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**HHFW Heating Efficiency and Current Drive Enhancement at Longer Wavelengths on NSTX**[1]

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High harmonic fast wave (HHFW) heating and current drive (CD) are being developed on NSTX for supporting startup and sustainment of the ST plasma. Considerable enhancement of the core heating efficiency ($\eta$) under CD conditions has been demonstrated, correlating strongly with locating the onset density for fast wave perpendicular propagation – $n_{onset} \propto B_\phi \times k_{||}^2/\omega$ – away from the antenna/wall. FW fields propagating close to the wall with decreasing $B_\phi$ and $k_{||}$ could enhance both parametric decay instability (PDI) losses and losses in sheaths and structures around the machine. HHFW RF power delivered to the core plasma of NSTX is strongly reduced as $k_{||}$ is reduced – for $B_\Phi$= 4.5kG, heating is $\sim$ 1/2 as effective at $k_\phi$= - 7m$^{-1}$ as at 14 m$^{-1}$ and $\sim$ 1/10 as effective at - 3m$^{-1}$. A dramatic increase in $\eta$ is observed for $k_\phi$ - 7m$^{-1}$ when $B_\phi$ is increased to 5.5 kG (central $T_e$ near 4 keV at $P_{RF}$ = 2 MW), when the density 2 cm in front of the antenna is at or below $n_{onset}$. However, $\eta$ is not improved when the density immediately in front of the antenna is elevated relative to the onset value. Furthermore, $\eta$ at even lower $k_\phi$ still falls off rapidly with the $k_\phi$value. Measured edge ion heating, attributable to PDI, does not change significantly with $B_\phi$ and thus the improvement in $\eta$is attributed to a reduction of surface FW losses. This work is important for understanding the role of perpendicular propagation of fast waves near the antenna/wall on surface power losses generally, and has important implications for FW heating efficiency in the standard minority regimes as well. For example, the antenna bombardment observed for $k_{||}$ near zero excitation on TFTR can be attributed to $n_{onset}$ being exceeded at the antenna face. Improved detection of CD effects under conditions of higher coupling efficiency on NSTX will be presented.

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