Modeling of fast neutral-beam-generated ion effects on MHD spectroscopic observations of RWM stability in DIII-D plasmas

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Abstract. Experiments conducted at DIII-D investigate the role of drift kinetic damping and fast neutral beam injection (NBI)-ions in the approach to the no-wall β_N limit. Modelling results show that the drift kinetic effects are significant and necessary to reproduce the measured plasma response at the ideal no-wall limit. Fast neutral-beam ions and rotation play important roles and are crucial to quantitatively match the experiment. In this paper we report on the model validation of a series of plasmas with increasing β_N, where the plasma stability is probed by active magnetohydrodynamic (MHD) spectroscopy. The response of the plasma to an externally applied field is used to probe the stable side of the resistive wall mode and obtain an indication of the proximity of the equilibrium to an instability limit. We describe the comparison between the measured plasma response and that calculated by means of the international tokamak physics activity benchmarked version of the drift kinetic MARS-K code [Y.Q. Liu, et al., Phys. Plasmas **15**, 112503 (2008)], which includes the toroidal rotation, the electron and ion drift-kinetic resonances, and the presence of fast particles for the modelled plasmas. The inclusion of kinetic effects allows the code to reproduce the experimental results within ~13% for both the amplitude and phase of the plasma response, which is a significant improvement with respect to the undamped MHD-only model. The presence of fast NBI-generated ions is necessary to obtain the low response at the highest β_N levels (~90% of the ideal no-wall limit). The toroidal rotation has an impact on the results, and a sensitivity study shows that a large variation in the predicted response is caused by the details of the rotation profiles at high β_N.

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