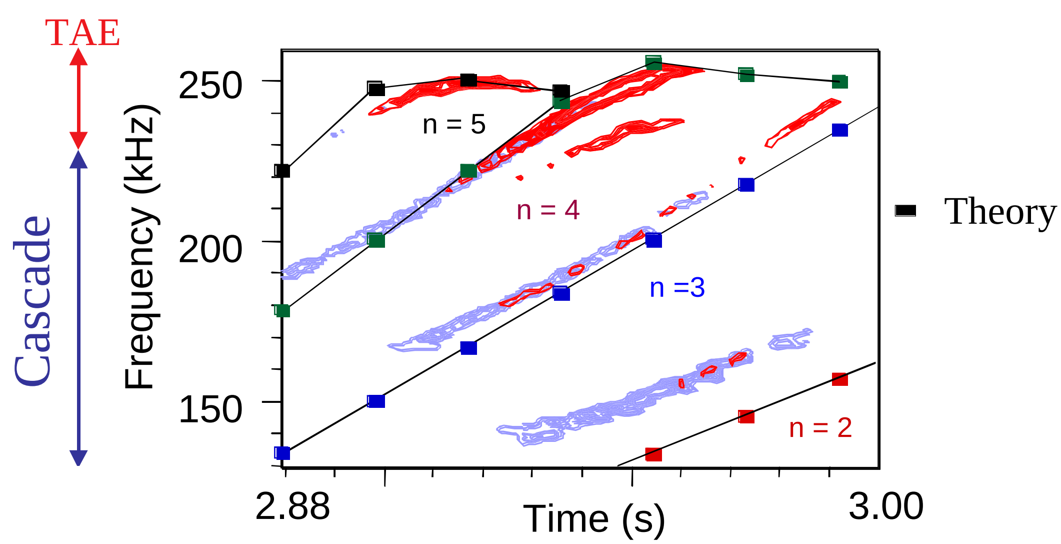
New Understanding of Plasma instabilities Advances Fusion Science

Recent fusion experiments and theory advances offer new hope in understanding and possibly eliminating instabilities in plasma, according to a team of researchers collaborating on experiments in Europe, Japan, and the U.S. Scientists report that newly discovered plasma instabilities — oscillations known as "Cascade Modes" — may help fusion researchers to better understand and predict plasma behavior in a fusion reactor, as well as aid in the development of methods for suppressing the instabilities.

Isotopes of hydrogen such as deuterium and tritium are used as the fuel in a fusion reactor. At temperatures near 100 million degrees the fuel burns to produce highly energetic particles that generate the electricity and sustain the reaction. While these reaction products are expected to sustain the fusion burn, they can also do other things like excite high frequency disturbances. These high-frequency disturbances are traveling waves that can catch hot particles riding close to the wave speed, much like a surfer catches a wave and rides it to the beach. If these waves are too strong, the hot particles may ride the wave to the reactor walls and lose their energy before effectively heating the plasma. Previously, the dominant waves predicted to be driven by these energetic particles in a fusion reactor were the Toroidal Alfvén Eigenmodes (TAEs), first identified during experiments conducted on the Tokamak Fusion Test Reactor (TFTR) and in the DIII-D device in the U.S. Experiments on TFTR, which was at the DOE Princeton Plasma Physics Laboratory, concluded in 1997.



The figure illustrates the comparison of experiment and theory for the TFTR D-T experiments. The TAE range of frequency is indicated in red and represents only a narrow range of the observed frequency of the modes (in blue). The solid lines are theory estimates of the Cascade Mode frequency for different toroidal mode numbers, showing strong agreement with experiment.

Deuterium-tritium experiments on the TFTR succeeded for the first time in exciting high-frequency disturbances driven entirely by the fusion reactions (see figure). While these were originally considered to be TAEs, international collaborative experiments on the JET (U.K.) and JT-60U (Japan) tokamaks have led to a reinterpretation of the original observations on TFTR, and a resolution of outstanding anomalies in the original description. This advance will allow for improved prediction of disturbances in a future fusion reactor, with the potential to better understand and control these instabilities.

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Further information

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