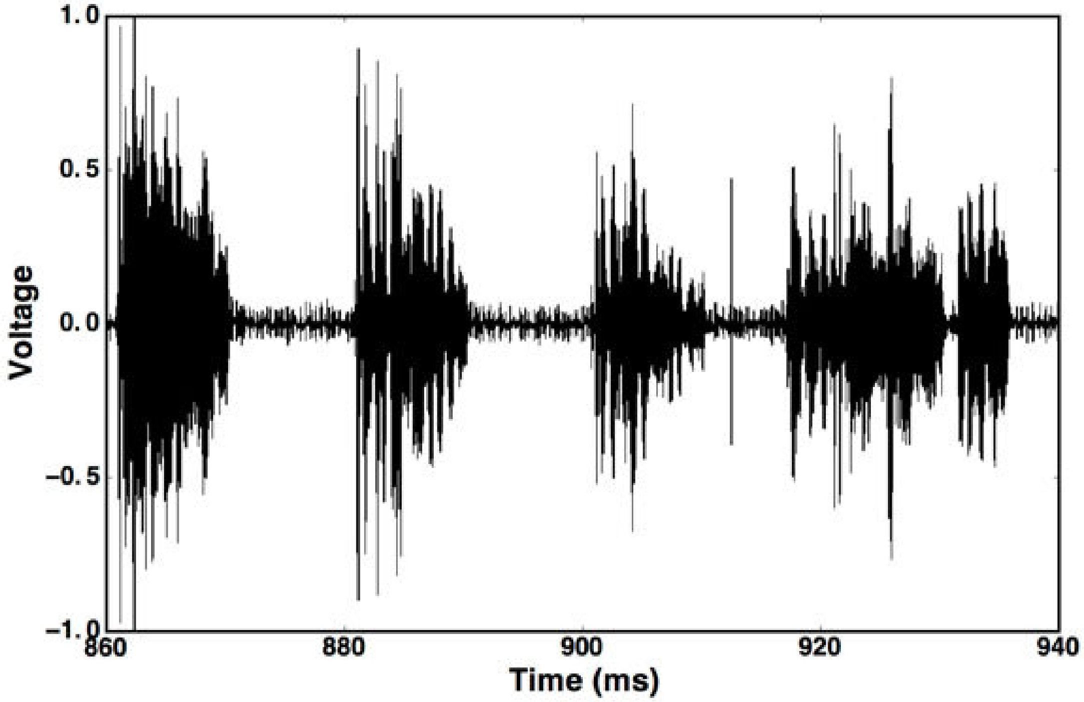
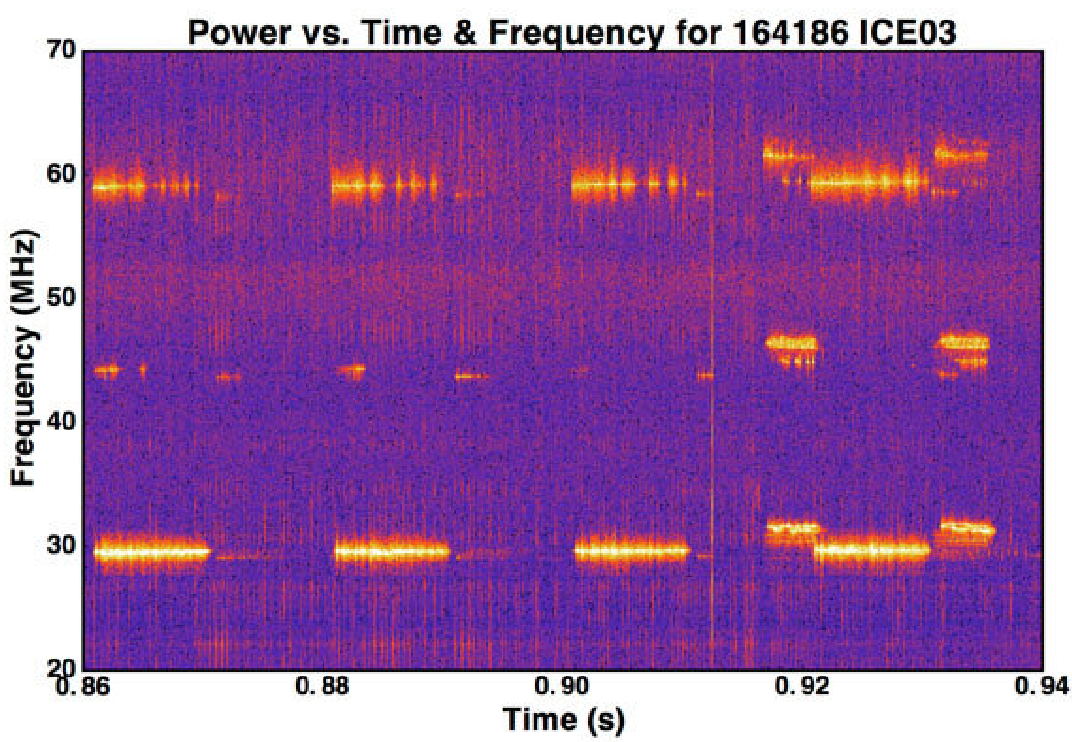
New insights could help tame speedy ions in fusion plasmas

October 21 2019


1.0
0.5
0.0
−0.5
−1.0
Voltage
860
880
900
920
940
Time (ms)


Power vs. Time & Frequency for 164186 ICE03
70
60
50
40
30
20
Frequency (MHz)
0.86
0.88
0.90
0.92
0.94
Time (s)

The top image is an example of raw data the team captured at DIII-D showing fluctuations in the magnetic field. An equation known as a Fourier Transform was used to plot the frequency and duration of individual waves, represented by the orange bars in the bottom image. Credit: DIII-D National Fusion Facility.

To create a practical fusion energy reactor, researchers need to control particles known as fast ions. These speedy ions, which are electrically charged hydrogen atoms, provide much of the self-heating ability of the reactor as they collide with other ions. But they can also quickly escape the powerful magnetic fields used to confine them and overheat the walls of the containment vessel, causing damage.

A team at the DIII-D National Fusion Facility recently took a different approach to studying these difficult-to-measure particles. The research showed promising results that have not only yielded insights into the physics of the particles themselves, but they may also lead to new and reliable ways to monitor and manage how well fast ions are contained in future reactors.

"This is really an exciting time to be working on these types of challenges in fusion energy," said DIII-D researcher Kathreen Thome. "The global fusion community is picking up pace on the road to energy output, and every bit of additional insight we can generate into these problems moves us closer to that destination."

Part of the research challenge in measuring the fast ions lies in the harsh environment at the heart of a tokamak, a type of fusion reactor. Delicate sensors used in today's research tokamaks would simply be destroyed in future fusion reactors, which will have much higher power. The DIII-D team used a rugged magnetic sensor and high-performance computing to capture and interpret a small wiggle created in the device's magnetic field by these fast particles. This magnetic field fluctuation (Figure 1) provides information on the properties and behavior of the speedy ions and how they interact with plasma waves.

The next step for the fusion community will be to use the data generated to expand the capabilities of computer models that interpret the behavior of fast ions based on these wiggles. Once models are made more effective, they could be coupled with the rugged magnetic sensors in future high-power reactors to provide real-time control of the conditions that affect fast ions. If that feedback loop can be established, the fast ions could not only be kept from damaging the tokamak walls, they could be used to heat the plasma more efficiently.

More information: Abstract:

High-Frequency Energetic-Ion Modes in the DIII-D Tokamak
3:00 PM-5:00 PM, Thursday, October 24, 2019
Room: Floridian Ballroom CD
meetings.aps.org/Meeting/DPP19/Session/VI3

For additional information see also:

Thome et al., 2019, *Nucl. Fusion*. Central Ion Cyclotron Emission in the DIII-D Tokamak, iopscience.iop.org/article/10. … 741-4326/ab20e7/meta

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