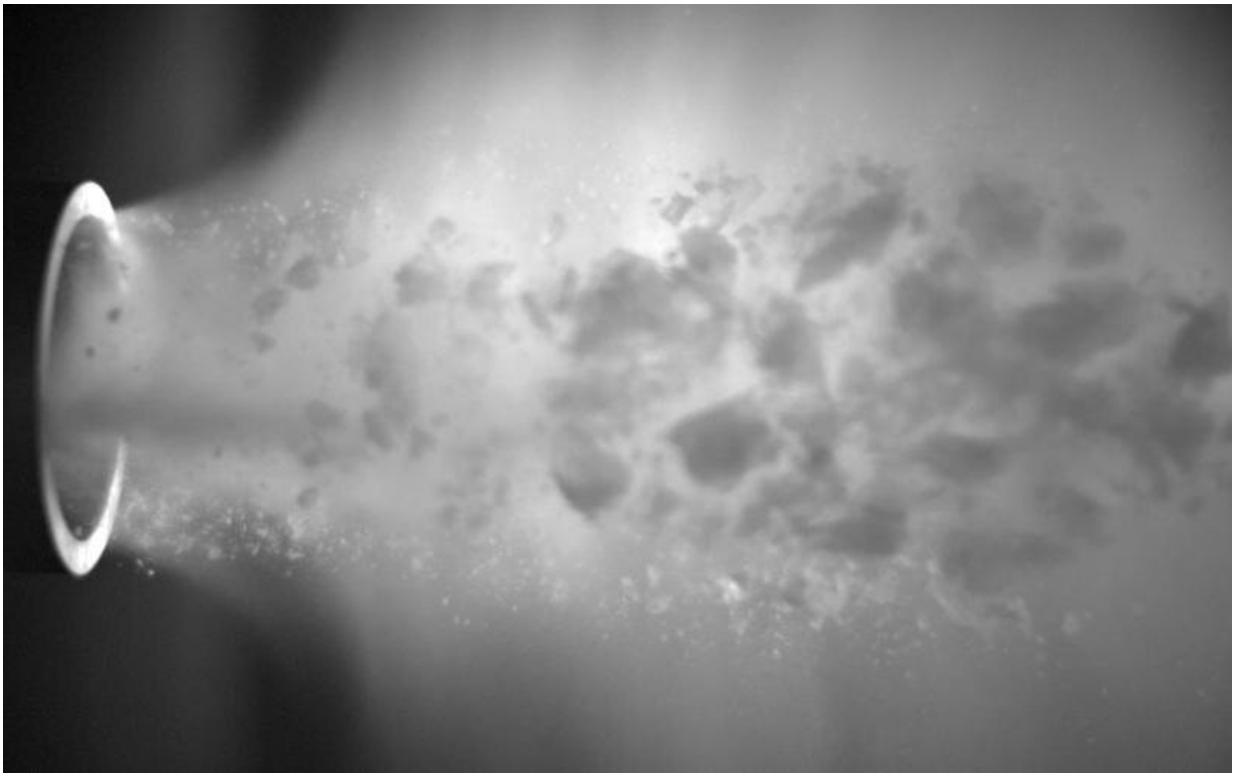
Working to make measurements of plasma disruption mitigation methods more accurate

October 15 2021



A fragment plume generated by a deuterium pellet. Credit: Trey Gebhart/ORNL

A team of fusion researchers at the Department of Energy's Oak Ridge National Laboratory used datasets from measurements on the Joint European Torus, or JET, tokamak to model an improved method for quantifying the amount of plasma-radiated power during a disruption of

normal operations.

This method, called synthetic diagnostics, could inform disruption mitigation systems for high-power fusion devices such as the ITER tokamak now in assembly. The results were published in the *Review of Scientific Instruments*.

In tokamaks, plasma temperatures can match or exceed those at the core of the Sun. The plasmas are confined by magnetic fields inside a vacuum vessel, suspended away from the walls of the machine.

"Disruptions are rapid events in which magnetically confined plasma loses its magnetic and thermal energy, which can severely damage a tokamak by melting or eroding its plasma-facing components," said ORNL scientist and co-author Jack Lovell.

The shattered pellet injection, or SPI, technique injects fragments of a single shattered pellet into plasma disruptions to make them less severe. Typically, the shattered pellet is made of deuterium and another element, such as neon, which is found to aid plasma radiation.

SPI has proven successful so far, but scientists want to make this tool even more accurate by learning and predicting how much plasma radiation could result from different disruption scenarios.

This is tricky because measuring plasma radiation on fusion devices, such as JET, is difficult due to space and packaging limitations caused by the complex geometry of a tokamak and the competition for space from the other systems needed to make these devices operate.

To have a better view, Lovell and his team used a technique called synthetic diagnostics, which uses a computational code to simulate radiated power measurements under different disruption circumstances,

taking into account the configuration of the machine and its diagnostic tools.

The base data for the calculation was obtained from a bolometer, a device currently in use in JET, used to measure the total power radiating from the plasma.

"We looked at how much spatial variation there would be in radiation during a disruption, as well as how much certainty the scientists can place in the synthetic model, given that the data acquired by the measurement instrument is always limited in the extreme environment that takes place inside a tokamak," said Zeke Unterberg, Fusion Energy Power Exhaust and Particle Control group leader at ORNL.

From this variation, the team found that changes in the distribution of radiated power from different plasma and pellet combinations significantly affect the calculation of total power.

This research has improved the understanding of experimental measurements to enable scientists to distinguish between diagnostic measurement artifacts and actual changes in tokamak disruption physics.

Ideally, disruptions would be avoided during operation, but a mitigation system provides important protection for whenever that is not possible. Collecting experiences and data from JET is part of the crucial preparation for ITER, the world's largest scientific collaboration which seeks to demonstrate a self-heated burning plasma and 500 megawatts of fusion power.

"High-power operations, plus understanding plasma disruptions and how to handle them in a tokamak, are critical challenges to resolve for fusion energy development," said Unterberg.

Such knowledge reduces the risk of arriving at false conclusions about the efficacy of disruption mitigation. In fact, this new method allows researchers to reduce the uncertainty of SPI efficacy by a factor of six, which will help ensure that future design and technology decisions are based upon accurate assessments.

More information: J. Lovell et al, Methods to determine the radiated power in SPI-mitigated disruptions in JET, *Review of Scientific Instruments* (2021). DOI: 10.1063/5.0014654

Provided by Oak Ridge National Laboratory