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Zonal flow decay in tokamaks with resonant magnetic perturbations: role of broken axisymmetry

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We investigate the role of nonaxisymmetric magnetic perturbation in zonal flow decay. Externally imposed 3D resonant magnetic perturbations (RMPs) can mitigate or suppress dangerous large edge localized modes (ELMs) in H-mode plasmas [1-3]. However, experiments from various tokamaks [4-7] have reported increase of the H-mode transition power threshold in the presence of RMPs. Motivated from this observation, we perform an analytic theoretical study of RMP effect on zonal flow evolution in tokamak plasmas using gyrokinetic equations [8,9]. Extending previous theoretical works on zonal flow response in tokamaks [10,11] and helical devices [12,13], we calculate long time evolution of zonal flows in tokamak plasmas in the presence of RMPs. We find out that tangential (to the tokamak magnetic field) component of the RMP field induces secular magnetic drifts of zonal flow carrying particles in radial direction, and these secular drifts result in long-term collisionless zonal flow decay toward zero. Zonal flows can play a key role in triggering H-mode transition by regulating drift wave turbulence [14,15]. Therefore, our result indicates lower zonal flow level and thus higher H-mode transition power threshold in the presence of stronger RMP field. Our result also indicates more significant increase of the power threshold for higher-n (toroidal mode number) RMPs [16]. This n-dependence agrees with the trend recently observed in KSTAR [17].

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