The ECH Launcher for ITER*

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Electron cyclotron startup, heating, and current drive are planned for ITER. Power of 50 MW at 170 GHz must be supplied to the plasma in such a way that it can heat and drive current effectively over a range of central magnetic field from 4.0 to 5.7 T. Ideally, the profile of driven current should also be controllable so that discharges with hollow profiles may be maintained. A potential application of ECCD is stabilization of neoclassical tearing modes, which may lead to a doubling of the accessible plasma pressure. For these applications ECH has important advantages in terms of antenna technology due to small size, high power density, and remote location. ECH also has large advantages with regard to reactor properties, such as tritium containment, neutron shielding, mechanical support, and modularity.

The ECH heating and bulk current drive in ITER can be obtained using a single midplane port. Modeling using the TORAY code shows that steering of the beam in the toroidal direction in a plane of constant elevation can provide control over the radial location of the deposition. The Doppler shift moves the absorption toward the antenna (toward large major radius) as the wave becomes more tangential. The magnitude of the shift depends on the plasma temperature, but a steering capability of ±15 degrees at the antenna can provide nearly central heating and current drive for the required range of toroidal field. Similarly, current drive at a minor radius of up to 0.7 can be obtained with moderately high efficiency, but beyond that minor radius trapping and third harmonic absorption reduce the efficiency dramatically.

The engineering aspects of the ECH launcher are being developed. Thermal loads are modest, except for the rf heating of the mirrors, since the launchers are placed behind the first wall/blanket, with the rf propagating through slots in the blanket. Mechanical loads due to disruption forces are moderate. The steering mechanism must be robust, with a compromise between the complexity of individual control of each mirror and the unreliability and inflexibility of a single control for all mirrors. The instrumentation and cooling systems face the same compromise. Analysis of failure modes and consequences must determine the optimum approach.

Stabilization of neoclassical tearing modes requires that currents be driven at the q=3/2 and/or q=2 surfaces. The control necessary to accomplish this using 170 GHz power can be done using a launcher 2.5 m above the midplane. The requirements on this system for mode stabilization are probably inconsistent with those for the main heating/current drive system.

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