La Haye Press Release

"Avalanche Control" of a Magnetic Island in DIII–D

Tearing modes in plasmas can form magnetic islands that destroy toroidal symmetry and lower confinement. Neoclassical tearing modes can arise in high beta (large plasma pressure) discharges when the pressure driven plasma current ("bootstrap") is helically deformed. Such plasmas are metastable before the appearance of the instability. An analogy is a mountain top with a large buildup of snow. The snow pack is metastable until a noise or tremor disturbs it sufficiently to start an avalanche. The m=3, n=2 tearing mode (whose magnetic field perturbation wraps around three times poloidally for every two times toroidally) is commonly excited at high beta by the periodic m=1, n=1 sawtooth instability.

Avalanche control of a mountain snowpack is routinely done by setting off a loud noise that lets the snow benignly avalanche before a big buildup. However, the equivalent process in a tokamak would be to avoid the instability by reducing the plasma pressure, which is undesirable. Instead, the metastable condition is eliminated in DIII–D without lowering the plasma pressure, by applying precisely aligned electron cyclotron current drive prior to the full buildup of the plasma pressure. This approach is analogous to constructing a barrier at one critical location on the mountainside before the snow builds up, in order to stabilize the snowpack in place without an avalanche when the snowpack is fully developed. By use of sufficient current drive (relative to the bootstrap current) and by maintaining good alignment of the m=3, n=2 rational surface on the peak current drive, the m=3, n=2 neoclassical tearing mode is not excited by the sawteeth as the metastable condition is eliminated despite maintaining high beta.

Accurate real-time knowledge of the plasma's internal magnetic structure is necessary to successfully align the stabilizing current drive. This was a key feature of this year's experiment. The Figure shows that misalignment between the peak current drive location and the rational surface must be kept to less than half of the current drive width for the control to be effective. Stability can be achieved at peak current drive of a fraction of the local bootstrap current if alignment is very good.

The operating conditions for these DIII-D discharges are typical of the ITER baseline scenario and show promise for use of this stabilization technique in ITER. Methods developed in DIII-D for the m=3, n=2 tearing mode control will also eventually be used on the more deleterious longer wavelength m=2, n=1 instability.

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