Influence of plasma flow shear on tearing in DIII-D hybrids*

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That plasma flow shear has a stabilizing effect on tearing stability is a new insight found from experiments on DIII-D, JET, and NSTX [1]. High-order (m/n=4/3 or 3/2) tearing modes are a key beneficial feature in hybrid scenarios that act to regulate the q-profile to keep $q(0)$~1 with the absence of large m/n=1/1 sawteeth. The destabilization of low-order (m/n=2/1) tearing acts as the limit on achievable beta [2]. Hybrid discharges in DIII-D with 4/3 tearing modes under large co- to I_p neutral-beam torque can be run steadily just below the 2/1 tearing beta limit. However, reducing the torque has consequences on both the existing 4/3 tearing mode amplitude and the beta at which the 2/1 tearing mode destabilizes. It is found that flow *shear* (not flow) at a rational surface is best correlated with both decreased 4/3 mode amplitude and higher beta 2/1 mode onset. The working physics model is that flow shear is classically stabilizing, i.e., makes the tearing stability index Δ' more negative; this both reduces the amplitude of neoclassical tearing modes and makes mode destabilization more difficult (requiring higher beta). However, a detailed understanding of the effects of flow shear on tearing stability remains a challenge for theory and modeling. The classically stabilizing effect of flow shear in DIII-D (and indeed future larger tokamaks) is in the regime of large magnetic Prandtl and very large Lundquist numbers [3]; this is significant for sorting out which physics of flow and flow shear is relevant and would be stabilizing or even destabilizing. Experimental data with applied torque varied from all co- to I_p to near-balanced neutral beams in the DIII-D hybrid scenario with 4/3 mode ”regulation” will be presented, showing mode amplitude, 2/1 onset, and criticality for 2/1 mode locking. Future tokamaks with large inertia and low applied torque may have less tearing stability than now expected.

[1] R.J. La Haye, et al., accepted for publication in Phys. Plasmas.

[2] P.A. Politzer, et al., Nucl. Fusion **48**, 075001 (2008).

[3] R. Coelho and E. Lazzaro, Phys. Plasmas **14**, 012101 (2007).

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