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Experimental results from three-ion species heating scenario on Alcator C-Mod

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Recent experiments on Alcator C-Mod using a small fraction of 3He added to a H(D) plasma have demonstrated efficient ion cyclotron radio frequency (ICRF) heating and indications of MeV 3He tail temperatures. For high toroidal magnetic field B0=8 T discharges with D majority, 3He minority absorption is typically used and has low single pass absorption compared to the H minority absorption scenario. We have observed strong toroidal rotation that is correlated with RF power absorption on thermal 3He ions via mode converted waves. ICRF can also generate high energy ions and this provides a tool to study fast ion dynamics and optimize the quality of plasma confinement. This new scenario has much higher absorption and works by adjusting concentrations of the majority and two minority species to arrange that the polarization of the ICRF wave is favorable for ion heating at the location of the cyclotron resonance of a third trace species.

Experiments using a H:D:(3He) three-ion scenario were carried out on C-Mod with an 8T field and an H:D ratio of approximately 2:1. The 3He fraction was varied from 0.4% to 2%. A strong increase in toroidal Alfvén eigenmode (TAE) activity coincided with the addition of 3He to the H(D) plasmas. TAE activity is indicative of the formation of fast ions with a energy on the order of 1 MeV. Increased heating localized around the 3He fundamental cyclotron layer was also observed. We will present analysis of the minority ion temperature using Fokker-Planck calculations coupled with a full wave code over a range of 3He fractions. These temperatures will be compared with theoretical calculations of TAE thresholds. A synthetic PCI diagnostic using the modeled 3D RF fields will be compared to the experimental PCI to determine the breakdown between the two competing absorption mechanisms present in mode conversion layer. These mechanisms can either heat electrons or ions or drive momentum in the ion channel. We will conclude with a discussion of the applicability of this scenario to the upcoming D-T campaign on JET, operations on ITER and as a source of pseudo-alphas on W7-X.

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