Investigating the effect of neoclassical tearing modes on fast ions in ASDEX Upgrade: measurements and modelling

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Neoclassical tearing modes (NTMs) are pressure-driven MHD instabilities which degrade the plasma performance and can lead to disruptions. They form at rational surfaces, typically appearing in plasmas with high β_N values, and have been observed to be responsible for fast-ion losses[1, 2, 3]. Here we present first measurements of the internal redistribution of neutral beam injected fast ions caused by NTMs in ASDEX Upgrade, as inferred from tomographic reconstructions and radial profiles of fast-ion D_α spectroscopy. Depending on its size and amplitude, the NTM can cause a significant reduction of the fast-ion density. Neoclassical simulations using an axisymmetric transport code have been performed, considering the NTM-induced modification of plasma profiles, but not the structure of the magnetic perturbation itself. In this case the simulated fast-ion transport is not sufficient to explain the observations and additional anomalous diffusion is needed. This is especially the case for $(m,n) = (2,1)$ NTMs, where m and n refer to the poloidal and toroidal mode numbers, respectively. To carry out more sophisticated simulations, considering the 3D magnetic structure of the NTMs, we describe the perturbation analytically, add it to the axisymmetric equilibrium and feed it into the full-orbit Monte Carlo fast-ion codes LOCUST[4] and ASCOT[5]. The resulting predicted fast-ion redistribution is presented and compared with the experimental results.

References

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