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TEMPEST simulations of collisionless damping of geodesic-acoustic mode in edge plasma pedestal*

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The fully nonlinear 4D TEMPEST gyrokinetic continuum code produces frequency, collisionless damping of geodesic-acoustic mode (GAM) and zonal flow with fully nonlinear Boltzmann electrons for the inverse aspect ratio ϵ-scan and the tokamak safety factor q-scan in homogeneous plasmas [1]. The TEMPEST simulation shows that GAM exists in edge plasma pedestal for steep density and temperature gradients, and an initial GAM relaxes to the standard neoclassical residual, rather than Rosenbluth-Hinton residual due to the presence of ion-ion collisions. The enhanced GAM damping explains experimental BES measurements on the edge q scaling of the GAM amplitude.

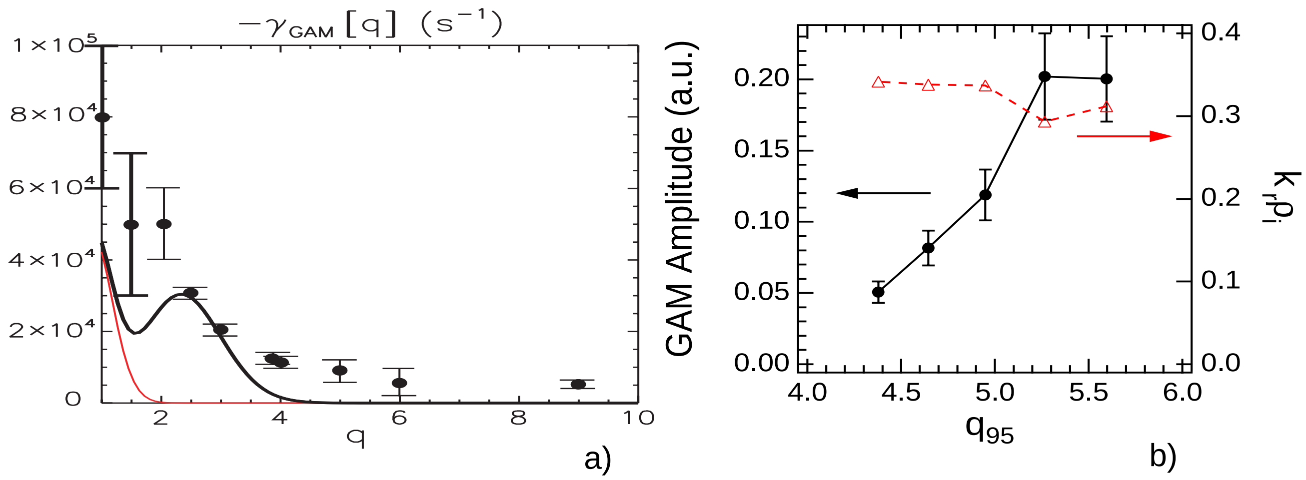

Figure 1: a) GAM damping rate γ_G vs q for $\epsilon = 0.2$. The black (red) solid curve comes from theory with (without) the finite-orbit-width (FOW) effect [2] and the points are TEMPEST simulation results; b) Integrated GAM amplitude versus q_{95} within one discharge near $r/a = 0.9$ during the current ramp up (acquired at 100ms intervals) at DIII-D from BES measurements[3].

Fig. 1b) shows that the GAM amplitude has a strong dependence on q_{95}, with the GAM increasing in amplitude between $4.2 < q_{95} < 6.0$, and undetectable at lower q_{95}. This observation is qualitatively consistent with the strong dependence on the safety factor q of the collisionless kinetic damping rate from the linear theoretical calculations and nonlinear TEMPEST simulations as shown in Fig. 1a) that GAM should be strongly damped at low q_{95} due to the enhanced resonant ion Landau damping. The measured GAM $k_r\rho_i \simeq 0.3 - 0.35$ with little dependence on q_{95} is higher than those in our simulations $k_r\rho_i \simeq 0.14$, which would further enhance the multiple-resonance damping due to the FOW effect of passing particles $k_r\delta_i \sim k_r\rho_i q$.

[1] Xu X Q *et al.*, submitted Phys. Rev. Lett., 2007.
[2] Sugama H *et al.*, J. Phys. Plasmas **72**, 825(2006); Z. Gao *et al.*, IAEA-CN-149/TH/P2-5.
[3] G. R. Mckee *et al.*, Plasma Phys. Control. Fusion **48**, s123(2006).

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