ICRF Mode Conversion Studies with Phase Contrast Imaging and Comparisons with Full-Wave Simulations*

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Waves in the ion cyclotron range of frequencies (ICRF) are widely used to heat tokamak plasmas. In Alcator C-Mod, fast waves (FW) are used for hydrogen minority heating. When the minority heating is weak, the FW may convert to ion cyclotron waves (ICW) and ion Bernstein waves (IBW) around the ion-ion hybrid resonance (mode conversion). The mode converted waves (ICW/IBW) are damped fairly strongly and heat the plasma in the vicinity of the hybrid resonance. The waves are of interest as an actuator to control plasmas not only through localized heating but also through flow drive [1] and current drive [2]. Full-wave simulations are essential to describe these processes accurately, and it is important that these simulation codes be validated. On C-Mod, direct measurements of the mode converted waves have been performed using Phase Contrast Imaging (PCI) [3]. PCI is a type of an interferometer that measures fluctuating line-integrated electron density. A CO_2 laser is used and detected by a one-dimensional HgCdTe detector array. The beam passes through the plasma vertically and the system is sensitive to fluctuations with radial wavenumber k_R = 2-15 cm^{-1}. The mode converted waves have k_R = 5-10 cm^{-1}, which makes our PCI a suitable diagnostic for measurements of these waves. Two dimensional full-wave codes TORIC [4] and AORSA [5] are used to simulate the rf wave field. AORSA is coupled to a Fokker-Planck code CQL3D [6], which allows calculation of the wave field in regimes where minority ion species concentration is small, and modification of the distribution function due to the wave absorption is significant. The simulated electron density fluctuations of the waves are line-integrated and diagnostic response is applied, thereby "synthesizing" PCI signal for direct comparison to the measurements.

The experiments were performed in D-H and D-^{3}He plasmas over a wide range of ion species concentrations. Toroidal variation of the wave field was observed from measurements using antennas at different toroidal locations. The observed fluctuation intensity was small at low minority concentration and increased as the concentration was increased, consistent with stronger mode conversion at weaker minority heating. However, the observed density fluctuation intensity was smaller than those predicted by AORSA/CQL3D in general. Detailed comparison of measurements and simulations at different ion species concentrations will be presented.

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