# Reduction and elimination of edge instabilities in high performance, steady-state fusion plasmas

The Science

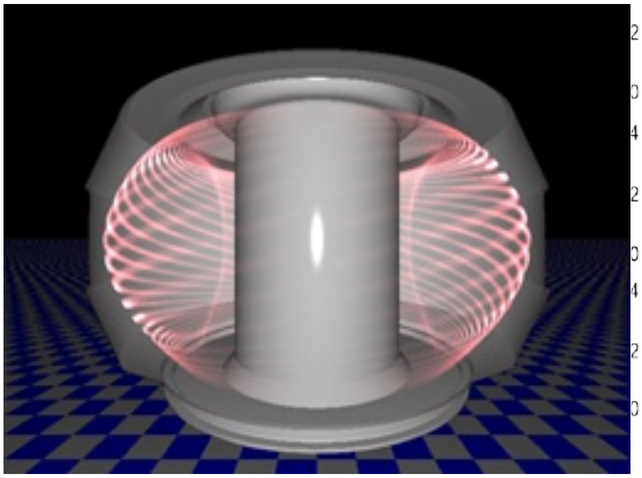
Small magnetic fields have been applied to the edge of a high pressure plasma in a magnetic fusion machine to reduce and eliminate instabilities to reduce pulses of heat to the walls. This result was obtained in a high pressure plasma that was operated in near steady-state conditions.

The Impact

Scientists in several countries are working to develop the tokamak as a fusion reactor. This machine uses strong magnetic fields to confine plasma, that state of matter in the interior of stars, in order to obtain the required fusion reactions. Recent experiments in a tokamak have applied small magnetic fields in a high pressure and nearly steady state plasma to successfully eliminate pulsed heat loads to the wall of a tokamak, as required in a reactor.

Summary

A practical fusion machine must meet several criteria, including confining a high pressure plasma, operating in steady-state and having acceptable heat loads to its walls. Recent experiments in the DIII-D National Fusion Facility, a tokamak operated by General Atomics, have produced plasmas in which all of these criteria are simultaneously met. A key enabling technology was the use of very small magnetic fields, with a different structure than the strong confining field, to reduce and eliminate instabilities at the plasma edge in high pressure, nearly steady-state plasmas. These bursty instabilities, illustrated by the pink stripes in figure 1, provide pulses of heat to the walls. These pulses cannot be tolerated in a fusion reactor, including the ITER device under construction in France, because they will lead to fast erosion of wall material. Control of these instabilities is demonstrated in Figure 2, which shows a burst of plasma light during each edge instability. In the reference discharge, the edge magnetic field was not applied and edge instabilities occurred throughout the duration of the plasma. However, for application of the fields, as shown by the red line in the middle panel, the frequency and size of the instabilities was dramatically reduced. When this field was doubled in magnitude (bottom panel), the instabilities were completely eliminated, thus removing the undesired heat pulses to the walls. This suppression of edge instability by application of small magnetic fields has been achieved for the first time in a high pressure plasma that is operating in essentially steady state conditions. These results are very promising for ITER and future machines and new experiments will be used to further improve these plasmas.



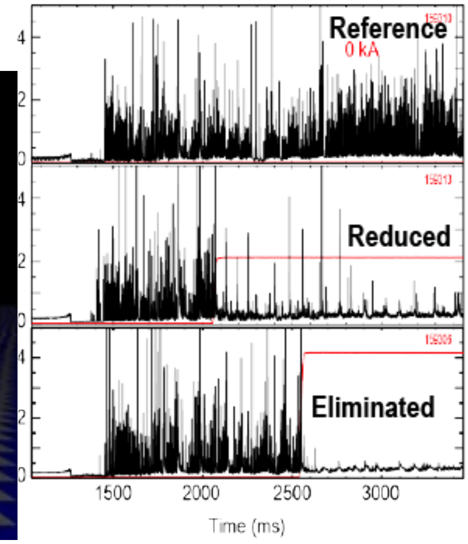

Reference
0 kA
Reduced
Eliminated
0
2
4
1500
2000
2500
3000
Time (ms)

Fig 1

Fig 2