

## ***Driving Current Efficiently With Millimeter Waves***

Plasma confinement devices of the tokamak type require a current in the plasma to support the equilibrium. This current can be supported by magnetic induction, but this conventional process is inherently limited in duration. In order to have a steady state tokamak, it is necessary to have noninductive means of supporting the current. One approach, which has been applied extensively on the DIII-D tokamak, is to drive current within the plasma by injecting into it high power millimeter waves. In this way, the plasma current can be sustained for as long as the wave power is applied.

The millimeter waves require high power, so any effect which reduces the efficiency of the current drive process must be ameliorated. For example, in a tokamak the magnetic field varies in magnitude along a magnetic field line. A region of increasing magnetic field acts like a hill and tends to slow or stop the electrons which carry the plasma current. In past experiments on DIII-D, this "trapping effect" was shown to cause the current driven by millimeter waves to become very small or even reverse under some conditions. However, theory suggested that under conditions of higher electron temperature and density, the trapping effect should diminish or even vanish due to relativistic effects.

Experiments this year on DIII-D have borne out this prediction of theory. The experiments show that when the electron pressure (i.e., density multiplied by temperature) is increased to normalized values more relevant to a power-

producing plasma, the efficiency of current drive improves dramatically. In many situations, the deleterious effects of trapping observed at lower pressure have been shown to completely disappear. These results support the use of current drive to support steady-state operation of tokamaks.



*Gyrotrons generate high power millimeter waves for current drive*

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