Prompt Non-resonant Neutral Beam-ion Loss induced by Alfvén Eigenmodes in the DIII-D Tokamak

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Abstract. Prompt neutral beam-ion loss due to non-resonant scattering caused by toroidicity-induced and reversed shear Alfvén eigenmodes (TAE/RSAEs) have been observed in DIII-D. The coherent losses are of full energy beam ions born on unperturbed trapped orbits that would carry them close to a fast ion loss detector (FILD) within one poloidal transit. However, in the presence of AEs, the particles are expelled from the plasma before completing their first poloidal orbits. The loss signals on FILD emerge within 100 μs after the beam switch-on (which is the time scale of a single poloidal transit) and oscillate at mode frequencies. Time-resolved loss measurements show a linear dependence on the AE fluctuation amplitude and a radial "kick" of ~10 cm by an n=2 RSAE at $\delta B/B \leq 1\text{x}10^{-3}$ can be directly inferred from the measurements. Full-orbit modeling of the fast-ion displacement caused by the AEs is in good quantitative agreement with the measurements. Direct interactions of the mode and the beam-ion orbit can account for a large fraction of fast ion losses observed in such DIII-D discharges. The first orbit non-resonant loss mechanism may also contribute to enhanced localized losses in ITER and future reactors. A new diagnostic of the radial displacement is inspired by these findings and can be used to study the interaction between fast ions and various MHD modes as well as three-dimensional fields.

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