Updated computer code improves prediction of particle motion in plasma experiments

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PPPL physicist Mario Podestà, Credit: Elle Starkman

A computer code used by physicists around the world to analyze and predict tokamak experiments can now approximate the behavior of highly energetic atomic nuclei, or ions, in fusion plasmas more accurately than ever. The new capability, developed by physicist Mario Podestà at the U.S. Department of Energy's (DOE) Princeton Plasma Physics Laboratory (PPPL), outfits the code known as TRANSP with a subprogram that simulates the motion that leads to the loss of energetic ions caused by instabilities in the plasma that fuels fusion reactions. The code, whose name is derived from the term "transport," is housed at PPPL.

Podestà modeled the highly energetic ions that are used to heat the plasma. These particles, which physicists inject as neutral atoms, are ionized inside the plasma and increase its thermal energy. The model could also apply to fusion-generated energetic particles in future tokamaks.

Physicists need to predict and minimize the loss of these ions from the plasma in doughnut-shaped facilities called tokamaks to achieve a high level of performance. Sudden loss can halt fusion reactions and damage plasma-facing components. Predicting and controlling heat loss will be crucial for ITER, the international tokamak under construction in France, in which temperatures are to reach 150 million degrees Celsius, or 10 times the heat at the core of the sun.

Podestà's results build on research he conducted in 2015. "The original work with my model focused on reproducing, modeling, and interpreting results from existing experiments," he said. "This new work explores the possibility of using that same model to predict energetic particle transport in future experiments."

The revision, reported in July in the journal *Plasma Physics and Controlled Fusion*, employs a subprogram called a "kick model" to simulate the movement of fast ions caused by instabilities in the plasma. The kick model captures only the minimum amount of physics necessary to simulate this specific phenomenon.

The subprogram enables the completion of calculations in a matter of hours, rather than weeks or months. Using the kick model means sacrificing some accuracy, but it allows researchers to get results more quickly. "That's the trade-off," Podestà said. Support for this research comes from the DOE's Office of Science (Fusion Energy Sciences).

Podestà tested his modified version by comparing it with data produced by PPPL's National Spherical Torus Experiment (NSTX) prior to its upgrade. The modified code predicted levels of energetic particle transport that agreed with the NSTX experiments.

The new approach suggests that with further modifications, such forecasts can be made more reliable with just a limited increase in computing time. "The question before this research was whether we can predict what will happen in future experiments, with a minimum amount of prior information," Podestà said. "It now appears that we can, and these favorable results motivate further improvements to the model."

More information: M Podestà et al, Computation of Alfvèn eigenmode stability and saturation through a reduced fast ion transport model in the TRANSP tokamak transport code, *Plasma Physics and Controlled Fusion* (2017). DOI: 10.1088/1361-6587/aa7977

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