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TH/P7-10: Theory of External Geodesic Acoustic Mode Excitation

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It is extremely appealing to externally excite geodesic acoustic modes in a tokamak, either to artificially reduce the turbulent transport provided sufficiently large amplitude is achievable, since GAMs are theoretically expected to impact the transport, or for diagnostic purposes, since the GAM frequency is dependent on the temperature and flux surface shapes. Moreover, even when not sufficient to suppress the turbulence completely, raising the GAM amplitude may lower the LH transition threshold. It can be shown that injection of momentum by heating, neutral particle beams or various plasma waves tends to be rather inefficient. In contrast resonant excitation by magnetic perturbations by external coils is a viable and potentially efficient method. (In principle, this could already be done at present, e.g., in the DIII-D tokamak with the in-vessel ELM stabilization coils).
An elegant way to compute the action of external coil currents on the interior flux surfaces has been discovered, which allows analytical estimates and the coupling of a novel dynamic equilibrium code with a turbulence code to study the resonance in detail. To describe the induced resonance layer within the turbulence calculation it is essential to retain the radial variation of the GAM frequency throughout the computational domain, i.e. use a nonlocal framework and not rely on the flux tube/local approximation. The peaking and phase variation due to the resonance lead to strong flow shear at the resonance, and a modulation and partial suppression of the turbulence by the GAMs. The results offer several control knobs to influence the drive effectivity and aid in designing a GAM drive antenna.
For example, the ELM suppression coils (internal, or I-coils) in DIII-D can produce a perturbation field of 0.02mT at 7kHz, yielding a displacement of about 6mm under good conditions according to the mentioned analytical estimates, while displacement amplitudes larger than 2mm can be readily detected by spectroscopic imaging and Doppler measurements.
Considering all possible optimizations it is evident that generation of geodesic oscillations by external fields is an efficient, viable method with potentially far reaching impact which would allow for the first time to influence poloidal rotation on the fine radial scales relevant to the turbulence.

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