DIII-D
NATIONAL FUSION FACILITY

Research Highlights
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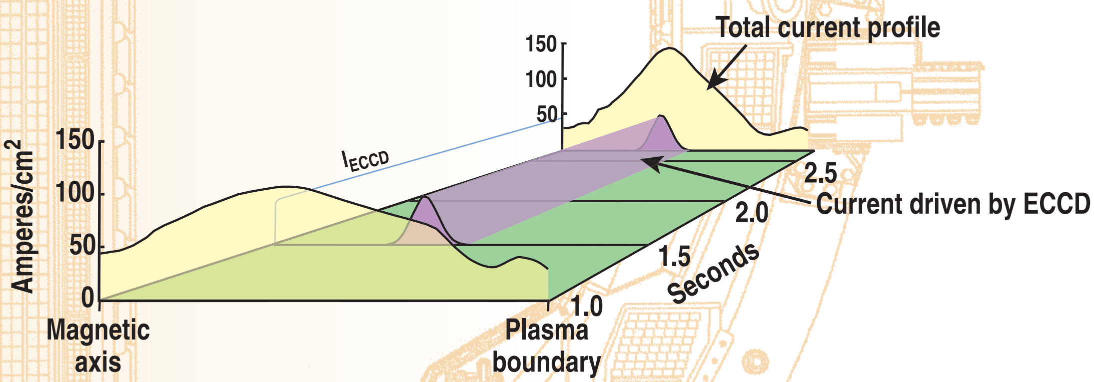
High Power Microwaves Control Plasma Current Profile

Much of the confinement in the tokamak is provided by magnetic fields driven by electrical current flowing in the plasma. In "conventional" tokamaks, this current is provided mainly by a pulsed transformer, inherently limiting the plasma's duration to hundreds or thousands of seconds. Advanced Tokamak (AT) research seeks to eliminate this pulsed plasma constraint by replacing this pulsed inductive current with current drive scenarios that are compatible with steady-state operation while maintaining high fusion performance. Recent experiments in the DIII–D tokamak have produced demonstrations of such scenarios. The broad high pressure profiles in these plasmas produce two advantages: high fusion performance, and a large self-generated "bootstrap" current that accounts for over half of the total plasma current. An additional 30% of the current is driven by the neutral beam heating system. With no other current drive, the plasma's current profile would relax and become more peaked near the magnetic axis, ultimately triggering magnetohydrodynamic instabilities in the plasma. In order for this high performance plasma to become steady state, the remaining inductive current, concentrated near the half-radius of the plasma during the high performance phase, must be replaced with something else. In DIII-D this current can be generated by an electron cyclotron current drive (ECCD) system, comprised of a number of gyrotrons capable of producing megawatts of microwave power at 110 GHz. These microwaves can be aimed to drive current at a desired location in the plasma. In the recent experiments, 120 kA, about 10% of the total current, was driven by ECCD in this region. The combination of bootstrap, neutral beam and ECCD resulted in a high performance plasma with over 90% of the current driven noninductively and with the current profile relaxation significantly slowed. Similar results have been observed in two different AT regimes in DIII–D, indicating that the promise of ECCD is ubiquitous and is not confined to a particular set of parameters. This first demonstration of a large ECCD effect in a high pressure tokamak plasma is an indication of the promise of the planned full gyrotron system. Calculations based on these results indicate that this planned system, in conjunction with neutral beam and bootstrap driven current, will be capable of sustaining the current profile in a high performance plasma for the full duration of the DIII-D plasma.



Without the ECCD, the plasma current would normally "shrink" toward the magnetic axis. Off-axis current driven by ECCD slows this evolution and can maintain a nearly steady current profile with the maximum value away from the axis, favorable for high fusion performance and bootstrap current.

About DIII–D

DIII–D (Dee Three Dee) is a National Fusion Facility where researchers advance fusion science to provide the basis for fusion as a long-term energy source. DIII–D is the largest, best diagnosed, and most versatile of all U.S. fusion experimental devices. It is the focus of over 60 active collaborations and research agreements including 8 national labs, 18 U.S. universities, and 14 other nations including Japan, Korea, Germany, France, England, China, and Russia. DIII–D is operated by General Atomics in San Diego, California. Please visit our website at http://fusion.gat.com

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