Effects of MHD instabilities on Neutral Beam current drive

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Neutral beam injection (NBI) is one of the primary tools foreseen for heating, current drive (CD) and q-profile control in future fusion reactors such as ITER and a Fusion Nuclear Science Facility. However, fast ions from NBI may also provide the drive for energetic particle-driven instabilities (e.g. Alfvénic modes - AEs), which in turn redistribute fast ions in both space and energy, thus affecting the control capabilities and overall efficiency of NB-driven current. Based on experiments on the NSTX tokamak, the effects of AEs and other low-frequency MHD instabilities on NB current drive efficiency are investigated. It is found that instabilities do indeed reduce the NB-driven current density over most of the plasma radius by up to ~50%. Experimental results are then used to benchmark numerical tools to simulate NB-CD in the presence of instabilities. A new fast ion transport model, which accounts for particle's transport in phase space as required for resonant AE perturbations, is developed for the tokamak transport code TRANSP and utilized to obtain consistent simulations of NB-CD. Predictions for the NSTX-Upgrade device, which features a new set of off-axis NB injectors, are finally discussed for projected scenarios with different levels of MHD activity.

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