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Nonlinear decay and plasma heating by a toroidal Alfvén eigenmode

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Shear Alfvén wave instabilities such as toroidal Alfvén eigenmode (TAE) [1] are expected to play important roles in magnetic confinement fusion devices as energetic particles (EPs) contribute significantly to the total power density [2, 3]. TAE can be driven unstable by EPs, and in turn, induce EP transport and degrade overall plasma confinement.

In this work, nonlinear decay of TAE into a geodesic acoustic mode (GAM) and a lower kinetic TAE (LKTAE) with the same toroidal/popoidal mode number is investigated due to its crucial implications on TAE nonlinear saturation, improved confinement, as well as EP power channeling, including fusion-alpha power density to bulk thermal plasma heating [4]. The parametric dispersion relation is derived and analyzed, and the parameter range for this process to occur and dominate over other mechanisms is discussed. The nonlinearly generated LKTAE and GAM can be dissipated via electron and ion Landau damping, respectively, leading to anomalous EP slowing down and channeling of EP power to thermal ion heating. The thermal plasma heating rates are also estimated. Furthermore, the nonlinearly generated GAM, as the finite frequency zonal flow, could contribute to regulating drift wave turbulence and consequently, improved confinement.

References

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