Measurements of Alfvén Eigenmode Induced Fast-ion Transport in DIII-D*

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The onset threshold for fast-ion transport due to Alfvén eigenmode (AE) activity in DIII-D appears to differ between various fast-ion diagnostics, indicating a phase-space dependence of fast-ion transport. A method for measuring fast-ion transport using a source modulation technique will be discussed. In the experiment, the AE activity is varied with total neutral beam injected power, while the fast-ion pressure profile is modulated using an off-axis neutral beam. The neutral-particle analyzer (SSNPA) is sensitive to the trapped particle population and indicates sudden onset of transport at 6 MW beam power, while the neutron diagnostic, which is sensitive to the high-energy, counter-passing particles, exhibits threshold near 4 MW. Fast-ion D α (FIDA) spectroscopy indicates radially localized transport of the co-passing population corresponding to the location of mid-core AEs. Transport is determined from the continuity equation for fast-ions, where the time evolution of the measured fast-ion population depends on the source (the modulated beam), the sink (fast-ion thermalization), and transport (due to resonant wave-particle interactions with AEs). The analysis is more complicated than conventional transport analysis techniques, since the measurement is a convolution of the fast-ion distribution function and the instrument weight function which depends on fast-ion energy, pitch, and the diagnostic geometry. The source can be calculated using TRANSP to find the classical fast-ion distribution function in the absence of transport, and the FIDASIM code produces synthetic FIDA and SSNPA signals. At the lowest beam power where transport is small, the modulated FIDA, SSNPA, and neutron signals closely match the simulated signals. At large beam powers, the measured signals deviate substantially from the classical simulations. Recent upgrades to the FIDA diagnostic enables comparison to an expanded phase-space, with 11 oblique viewing chords spanning the full radius and 3 vertical viewing chords. Pinpointing the onset of transport in phase-space and the scaling law for stiff transport beyond threshold is useful in validating critical gradient models [1,2] that aim to predict alpha profiles, beam ion profiles, and losses in future burning plasma devices.

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References
