Toroidal modelling of core plasma flow damping by RMP fields in hybrid discharge on ASDEX upgrade

N. Zhang, Y.Q. Liu, P. Piovesan, V. Igochine, D.L. Yu1, . Wang, G.Q. Dong, G.Z. Hao, G.L. Xia, W.J. Chen, L. Liu, J.Q. Li, X. Bai, The HL-2A Team, The ASDEX Upgrade Team and The EUROfusion MST1 Team

Nucl. Fusion **60** (2020) 096006; https://doi.org/10.1088/1741-4326/ab9dce

Abstract:
In ASDEX Upgrade hybrid discharges, it is found that an externally applied n = 1 field preferentially distorts the plasma in the core, leading to significant flow damping there and elsewhere across the plasma radius. MARS-F/Q modeling of a neoclassical toroidal viscous NTV) torque that results from an amplified internal kink-type displacement in the plasma core is qualitatively consistent with the measured internal displacements, beta dependence, and rotation damping. Sensitivity studies indicate that the internal kink response and the resulting core flow damping critically depend on the plasma equilibrium pressure, the initial flow speed, the coil phasing and the proximity of q0 to 1. No appreciable flow damping is found for a βN plasma. A relatively slower initial toroidal flow results in a stronger core flow damping, due to the enhanced NTV torque. Weaker flow damping is achieved as q0 is assumed to be farther away from 1. Finally, a systematic coil phasing scan finds the strongest (weakest) flow damping occurring at the coil phasing of approximately 20 (200) degrees, quantitatively agreeing with experiments. This study points to the important role played by the internal kink response in plasma core flow damping in high-beta hybrid scenario plasmas such as that foreseen for ITER.