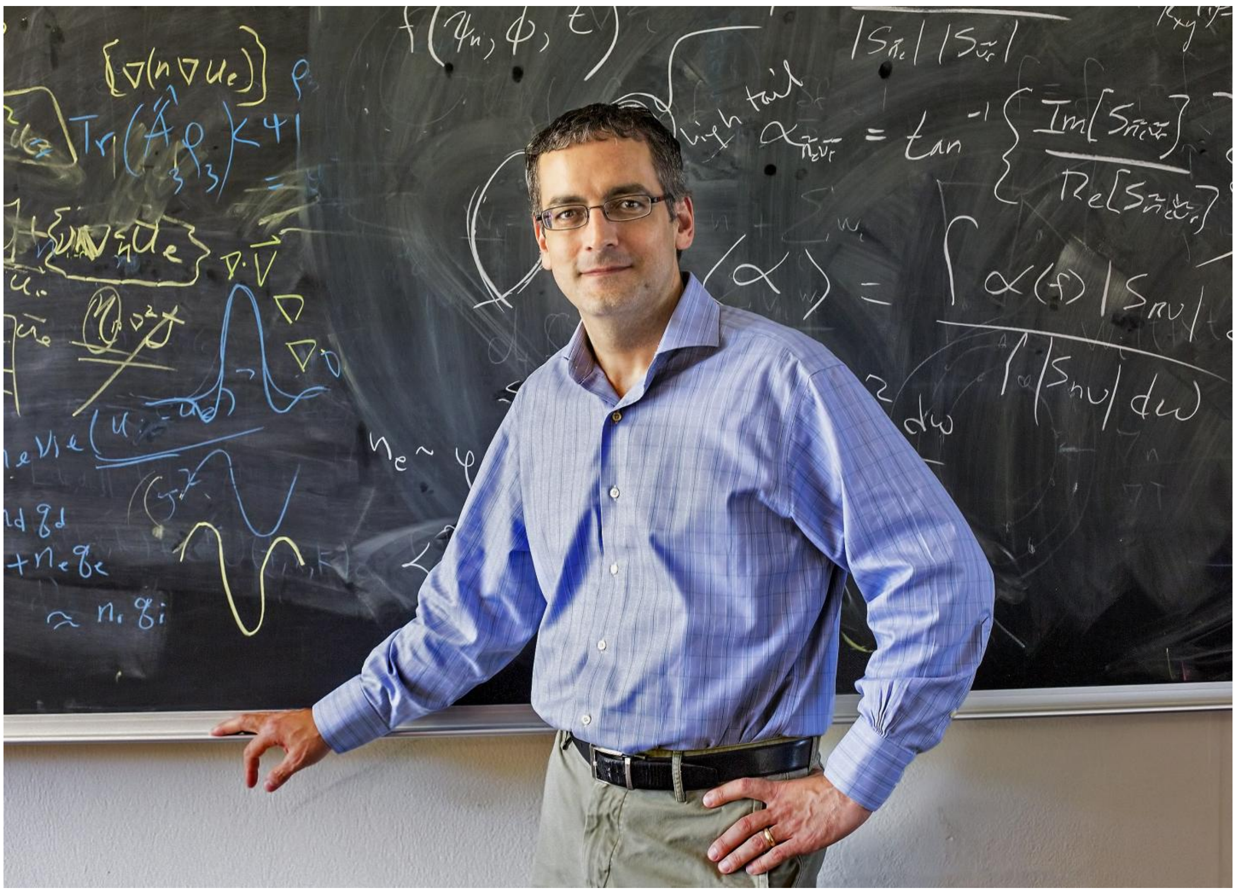
PPPL and Princeton help lead center for study of runaway electrons

August 22 2016



Physicist Dylan Brennan. Credit: Elle Starkman/PPPL Office of Communications

Runaway electrons, a searing, laser-like beam of electric current released by plasma disruptions, could damage the interior walls of future tokamaks the size of ITER, the international fusion experiment under construction in France. To help overcome this challenge, leading experts in the field have launched a multi-institutional center to find ways to prevent or mitigate such events.

"This is like a strike force to solve the problem and we need to get it right," said physicist Dylan Brennan of the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory (PPPL) and Princeton University. "It's very clear that runaways will be a problem," said Brennan, who with Xianzhu Tang of Los Alamos National Laboratory is co-lead principal investigator. "The goal is to take different scenarios for runaway electrons and come up with a recipe for solving them."

Causes and solutions for runaway electrons

The project, called "Simulation Center for Runaway Electron Avoidance and Mitigation," will combine simulations and data from worldwide experiments to explore the causes and solutions for runaway electrons. Members are from nine U.S. universities and national laboratories. Participants include the Oak Ridge, Lawrence Berkeley and Los Alamos national laboratories, the universities of Texas, California-San Diego and Columbia University and General Atomics in San Diego. Support totals $3.9 million over two years from the DOE's Office of Science.

Runaway electrons are relativistic—they travel at nearly the speed of light. To control these particles, researchers must utilize equations derived from Einstein's special theory of relativity, which describes the effect of relativistic speeds on moving bodies.

These equations apply to the huge ITER tokamak. "ITER will be operating in a regime of plasma parameters well beyond the reach of any existing tokamak experiment," said Amitava Bhattacharjee, head of the

Theory Department at PPPL. "Therefore, one must rely on the predictive power of theory and simulation, which must be validated by comparison with present-day experiments and extrapolated to ITER conditions."

Disruption mitigation system for ITER

Research of the center will contribute to a disruption mitigation system to be incorporated in ITER. The US ITER Project Office, based at Oak Ridge National Laboratory (ORNL), will be responsible for the system.

Tasks of the center will include:

- Establishing the physical basis for the generation and evolution of runaway electrons.
- Exploring the path for avoiding runaway electrons.
- Investigating the leading candidates for mitigating the problem.

A key center tool will be input from scientists supported by DOE's Advanced Scientific Computing Research (ASCR) program. It will handle the complex mathematics needed to simulate how runaways traveling at relativistic speed interact with the background plasma—a major issue in comprehending the problem. "There is still much that we don't understand," said Brennan.

Cutting-edge simulations

ASCR scientists will facilitate cutting-edge simulations with advanced codes on the Titan supercomputer at the Oak Ridge Leadership Computing Facility (OLCF) at ORNL, and on supercomputers at the National Energy Research Scientific Computing Center (NERSC) at Lawrence Berkeley National Laboratory. The center will cross-check the results to verify their accuracy. OLCF and NERSC are DOE Office of Science User Facilities.

Another critical step will be to close the gap between theoretical explanations of runaway electrons and experimental observations, for which wide discrepancies have been found. The center will determine how well its simulations fit the experimental data—a key factor needed to create confidence in the group's predictions for ITER.

Also under study will be the primary methods for mitigating runaway electrons. These methods inject impurities in the form of massive gas or shattered pellets to cool the plasma and shut it down before disruptions can occur. But such techniques could also cause the electrons to accelerate; the center therefore aims to define the best mix of impurities and their injection rates for avoiding the problem.

Provided by Princeton Plasma Physics Laboratory