Experimental determination of the threshold for “stiff” fast-ion transport by Alfvén eigenmodes

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Three separate DIII-D experiments suggest critical threshold-like behavior for fast-ion transport in the presence of many, small-amplitude Alfvén eigenmodes (AE). During the current ramp, although the amplitude of AE activity is largest for peaked beam deposition profiles, the measured fast-ion profile is nearly identical [1]. Similarly, in steady-state scenario plasmas, fast-ion transport is large in plasmas with many AEs but nearly classical in plasmas with few AEs [2,3]. Recent experiments concentrate on accurate determination of the threshold for appreciable transport. Modulation of one beam source permits measurement of the incremental fast-ion transport vs. AE amplitude. The AE amplitude is varied by scanning the average beam and electron cyclotron heating power. Neutral-particle analyzer (Fig. 1), fast-ion Dα (FIDA), neutron, and scintillator loss detector diagnostics all detect a rise in transport above a certain phase-space dependent AE amplitude threshold. The FIDA data indicate that the peak of the modulated fast-ion flux occurs at normalized minor radii of ρ=0.3-0.6, corresponding to the radial location of AEs.

These experiments are guiding development of “critical gradient” models that can predict alpha profiles in future devices. The threshold for appreciable transport is one key issue. The data show that a threshold based on marginal AE stability is too pessimistic. Initial analysis [3] suggests that the onset of stochasticity due to island overlap is necessary. Another hypothesis under investigation is that stiff critical gradient transport results only when the AE growth rate exceeds the ion temperature gradient mode rate at the same low toroidal mode number.

References

![Fig.1. As the average injected beam power increases, the amplitude of AE activity increases until, above a threshold, the modulated fast-ion flux suddenly increases.](image)