Recent Findings Relative to Advanced Tokamak Modes and Their Implications for Fusion Energy*

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An advanced tokamak is characterized by increased confinement and stability obtained through modifications to the shape and profiles of the plasma. These modifications have to be self-consistent. The increased confinement makes it possible to make smaller and thereby lower cost reactors for the same power output as compared to conventional tokamaks. Three potential modes for advanced tokamaks are currently being studied on DIII-D: radiative improved mode, high internal inductance l_i mode, and negative central shear (NCS) mode. In the radiative improved mode the confinement is increased by adding impurities to the plasma edge. The impurities seem to suppress the plasma turbulence, and thereby increase the confinement. The high l_i mode, which is observed in both L-mode and H-mode and is compatible with the radiative improved mode, has been produced transiently by rapidly reducing the plasma current or by increasing the plasma volume. The improved confinement is believed to arise from a stabilizing effect of magnetic shear on both the ideal high *n* ballooning modes and electrostatic microinstabilities. The NCS mode is obtained by injecting neutral beams during the plasma current ramp up, which created a non-monotonic q profile that has a minimum which is not at the plasma center. A transport barrier is established near the q_{min} location in NCS mode. This internal transport barrier is believed to be due to ExB shear stabilization. Since the current density profile is fairly broad in the NCS mode, the mode is subject to resistive wall mode instabilities, which will have to be stabilized. Plasma rotation or virtual rotating walls might be able do this.

Computer simulations have been made of these modes and they show encouraging possibilities. These modes are now lasting over 2 seconds (16 τ_E) in DIII-D and better understanding and new hardware (electron cyclotron heating) are intended to extend the duration of these modes to near steady state. Six 1 MW gyrotrons have been commissioned and four have been used in the advanced tokamak experiments. Additional hardware has been and will have to be developed for the ECH system to fully utilize it: diamond windows and long-pulse launchers. Power supplies have been installed to drive an array of external saddle coils and use them to stabilize the resistive wall modes. A new upper-inner divertor has been installed in DIII-D to study the effect of closed divertor versus open divertor. New required diagnostics include the motional Stark effect diagnostic, the resistive wall mode probes, the central Thompson diagnostic, and the Li-beam diagnostic.

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