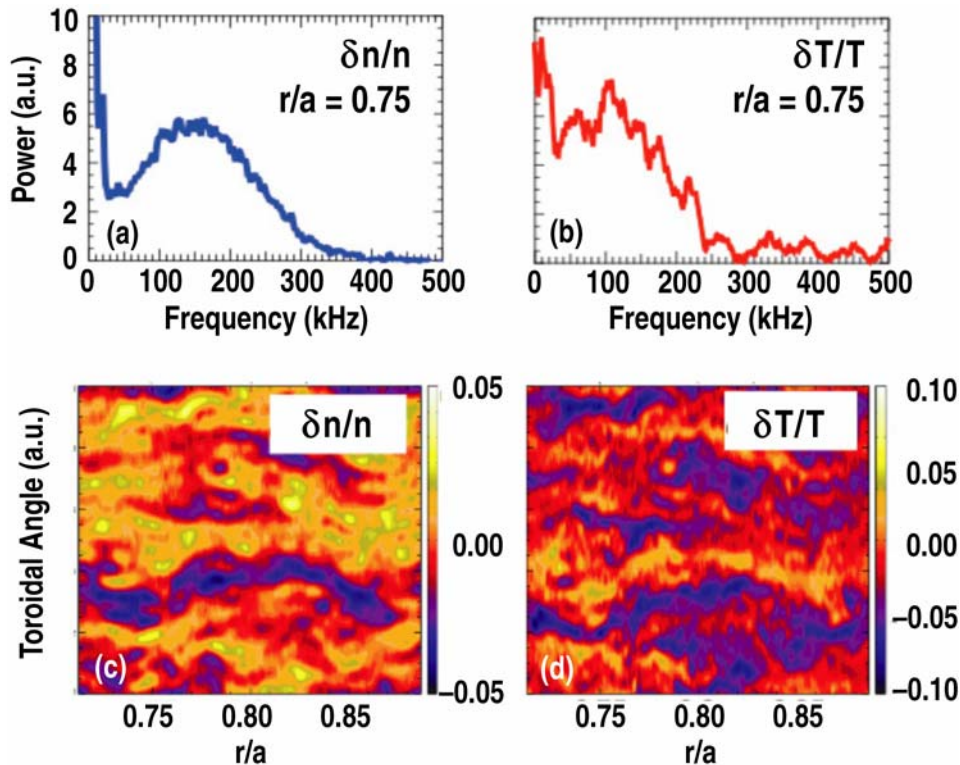


Keeping Cool While Studying Plasma Turbulence at 100 Million Degrees

New measurements of temperature fluctuations combined with a unique comparison to density fluctuations provide insight into tokamak core turbulence.

Imagine your job was to measure the characteristics of water motion in a pot of boiling water or in a fast-flowing mountain stream. How would you make such a measurement? Now, consider if you had to make this measurement in a plasma that is at 100 million degrees Celsius and moving close to the speed of sound. This is the challenge that fusion researchers face in their desire to learn more about how heat and particles flow out of fusion plasmas. In recent years, state-of-the-art measurements have been developed that allow researchers to study turbulence in this challenging environment. Now, for the first time, spatial profiles of both density and temperature fluctuations have been achieved in these high temperature fusion plasmas. Measuring fluctuations in temperature and density together, at the same time and place, in the core of a hot fusion plasma allows the physics of turbulent driven transport in these plasmas to be explored through detailed comparison to state-of-the-art computer simulations.

Utilizing this new measurement capability, researchers have already discovered that the response of density and temperature fluctuations to changes in how the plasma is heated is complex. For example, when high energy beams are used solely for heating, the density and temperature fluctuations are found to be similar in their amplitudes across a wide range of characteristic frequencies and spatial locations [Figure (a) and (b)]. This observation is consistent with predictions of state-of-the-art plasma simulations using theoretical models of turbulence [Figure (c) and (d)]. However, in another case in which microwave heating is utilized in addition to high-energy beams, the density and temperature fluctuations respond differently. The amplitude of the temperature fluctuations increases, correlating with increased heat transport. In contrast, the amplitude of the density fluctuations does not change. Such contrasting data will provide a unique opportunity to test and refine the physics embodied in advanced turbulence simulations.



(a) and (b) Measurement of density and temperature fluctuations at the same radial location in the core plasma. (c) and (d) Simulation of density and temperature fluctuations at the same radial location in the core plasma.

This research involves scientists from the University of California-Los Angeles, University of California-San Diego, University of Wisconsin-Madison, and General Atomics.

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