**Imaging Neutral Particle Analyzer Measurements of Mode-Induced Fast Ion Distribution Function Fluctuations in the DIII-D Tokamak**

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Imaging neutral particle analyzers (INPA) provides precise measurements of the radial, energy and pitch angle of confined fast ions in the DIII-D tokamak [1, 2] including the local fast ion distribution function via tomographic inversion [3] and fast ion phase space flow induced by multiple small-amplitude Alfvén eigenmodes (AE) [4,5]. Recently, two significant improvements have been made to the DIII-D INPA system. Photomultiplier tubes (PMT) are now used to monitor the phosphor light emission of the INPA with large bandwidth. To reduce the electromagnetic noise, the emitted photons are transferred out of machine hall via ~100 m optical fibers. Local fluctuations of the fast ion density with frequencies up to ~250 kHz are observed, which are caused by neoclassical tearing modes, ellipticity-induced AE modes and beta-induced AE modes. This new capability to measure the steady and fluctuating fast ion density of fast ions locally in phase space will shed light on the understanding of diffusive and convective transport during resonant interactions between energetic particles and waves. The second improvement is the development and installation of a new INPA. Complementing the initial DIII-D INPA system [1,2] which probes passing fast ions, this new INPA provides energy-resolved radial profiles of local trapped fast ion density. It measures the counter-Ip (co-Ip) leg of trapped particles, when the plasma current is in the counter-clockwise (clockwise) direction. The new system images a broad radial range from the plasma core to the edge and deuterium energies up to >100 keV at a pitch of about 0.45, with energy resolution of ~10 keV, radial spatial resolution of ~10 cm and pitch resolution of ~4 degree. The initial data demonstrates that the system has exceptionally good signal to noise. This new trapped INPA system also provides the opportunity to extend previous studies of AE-induced fast ion flow to the phase space occupied by fast ions on trapped orbits.

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