

Nature Provides a Beneficial Fluctuation

Beneficial Fluctuation that Regulates Particle Transport Found to Exist in a Very Narrow Region at the Plasma Edge

One of the main goals of magnetic confinement fusion research is to optimize the confinement of energy in the plasma. In many cases improvements in the confinement of energy is accompanied by increases in the confinement of particles, so that in these cases particle confinement is *too* good. This is a problem because well-confined impurity particles (non-fuel particles) continually radiate power and cool the core, thus 'leaking' plasma energy. So some loss of particles (both impurities and the "burned" fuel) is in fact necessary for sustained fusion. In a tokamak at MIT - the Alcator C-Mod - a mode of operation has been found that maintains good energy confinement characteristics, but allows some leakage of particles. Investigations of this favorable mode have shown a "quasi-coherent" fluctuation provides the particle transport mechanism. A "quasi-coherent" fluctuation is an oscillation that occurs over a relatively narrow range of frequencies. In this case the oscillation is in the local plasma density and in the local electric and magnetic field. Research has shown that the strength or magnitude of the oscillation is proportional to the particle "leakiness" of the plasma, essentially confirming

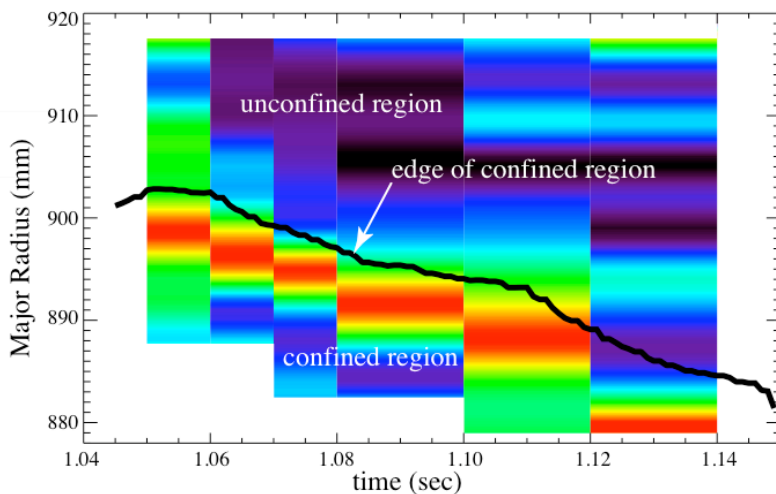


Figure 1: Shown are the location and extent of the density fluctuation versus time and space, where the magnitude of the density fluctuation is shown using the color scale. The edge of the plasma is being moved intentionally during this time period. The peak in the magnitude of the fluctuation is observed to exist just inside the confined plasma edge (the black line) and to move with it. There is fluctuation beyond the confined region as well. The five panels are time periods over which the fluctuation data are averages and each panel's color scale is adjusted so that red is the maximum during that time period.

that it is responsible for the particle transport regulation. This serves as an example where nature has provided a beneficial and unexpected effect. One of the most interesting aspects of the fluctuation is that it exists in a very narrow region at the extreme edge of the confined plasma. Indeed, on Alcator C-Mod the fluctuation is just a few millimeters in cross-sectional extent and located within a mm or two of the plasma edge. Thus the oscillation continuously pushes particles out of the confined region. These aspects are shown in figure 1, where the measured magnitude of

the fluctuation is shown using the color scale (red is strong, black is weak) in relation to the edge of the plasma (the black line), which is purposely being moved with time. In addition, computer simulations of the plasma edge by researchers X. Xu and W. Nevins of Lawrence Livermore Laboratory show a fluctuation which has all of the characteristics of the phenomenon that are measured, i.e. it is quasi-coherent; it is an electromagnetic oscillation affecting the density; and it exists in a narrow region at the plasma edge. The detailed mechanism by which the oscillation is generated is still under investigation.

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