# Enhanced Localized Energetic Ion Losses Resulting from First-orbit Linear and Nonlinear Interactions with Alfvén Eigenmodes in DIII-D*

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First observations of enhanced prompt neutral beam-ion losses due to non-resonant scattering by Alfvén eigenmodes (AEs) in DIII-D provide a novel measure of the displacement of fast-ions due to individual modes. The coherent losses are from full energy beam-ions born on unperturbed trapped orbits that pass close to a fast-ion loss detector (FILD) within one poloidal transit. However, the perturbing effect of AEs can cause the particles to be expelled from the plasma before completing their first poloidal orbit. The FILD signals emerge within 100 μs after the beam switch-on, which is the time scale of a single poloidal transit, and oscillate at the mode frequencies. This loss mechanism can account for a large fraction of fast-ion losses observed in some DIII-D discharges (even for mode amplitudes as low as $\delta B/B \leq 1\mathrm{x}10^{-3}$). Time-resolved loss measurements show a linear dependence on the AE amplitude. Simulations with the full-orbit-following SPIRAL code reveal that the dominant losses are due to a change of the magnetic moment rather than the toroidal canonical momentum. A fast-ion radial displacement of ~10 cm is directly measured, which provides a unique experimental validation of SPIRAL simulations and suggests a new diagnostic method.

The FILD signals also probe nonlinear interactions, needed to develop a self-consistent model of AE induced transport. Oscillations in the beam-ion losses are observed at the sum and difference frequencies of two AEs as well as at the second harmonics — these oscillations are absent in magnetic, density, and temperature fluctuations. The nonlinear features seen by FILD can be explained by an analytical model, where changes in phase caused by deflections of the orbit at fundamental frequencies generate the additional frequencies. SPIRAL simulations that include the toroidal geometry, beam deposition profiles, and realistic eigenmodes show good agreement with the observations.

*Supported by the US DOE under SC-G903402 & DE-FC02-04ER54698.