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Observation of ICRF Mode Conversion Plasma Flow Drive on Alcator C-Mod[1]

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Plasma flow driven by externally launched rf waves could be important in stabilizing micro- and macro-instabilities in tokamaks. We report the first observation of both toroidal (V_ϕ) and poloidal (V_θ) flows driven via an ICRF mode conversion (MC) process in D(^{3}He) plasmas. At modest ^{3}He levels ($n_{3He}/n_e \sim 8\%$), in relatively low density plasmas, $<n_e> \leq 1.3\times10^{20}m^{-3}$, heated with 50 MHz rf power ($B_{t0} \sim 5.1$ T), strong V_ϕ in the co-current direction is observed by high-resolution x-ray spectroscopy. The central V_ϕ scales with the applied rf power ($\leq$ 30 km/s per MW), and is at least a factor of 2 more than the empirically determined intrinsic plasma rotation [1]. The rotation near the plasma center ($r/a < 0.3$) responds more quickly to the applied rf power than the outer region, indicative of a local flow drive source. Localized poloidal rotation ($0.3 \leq r/a \leq 0.5$) in the ion diamagnetic drift direction is observed when $P_{rf} \geq 1.5$ MW and increases with power ($\sim$ 2 km/s at 3 MW). Turbulence spectrum broadening seen by a phase contrast imaging (PCI) system indicates strong flow also exists in the main ions. The mode converted ion cyclotron wave (MC ICW) is observed by PCI and confirmed by 2-D full wave TORIC code simulation. The simulation result shows that due to the up-shifted $k_{||}$,the MC ICW is strongly damped on ^{3}He ions in the vicinity of the MC layer, approximately on the same flux surfaces where poloidal flow is observed. The involvement of ion heating and short-wavelength slow wave is consistent with theoretical considerations for efficient rf flow drive. Our experimental results are comparable to the predictions [2], assuming similar ion interaction mechanism for the MC ICW and direct launch ion Bernstein wave. The feasibility of ICRF flow drive on ITER will be discussed. [1] J. E. Rice, et al, Nucl. Fusion **47**, 1618 (2007). [2] J. R. Myra and D. A. D'Ippolito, Phys. Plasmas **9**, 3867 (2002).

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