

Preventing particle leaks in fusion reactors

Much of the research into harnessing nuclear fusion energy focuses on reactors that use powerful magnets to manipulate ultrahot plasmas. Among the designs is the stellarator. Developed in the 1950s, it consists of a confinement chamber shaped like a twisted doughnut that is wrapped in a set of solenoidal coils, which generate the intense magnetic fields necessary to control plasma. Inside the chamber, deuterium and tritium nuclei fuse to form alpha particles and neutrons.

A major challenge in stellarator design is keeping the alpha particles confined in the chamber, where they maintain the temperature of the plasma and induce further fusion reactions. Escaping alpha particles reduce fusion energy generation and can damage components of the stellarator. But researchers have had trouble locating the holes in the stellarator's magnetic field through which the particles escape. Because it would be computationally infeasible to determine exactly where they are, researchers typically use perturbation theory to make an estimation. A growing amount of evidence indicates that those calculations miss the mark for certain stellarator designs.

Joshua Burby of the University of Texas at Austin and colleagues developed a nonperturbative method to track the loss of alpha particles by training a machine-learning model on data from particle simulations. The diagram shows how the predicted motion of particles in a fusion reactor in the new model (orange and red lines) are closely in line with the motion predicted by time-consuming exact calculations (blue and green lines). Along with helping to refine stellarators, the method could benefit researchers designing tokamaks and other types of magnetic confinement devices. (J. W. Burby et al., *Phys. Rev. Lett.* **134**, 175101, 2025; image courtesy of Max Ruth/University of Texas at Austin.)

—RD

TO SUBMIT CANDIDATE IMAGES FOR **BACK SCATTER** VISIT <https://contact.physicstoday.org>.