLAC National Accelerator Laboratory, a research team used bright, ultrafast X-ray pulses from SLAC's X-ray free-electron laser to create a high-speed movie of a fluorescent protein in action. With that information, the scientists began to design a marker that switches more easily, a quality that can improve resolution during biological imaging.

UNIVERSITY OF GEORGIA

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Biomass-Produced Electricity in the US Possible, but It'll Cost (/articles/view/681545/?sc=c57)

If the U.S. wants to start using wood pellets to produce energy, either the government or power customers will have to pay an extra cost, a new University of Georgia study has found.

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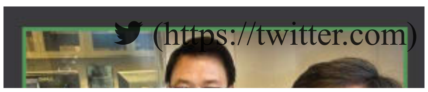

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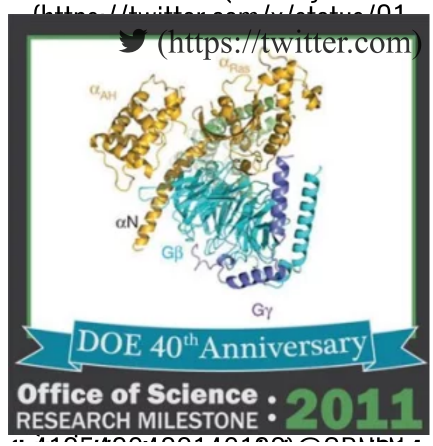

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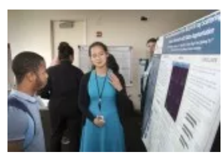

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