Spontaneous Excitation of Geodesic Acoustic Mode by Toroidal Alfvén Eigenmodes

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Zonal structures, such as the finite frequency geodesic acoustic mode (GAM), are generally believed to play important self-regulation roles in the dynamics of microscopic drift wave (DW) type turbulences. GAM can be spontaneously excited by DW turbulences, and scatter DW turbulences into the stable short radial wavelength domain, and consequently, suppress DW turbulence and associated transport. The spontaneous excitation of GAM by DW is usually believed to be important only in the edge of tokamak plasma due to minimized ion Landau damping and sharper pressure gradient to satisfy the select rules for resonant excitation. However, finite amplitude Alfvén waves, e.g. TAE, excited by energetic particles, such as fusion alphas, could overcome the GAM threshold conditions due to collisionless ion Landau damping, and drive GAM nonlinearly even in the plasma core region.

In this work, spontaneous nonlinear excitation of GAM by TAE is studied within the framework of gyrokinetic theory. The dispersion relation for the parametric decays of a pump TAE mode into a TAE lower sideband and a GAM is derived. It is shown that, in the ideal MHD first stability region, the condition for spontaneous excitation of GAM by TAEs is \( \omega_0^2 > V_A/(4q^2R_0^2) \), in which, \( \omega_0 \) is the pump TAE real frequency, \( V_A \) is the Alfvén speed, \( q \) is the safety factor and \( R_0 \) is the torus major radius. The corresponding threshold condition is also derived and suggests the decay process as an effective saturation mechanism for TAE.