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Optimization of the Plasma Response for the Control of Edge-Localized Modes with 3D Fields

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Measurements and modeling of the plasma response to applied 3D magnetic perturbations –specifically its dependence on collisionality, beta, and rotation –yield new insight into the physics of edge-localized mode (ELM) control and better define the criteria needed to achieve ELM suppression in ITER. ELM control depends on the coupling of the applied field to a stable edge mode that drives resonant fields on edge rational surfaces and is directly observed on high-field side (HFS) magnetic sensors. The edge mode amplitude is inversely proportional to pedestal collisionality yet is insensitive to global beta, consistent with a current-driven mode as opposed to a pressure-driven kink, and reinforcing the importance of ITER-like collisionality to resonant field drive [1]. Advances in ideal MHD modeling have identified highly stable, beta-independent plasma response modes that nonetheless drive strong resonant fields –showing a path to ELM control with minimal impact on global stability [2,3]. Onset of ELM-suppression is consistent with a transport bifurcation driven by the penetration of resonant fields, evidenced by sudden changes in: boundary heat flux, visible helical striations, pedestal-top rotation and fluctuations, and HFS magnetic effects [4]. Systematic torque and beta scans reveal a loss of ELM suppression consistent with two-fluid modeling predictions of a reduction in the penetrated field [5]. These results further the development of quantitative models for the conditions necessary to achieve ELM suppression, emphasizing both edge mode coupling for resonant field drive, and low pedestal-top electron rotation for resonant field penetration. Optimization of the equilibrium conditions and discharge evolution, in addition to the applied field structure, will be required to successfully achieve ELM suppression in ITER.

[1] C. Paz-Soldan et al, Nucl. Fusion 2016 (in press)
[2] C. Paz-Soldan et al, Phys. Rev. Lett. 114, 105001 (2015)
[3] N. Logan et al, Phys. Plasmas 2016 (in review)
[4] R. Nazikian et al, Phys. Rev. Lett. 114, 105002 (2015)
[5] R. Moyer et al, Nucl. Fusion 2016 (in preparation)

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Primary author: Dr PAZ-SOLDAN, Carlos (Oak Ridge Institute for Science Education)

Co-authors: GAROFALO, A. (General Atomics); WINGEN, A. (Oak Ridge National Laboratory); GRIERSON, B. (Princeton Plasma Physics Laboratory); LYONS, B. (General Atomics); HEGNA, C. (University of Wisconsin--Madison); LASNIER, C. (Lawrence Livermore National Laboratory); ORLOV, D. (University of California San Diego); STRAIT, E. (General Atomics); MCKEE, G. (University of Wisconsin-Madison); CALLEN, J. (University of Wisconsin-Madison); FENSTERMACHER, M. (Lawrence Livermore National Laboratory); LANCTOT, M.

(General Atomics); SHAFER, M. (Oak Ridge National Laboratory); FERRARO, N. (Princeton Plasma Physics Laboratory); LOGAN, N. (Princeton Plasma Physics Laboratory); SNYDER, P. (General Atomics); GROEBNER, R. (General Atomics); MOYER, R. (University of California San Diego); NAZIKIAN, R. (Princeton Plasma Physics Laboratory); WILCOX, R. (Oak Ridge National Laboratory); HASKEY, S. (Princeton Plasma Physics Laboratory); EVANS, T. (General Atomics); LUCE, T. (General Atomics); RHODES, T. (University of California Los Angeles); SOLOMON, W. (General Atomics); CHEN, X. (General Atomics)

Presenter: Dr PAZ-SOLDAN, Carlos (Oak Ridge Institute for Science Education)

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