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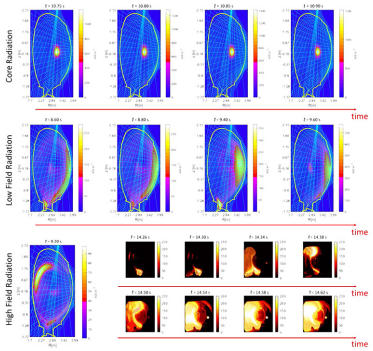
Catastrophic disruptions plague tokamak designs, but an innovative method offers an early warning to avert disaster.



Nuclear fusion has the potential to generate enormous amounts of electricity without contributing to climate change. One of the most promising reactor designs is the tokamak, which uses magnetic fields to confine high-temperature plasma. Unfortunately, all tokamak designs suffer from a fatal flaw: catastrophic collapses of the magnetic configuration, known as disruptions. These disruptions not only interrupt the fusion reaction, they can also damage components and cause additional downtime for inspections and repairs.

Rossi et al. described a technique for predicting disruptions by identifying early warning signs. They outlined an implementation to detect these warning signs in real time and avoid damage and shutdowns.

Disruptions often occur in the Joint European Torus (JET) tokamak facility and frequently follow anomalies in the radiation patterns. The team used an inversion method for bolometric measurements with high temporal resolution to detect these anomalies. Their approach was verified by the facility's cameras and a maximum likelihood tomography algorithm.

With even larger tokamak designs, like ITER, on the horizon, disruptions have the potential to become more frequent, more damaging, and harder to prevent. The team hopes their early warning method can minimize disruptions' impact.

"The warning times are such that, implemented in the next generation of devices, the proposed tools should provide the control systems enough notice to deploy effective prevention and avoidance strategies," said author Michela Gelfusa. "A systematic analysis of more than 1700 JET campaigns proves the effectiveness of the approach."

The authors are now looking forward to ITER and other future experiments, which might be able to use more advanced sensors and control systems to more effectively predict and avoid disruptions.

Source: "A systematic investigation of radiation collapse for disruption avoidance and prevention on JET tokamak," by Riccardo Rossi, Michela Gelfusa, Teddy Craciunescu, Luca Spolladore, Ivan Wyss, Emmanuele Peluso, Jesus Vega, Costanza Maggi, Joelle Mailloux, Mikhail Maslov, and Andrea Murari, *Matter and Radiation at Extremes* (2023). The article can be accessed at https://doi.org/10.1063/5.0143193.