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Experimental Quantification of the Impact of Large and Small Scale Instabilities on Confined Fast Ions in ASDEX Upgrade

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The transport of fast, suprathermal ions as generated by neutral beam injection (NBI) is an important topic in fusion research. In unperturbed plasmas the fast-ion transport is expected to be neoclassical, i.e. dominated by collisions, while an anomalous transport is observed in the presence of instabilities. This anomalous fast-ion redistribution must be investigated in detail because it may limit the heating and current drive performance in future fusion devices and could even damage the first wall.
At the ASDEX Upgrade tokamak, fast ions are generated by up to 8 different NBI sources and their distribution function can be measured by a comprehensive set of diagnostics: A multi-view fast-ion D-alpha (FIDA) spectroscopy diagnostic, neutral particle analyzers, neutron measurements and fast-ion loss detectors (FILD) permit studies in velocity space and real space.
A reduction of the central fast-ion density of up to 50% has been measured in experiments with strong sawtooth activity. Outside the q=1 surface, a corresponding increase is observed while the FILDs show no significant fast-ion redistribution to unconfined orbits. Simulations that assume flux aligned transport can explain the radial shape of this measured internal fast-ion redistribution well, but they underestimate its magnitude which could be explained by ExB drifts.
Measurements during strong activity of reversed shear Alfvén eigenmodes (RSAE) show significant differences to neoclassical predictions. The observed radial fast-ion profiles are strongly flattened and broadened compared to the predictions. Non-linear simulations of the RSAE-induced fast-ion transport using the HAGIS/LIGKA code will be compared with the experimental data.
In MHD-quiescent plasmas, a clear change of the radial fast-ion profiles is measured when replacing on-axis NBI with off-axis NBI. Neoclassical predictions are in very good agreement with this observation while simulations that assume an anomalous transport of 0.5m2/s do not fit the experimental data. This is, however, in contradiction with previous off-axis NBI current drive experiments that related the absence of a measurable fast-ion driven current to a turbulence-induced fast-ion redistribution. New off-axis NBI current drive experiments are, hence, being conducted to resolve this contradiction and the results of this investigation will be discussed.

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