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Lithium calms plasma

Coating plasma-facing components with lithium reduces edge transport and leads to better energy confinement in fusion machines

The confinement of hot tokamak plasmas is often aided by the presence of a transport barrier at the plasma edge that inhibits energy losses. This barrier typically exists only in a very narrow region at the plasma edge, giving a "pedestal" shape to the plasma pressure profile. Due to the narrowness of the barrier, achieving the high pedestal pressures that can improve plasma confinement often requires pressure gradients that are exceedingly steep, causing instabilities known as edge-localized modes (ELMs).

Recent experiments at the National Spherical Torus Experiment at the Princeton Plasma Physics Laboratory have uncovered a potential method for widening the edge transport barrier, allowing very high pedestal pressures and good confinement while avoiding excessive ELMs. These experiments have made use of lithium coatings applied to the plasma-facing components. The lithium strongly absorbs the plasma particles incident on these components, reducing the amount of "recycling" of these particles back into the plasma. This leads to a reduction in the radial particle flux in the edge region, and an increase in the global energy confinement.

2-D modeling of the edge plasma during these experiments has been performed to better understand the change in particle recycling as well as transport properties induced by the lithium coatings. With lithium the edge density is reduced, but a strong gradient exists in the density profile for a wider region (Figure 1). Similarly, a strong electron temperature exists across a wider region, leading to a significantly higher temperature at a normalized plasma radius of 0.8 — even though the input power has been reduced by half. The transport coefficients from this interpretive modeling show that the transport barrier at the edge is greatly expanded, with the region of low $D_\perp$ and χ_e reaching in to the inner boundary of the simulation at a normalized radius of 0.8. A sharp reduction in density fluctuations has also been measured in this region, indicating that the turbulence that typically causes edge transport is mitigated by the lithium coatings. These results will be presented at the APS meeting of the Division of Plasma Physics, and point to exciting possibilities for controlling the edge transport in spherical tokamaks using advanced density control techniques.

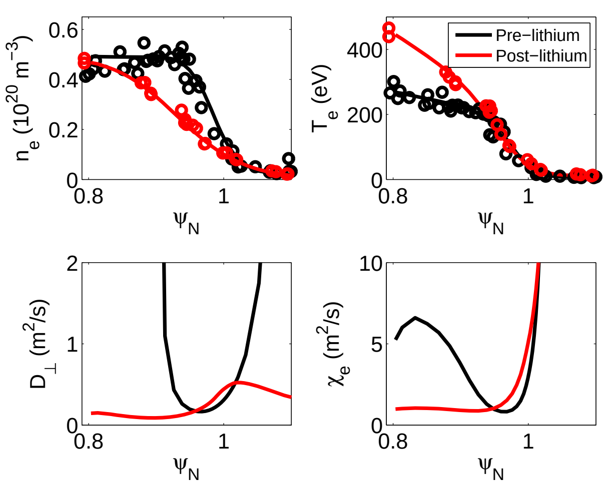

Figure 1: Density, temperature, particle and electron thermal diffusivities before (black) and after (red) lithium coatings are applied.

This work will be presented in the Invited Talk by John Canik, JI2.0001, Tuesday 2 PM.