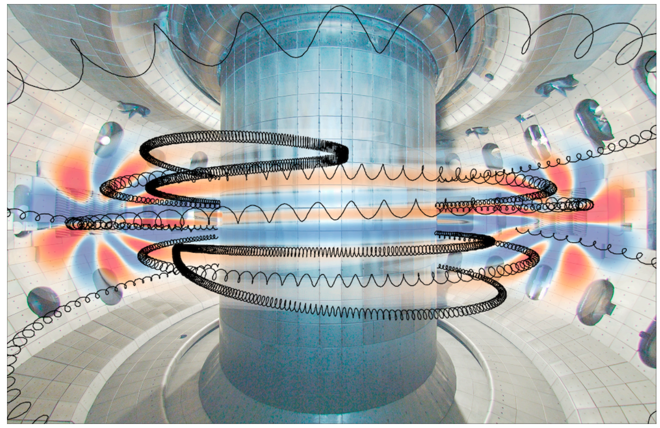
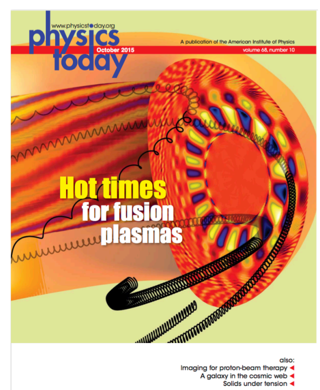
DIII-D Insights Concerning Wave-particle Interactions in Tokamaks Promote Confidence in ITER



Fusion plasmas in tokamaks exhibit a wide collection of electromagnetic waves that can affect the confinement of charged particles such that it becomes more difficult to maintain fusion-grade temperatures. One class of waves, known as the Alfvénic instabilities, interact strongly with energetic ions that are injected into the tokamak by powerful neutral beams. These interactions can result in the energetic ions striking the tokamak wall with damaging consequences. Researchers at the DIII-D National Fusion Facility have detailed these interactions and described the ways in which experiment and theory from present day tokamaks uncover the path to avoiding negative effects in ITER. For example, seemingly small changes to the magnetic field configuration of ITER can greatly reduce the waves' ability to eject energetic ions. This work was recently published as a feature article in Physics Today*, covering the ways in which an energetic ion orbit in a tokamak can resonate with an Alfvénic instability to produce a large amplitude wave that then pushes the ion outward. Understanding the physics of this process allows scientists to develop tokamak operating regimes in which these wave-particle interactions are minimized.



The Oct. 2015 cover of Physics Today highlights the DIII-D article.

The illustration at the top of the page provides a summary of the relevant physics. The background is a photo of the inside of the DIII-D tokamak. The walls are made of graphite (similar to a standard pencil), and a variety of openings along the wall provide access for diagnostics and the injection of neutral beams. No plasma is shown in this graphic, instead, a black trace shows the path taken by a single deuterium ion (a proton with one neutron attached) as it zips throughout the tokamak. This ion is pushed around by waves that form naturally in the plasma. A simulated snapshot of one such wave is shown by the red/blue contour and the ion passes through it many times along its path. If the wave pushes the ion out of the tokamak, then the fusion power is reduced and the reactor is less efficient, possibly to the point of losing the fusion power output entirely. An active area of fusion research focuses on measuring the deflection of ions due to these waves, with the intention of developing methods that prevent either the formation of the waves or minimize the loss of ions.
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*D.C. Pace, W.W. Heidbrink, and M.A. Van Zeeland, Physics Today **68**, 34 (2015)
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