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Study of the fast-ion distribution function in the TCV tokamak based on FIDA spectroscopy and the TRANSP code

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The behavior of fast particles in high temperature plasmas must be understood in view of future fusion devices. Fast particles result as a product of the fusion process and can be generated by neutral beam injection (NBI) or ion cyclotron heating. They heat the background plasma via collisions on electrons and ions and can, in case of an anisotropic velocity space distribution, drive non-inductive currents. The corresponding heating and current drive profiles depend strongly on the fast-ion confinement properties which can be affected in presence of plasma instabilities, such as Alfvén eigenmodes or sawtooth crashes. Since a clear experimental quantification and reliable theoretical predictions of the instability-induced fast-ion transport are still missing, detailed studies of the fast-ion distribution function are required.

In the TCV tokamak, fast ions can be generated by a newly installed NBI source with 1 MW of power, which started operation in January 2016. The beam has a tangential geometry and injects deuterium neutrals with a full energy of 25 keV. The fast-ion D-alpha (FIDA) technique is employed to study the corresponding fast-ion distribution function. Toroidal lines of sight that cross a diagnostic neutral beam collect strongly Doppler shifted Balmer Alpha radiation from fast ions after charge exchange. Good signal to noise ratios are obtained due to the application of a F/2 spectrometer and due to the presence of very large fast-ion densities in TCV, explained by the high ratio of NBI heating power to plasma volume (˜1 mˆ3).

For the interpretation of measured FIDA signals, the TRANSP[1] and FIDASIM[2] codes have been implemented at TCV. TRANSP predicts theoretical fast-ion distribution functions which are used as input for FIDASIM to calculate synthetic FIDA measurements. First comparisons between neoclassical predictions and measured FIDA spectra and profiles will be discussed. In addition, this contribution will present initial results on the effect of the fast-ion population on the loop voltage, internal inductance, normalized beta and the neutron rate. These quantities change significantly when NBI is turned on and allow one to address the fast-ion transport properties and to validate theoretical models.

[1] Hawryluk R. et al 1980 Phys. Plasmas Close Thermonucl. Cond. 1 19

[2] Heidbrink, W. et al., Commun. Comput. Phys. 10 (2011) 716.

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