7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Toroidal modeling of plasma flow damping and density pump-out by RMP during ELM mitigation in HL-2A

N. Zhang[1], Y.Q. Liu[2], D.L. Yu[1], Yi Liu[1], L. Liu[1], G.Z. Hao[1], X.X. He[1], T.F. Sun[1], S. Wang[1], G.Q. Dong[1], X.Bai[3,1], Z.B. Shi[1], W.L. Zhong[1] and M. Xu[1]

[1] Southwestern Institute of Physics, P. O. Box 432, Chengdu 610041, China, [2] General Atomics, PO Box 85608, San Diego, CA 92186-5608, USA, [3] ITER Organization, Route de Vinon, CS 90 046, 13067 Saint Paul Lez Durance, France

zhangn@swip.ac.cn

Abstract

Reduction of both the plasma density and toroidal flow speed, due to application of the predominantly n=1 (n is the toroidal mode number) resonant magnetic perturbation (RMP) for controlling the edge localized mode in the HL-2A tokamak, is numerically investigated utilizing the quasi-linear initial-value code MARS-Q (Liu *et al* 2013 *Phys. Plasmas* **20** 042503). Simulation results reveal that the neoclassical toroidal viscosity (NTV) due to 3D fields plays the key role in modifying the plasma momentum and particle transport in the HL-2A discharge. By comparing the modeling results with the measured density pump-out in the experiment, the electron NTV particle flux model, in combination with the free-boundary condition for the axisymmetric change of the density at the plasma edge, is found to yield the best agreement in terms of both the pump-out level and the overall time scale. Further sensitivity studies show that the simulated density pump-out level is reasonably robust against variations in the model assumptions, including the particle diffusion model and the non-ambipolar versus ambipolar NTV particle flux. The latter however affects the time scale for reaching the steady state solution. Finally, it is found that the plasma edge-peeling response, the NTV torque, as well as the plasma momentum and particle transport, all are sensitive to the toroidal phase difference between the upper and lower rows of the RMP coil currents in HL-2A, with the 30 degrees coil phasing producing the minimal side effects on the plasma.

Key words: RMP; density pump-out; flow damping; NTV

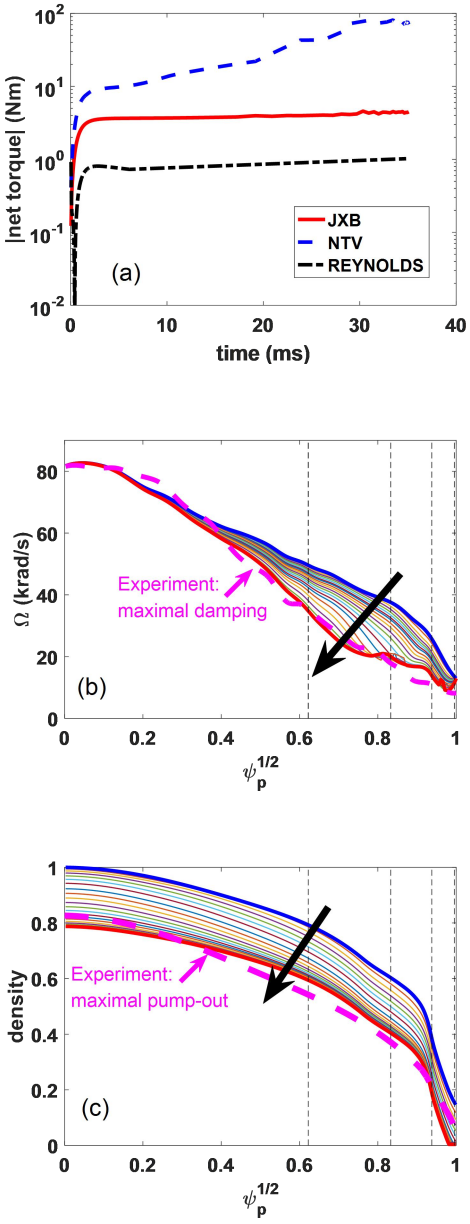

Figure 1 The MARS-Q quasi-linear initial-value simulation of the HL-2A discharge 36965 with the applied n=1 RMP field, based on an equilibrium reconstructed at 1150 ms.

References

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