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DIII-D Scientists Solve Key Challenge for Controlling “Runaway” Electrons in Fusion Plasmas

Discovery could help control potentially damaging bursts during plasma disruptions

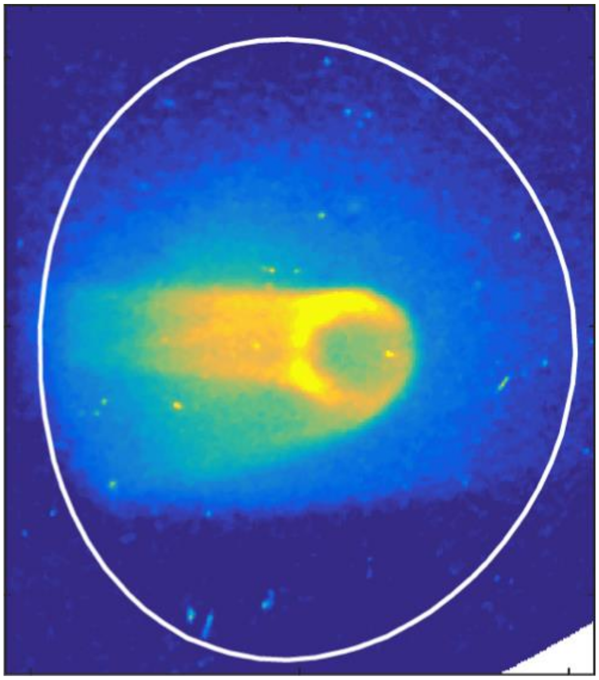

Image courtesy of General Atomics

This image shows an instability (the ring-like structure at the center) caused by a runaway electron (RE) beam inside the DIII-D tokamak as measured by a fast visible imaging camera. These instabilities suggest methods for controlling these damaging events.

The Science
Scientists at the DIII-D National Fusion Facility in San Diego have, for the first time, studied the internal structure and stability of high-energy runaway electron (RE) beams in a tokamak, a type of magnetic fusion device, using hard X-ray radiation. This could provide a way to control the damaging potential of REs in future fusion power plants.

The Impact
A sudden loss of plasma confinement in large tokamaks can lead to formation of a powerful population of relativistic electrons, known as "runaway electron beams," that can seriously damage a tokamak wall. Avoidance or mitigation of RE beams is of crucial importance for the ITER fusion reactor and the commercial power plants that will follow it. This research suggests that RE beams can be controlled and dissipated in a tokamak via exploitation of RE-driven instabilities.

Summary

The DIII-D team intentionally created a RE beam in order to analyze characteristics of the individual electrons. A unique approach, utilizing long-lived RE beams at low current and ultrafast measurements of the gamma radiation from REs, allowed the researchers to probe the internal structure of the RE beam. The results suggest that REs with a certain energy can excite plasma kinetic instabilities that could be used to weaken the beam before it causes damage. The study also showed that other types of instabilities, driven by RE current, are also possible, and these different instabilities could cause an uncontrolled release of the REs. It is not yet clear whether this latter effect would be a problem or benefit for future devices. Thus, further research on disruption mitigation and control is necessary.

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Publications
A. Lvovskiy, *et al.*, "Runaway electron beam dynamics at low plasma density in DIII-D: energy distribution, current profile, and internal instability." *Nuclear Fusion* **60**, 056008 (2020), [DOI: https://doi.org/10.1088/1741-4326/ab78c7]

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