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ITB formation in gyrokinetic flux-driven ITG turbulence

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Profile stiffness is a long standing problem, which may limit the overall performance of H-mode plasmas. In the JET experiment, while strong temperature profile stiffness is observed around the nonlinear threshold of ion temperature gradient, it can be greatly reduced by co-current toroidal rotation in weak magnetic shear plasma.
To understand such a mitigation mechanism of the stiffness, we investigate the impact of momentum injection on profile stiffness in flux-driven Ion Temperature Gradient (ITG) turbulence by means of a newly developed toroidal full-f gyrokinetic code GKNET. It is found that momentum injection can change the mean flow through the radial force balance, leading to Internal Transport Barrier (ITB) formation in which the ion thermal diffusivity decreases to the neoclassical transport level. Only co-current toroidal rotation can benefit the ITB formation in weak magnetic shear plasma, showing a qualitative agreement with the observations in the JET experiment. Note that the established ITB is enough stable in the quasi-steady state.
The underlying mechanism is identified to originate from a resultant momentum flux. According to the non-local ballooning theory and momentum transport theory, the mean flow shear triggered by co-current toroidal rotation provides the momentum pinch, which can reduce the relaxation of both toroidal rotation and mean flow profiles. On the other hand, the role of counter rotation is opposite so that the relaxation is enhanced. Thus, there exists a positive feedback loop between the enhanced mean flow shear and resultant momentum pinch only in the co-current toroidal rotation case, signifying a favorite trend to ITB formation.
Such a momentum pinch effect is also essential for ITB formation around the q_min surface in reversed magnetic shear plasma. We detect that the position of ITB is insensitive to the momentum source profile, which is determined only by the q_min surface. These results show a qualitative agreement with the observations in the JT-60U reversed shear discharges.

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