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Characteristics of magnetic braking depending on 3D field configuration in KSTAR

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Toroidal rotation braking by neoclassical toroidal viscosity driven by non-axisymmetric (3D) magnetic fields, called magnetic braking, has great potential to control rotation profile, and thereby improve tokamak stability and performance. In order to characterize magnetic braking in various 3D field configurations, dedicated experiments have been carried out in 2015 campaign, applying a variety of static n=1 3D fields in the different phasing of -90, 0, and +90. The 0 phasing fields achieved quiescent magnetic braking without density pump-out, which is consistent with vacuum and ideal plasma response analysis predicting deeply penetrating 3D fields without significant plasma response. On the other hand, strong resonant-type magnetic braking was achieved by the -90 phasing fields, which is identified by strong density pump-out and confinement degradation, and explained by excitation of kink response captured by ideal plasma response calculation. Very strong resonant plasma response was observed under the +90 phasing at q95~6.0, leading to severe confinement degradation and eventual disruption by locked modes. The strong resonant transport was substantially modified to non-resonant-type transport at higher q95~7.2, as the resonant particle transport was significantly reduced, and global rotation braking was changed to localized braking. This is well explained by perturbed equilibrium calculations indicating the strong kink coupling at lower q95 is substantially shielded by ideal plasma response for higher q95 discharge. These experiments will be presented and discussed in detail with experimental and numerical analyses for perturbed equilibrium, neoclassical and turbulent transport, and compared with n=2 magnetic braking experiments that produced significant variations of the NTV torque profile depending on the phasing of n=2 field coils. In particular, experiments in 2016 campaign will explore potential utilization of the non-resonant magnetic braking to improve global confinement and performance through toroidal rotation profile control, which will be presented with various diagnostics and transport analyses.

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