Containing a Star on Earth: Understanding Turbulence at 100 Million Degrees

Abstract

Nuclear fusion is a promising answer to the global energy challenge. It is a carbon-free source of energy, and its fuel is present in large enough quantities on Earth to meet the world's energy needs for thousands of years. Furthermore, unlike conventional nuclear fission power reactors, the operation of fusion reactors is intrinsically safe and the waste is short-lived. One of the remaining challenges for realizing magnetic fusion energy is to understand and mitigate the chaotic flows of ionized gas, or plasma, that lead to unacceptable energy loss from the hot core of the device. These microscopic, randomly varying, or turbulent, fluctuations of plasma flows arise owing to the strong differential in temperature from the hot core (>100,000,000 degrees) to the surrounding wall (<1,000 degrees) that must be sustained for fusion to occur. After introducing the concept of fusion energy, this talk will summarize the progress that has been made in characterizing, predicting and minimizing the detrimental characteristics of the plasma turbulence. Many of the observations show amazing similarities to turbulence found elsewhere in nature, from large scale flows observed in planetary atmospheres to energetic bubbles in boiling water. While serving as valuable and vivid analogies, these similarities also verify the broad relevance of the underlying physical principles found in a diversity of systems throughout the universe.

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Dr. Guttenfelder's current research focuses on understanding plasma turbulence in a variety of magnetic confinement configurations through the use of numerical simulation and measurement. Before joining the National Spherical Torus Experiment-Upgrade (NSTX-U) group at the Princeton Plasma Physics Laboratory (2010), he was a post-doc at the Centre for Fusion, Space & Astrophysics at the University of Warwick (UK). He received his Ph.D. from the University of Wisconsin-Madison (2008), performing research on the Helically Symmetric Experiment (HSX), where his interest in understanding plasma physics for the pursuit of fusion energy began. Prior to that, he received a Masters degree at Purdue University (2001), researching the effects of turbulence in combustion systems in the Flame Diagnostics Laboratory. He received his undergraduate degree in electrical engineering at the Milwaukee School of Engineering (1999), having followed his childhood love of electronics.