Proposal Submission for NSTX Research Forum 2001

Title	High power EBW heating
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The use of electron cyclotron (EC) waves for heating and current drive of magnetically confined plasmas has been traditionally limited to a plasma density range below cutoff of waves at the cyclotron frequency of interest. This restriction greatly limits the usefulness of EC heating, current drive and EC emission diagnostics on low-field plasma confinement devices such as ST's, RFP's and other plasma systems. The in-plasma mode

conversion of EC waves to electron Bernstein waves (EBW) offers the possibility of greatly extending the useful density range over which high frequency ECH type heating techniques and capabilities can be utilized. The EBW wave propagates only where the plasma frequency exceeds the cyclotron frequency. This necessitates a wave tunneling process for coupling power from outside the plasma. Idealized modeling of the EBW tunneling physics indicates that high coupling efficiency is theoretically possible through two different routes. Both routes depend strongly on the edge plasma density profile and require very precise control over the launched beam direction and quality. One approach is direct X-mode conversion (perpendicular launch) via wave tunneling through the critical layer. It has the advantage of a relatively simple launcher but may have low coupling efficiency. An alternate is the O-X-B scenario with O-mode propagation to the cutoff and a mode conversion at the turning point. Once it is excited, the absorption of the mode converted wave is extremely high. To get efficient mode conversion the density scale length must be very short. There are concerns that density fluctuations can interfere with the process.
The use of EBW for heating has been demonstrated in one experiment (W7AS), however, the state of the technology and experimental database are limited. The EBW emission results from CDX-U, MST, MAST and NSTX have been very encouraging. The CDX-U and NSTX results indicate that when steep edge gradients are present, emission coupling efficiencies of up to 20% can be obtained. Optimized launching structures and edge profiles should lead to higher efficiencies. An 18 GHz ECH system has been installed on NSTX to provide plasma pre-ionization and is also being used to conduct electron Bernstein wave (EBW) coupling experiments for $n_{||}=0$ launch. This system consists of two klystrons with separate waveguide transmission systems and corrugated horn launchers. The launch polarization is linear and can be adjusted to any plane by installing waveguide twists. The launch location is not currently optimized for EBW absorption. We propose to modify the launchers to improve the coupling. In addition, we propose to implement a high power system (2 ea. 200KW, 28 GHz gyrotrons). To aid in improving the coupling, edge density information from the ORNL reflectometer system and Thomson scattering will be used. The various launch and power supply options will be discussed.

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