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Investigation of Alfvén wave and Ion Temperature Gradient turbulence interaction under modified fast ion scattering conditions in DIII-D

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The DIII-D tokamak's 2024-2025 Fast Ion and Turbulence (FIT) thrust has sought to use a comprehensive suite of energetic particle and turbulence diagnostics to determine the interplay mechanisms between Alfvénic and Ion Temperature Gradient (ITG) driven turbulence in tokamak plasmas, an area of critical importance for the design and operation of future reactor relevant devices. As a result of this thrust, strong evidence that ITG turbulence is decreased in response to increased Alfvén eigenmode (AE) activity has been identified. The preliminary evidence indicates ITG suppression is due to theoretically predicted AE-driven zonal flows shearing apart turbulent eddies. Within this dataset, controlled experiments were conducted which modified the effective fast ion pitch-angle scattering rate (ν_{eff}) and ITG turbulence in the presence of a single marginally unstable Toroidal Alfvén Eigenmode (TAE) driven by a 2 MW, 81 kV neutral beam. These experiments have enabled investigation of the causality of AE activity and ITG suppression by directly modifying ITG turbulence under fixed Alfvén Eigenmode drive conditions (as diagnosed by Electron Cyclotron Emission, CO2 interferometry, and fast magnetics spectroscopy). The methods for ITG turbulence modification include: injection of low-voltage (45 kV) neutral beams, suppression of ITG turbulence via L-H transition, and modification of ITG turbulence by carbon impurity seeding. An L-H transition was induced by changing the plasma shape from Upper Single Null (USN) to Lower Single Null (LSN), and the injection of carbon impurities was performed using the DIII-D Impurity Powder Dropper (IPD) system. Initial detailed analysis indicates background drift-wave turbulence is effectively modified, with Alfvén Eigenmodes exhibiting critical gradient behavior at a normalized beam ion density gradient (a/L_{nb}) close to critical gradient predictions from linear gyro-kinetic calculations from the code CGYRO. Ongoing work seeks to further validate and test these observations using nonlinear gyro-kinetic simulations, as well as performing synthetic diagnostic modeling of these simulations for direct comparison to experimental measurements.

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