# SUPPRESSION OF NEOCLASSICAL TEARING MODES IN THE PRESENCE OF SAWTEETH INSTABILITIES BY RADIALLY LOCALIZED OFF-AXIS ELECTRON CYCLOTRON CURRENT DRIVE IN THE DIII–D TOKAMAK*

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Neoclassical tearing modes (NTMs) are islands destabilized and maintained by a helically perturbed neoclassical bootstrap current and represent a significant limit to performance at higher poloidal beta. The m=3, n=2 mode alone can decrease stored energy up to 30%. Radially localized off-axis co-current drive could replace the "missing" bootstrap current in the island O–point and stabilize the NTM, as was confirmed in ASDEX-Upgrade [1,2]. In that work, the periodic long-lived q=1 sawteeth instabilities which can provide seed islands to trigger the NTM (and are expected to occur in reactor tokamaks such as ITER-EDA) were abated by the m/n = 3/2 NTM and tended not to return with stabilization by the electron cyclotron current drive (ECCD).

Complete suppression of an m/n = 3/2 NTM island of full width w ≈ 7 cm (w/r ≈ 20%) was achieved in DIII–D in the presence of sawteeth. Discharges in DIII–D with near tangential beams exhibit strong periodic q=1 sawteeth instabilities which continue in the presence of NTMs and/or off-axis ECCD. Up to four 110 GHz gyrotrons producing up to 2.3 MW (injected) for at least 1 second are used for co-current drive well off-axis ($\rho \approx 0.6$). RF launch is chosen to maximize $J_{ECCD}$ at the island location rather than $I_{ECCD}$. The peak local $J_{ECCD}$ was $\gtrsim 1.5 \times J_{BS}$ aligned to $|\Delta r| \lesssim 1$ cm of the island O–point ($|\Delta r|/r \lesssim 3\%$). Beta recovered to about the pre-NTM level. Discharges in which the q=1 sawteeth instabilities are "frequency coupled" to the m/n = 3/2 NTM island rotation were resistant to full suppression. The conditions for suppression of both q=1 coupled and uncoupled NTMs on rf power, $J_{ECCD}$, alignment and means of alignment will be reported. Diagnostics and codes for measurement and analysis of the suppression physics include: (1) 35 channel motional Stark effect (MSE) poloidal field profile measurement for EFIT reconstruction which includes allowing local features with strong gradients for local current drive, (2) 32 channel fast electron cyclotron emission diagnostic for NTM island location and structure and (3) the TORAY-GA code for calculation of the predicted local rf current density.

[1] G. Gantenbein, et al., Phys. Rev. Lett. **85**, 1242 (2000).
[2] H. Zohm, et al., accepted for publication in a special issue of Phys. Plasmas.

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