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Review of recent GAM - turbulence interaction studies on ASDEX Upgrade

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The interaction of Zonal Flow / coherent Geodesic Acoustic Mode (GAM) flow oscillations and small-scale turbulence remains an important topic in tokamak confinement studies. Worldwide, significant progress has been made in recent years on the measurement, interpretation and numerical simulation of the GAM properties. On ASDEX Upgrade (AUG) recent attention has focussed on the temporal and spatial behaviour of the edge GAM, and its interaction with the background broad-band density turbulence using microwave reflectometry diagnostics. Experimentally, the GAM intensity (e.g. flow p.t.p. amplitude) is not constant but displays a low frequency (few hundred Hz) intermittency or "breathing" modulation of up to 50%, phase-shifted to a corresponding modulation of both the density turbulence and the broad-band (incoherent) flow perturbation level. The GAM spectral peak width (inversely related to the GAM growth-rate / lifetime) is also generally narrow at a few hundred Hz - consistent with the GAM amplitude modulation. In addition, the high frequency (short wavelength) component of the density turbulence may also be modulated at the GAM frequency, indicating a non-linear energy (spectral) transfer / coupling between the GAM and the background turbulence. Structurally, the GAM is zonal with radial widths of a few cms and radial propagation velocities of a few hundred ms^{-1}. In tokamaks the GAM is axially symmetric, i.e. an $n = m = 0$ form. However, the application of external, non-axisymmetric magnetic perturbation (MP) fields (capable of predominant toroidal mode numbers $n = 0,1,2$ and 4 in AUG) creates 3D stellarator-like field structure, impacting the GAM's radial extent, amplitude, and frequency, as well as enhancing the coupling to magnetic sidebands. There are clear thresholds in the MP field penetration (coil current strength and plasma density etc.) for the onset of the GAM modification. Enhanced GAM magnetic sidebands with an $m = 2$ poloidal structure also appear to be linked to the transition from a GAM radial frequency continuum to an eigenmode radial structure - as predicted by theory. The extent of the above effects are strongly dependent on plasma parameters and the measurement (radial) location. Finally, recent attempts to drive or enhance the natural edge GAM in AUG using localized deposition of ECRH power modulated around the expected GAM frequency have, so far, proven to be unsuccessful. Here, an overview of these AUG experimental studies, supported by numerical simulations, are presented.