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Long Time-scale dynamics of E×B staircase in flux-driven gyro-kinetic simulations under various heating conditions

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In the L-mode plasmas of Tokamak devices, a quasi-regular and quasi-stationary shear flow pattern, known as the “E×B staircase”, is observed in several recent experiments [1] and global gyro-kinetic simulations [2]. This quasi-regular shear flow structure is accompanied by isomorphic temperature gradient corrugations, showing a quasi-stationary existence and is prominent when the turbulence is near critical. Mechanisms for the formation and sustainment of E×B staircase are discussed theoretically [3] and numerically [2]. However, characteristics and dynamics of E×B staircase in the confinement time scale τ_E, and the dependence with different input powers are still not fully understood. In this work, a set of flux-driven gyro-kinetic simulations with different input powers are performed using GKNET code under adiabatic electron approximation, the impact of E×B staircase on turbulent transport, and the long-time scale evolution of E×B staircase coupled with local/global avalanches are discussed.

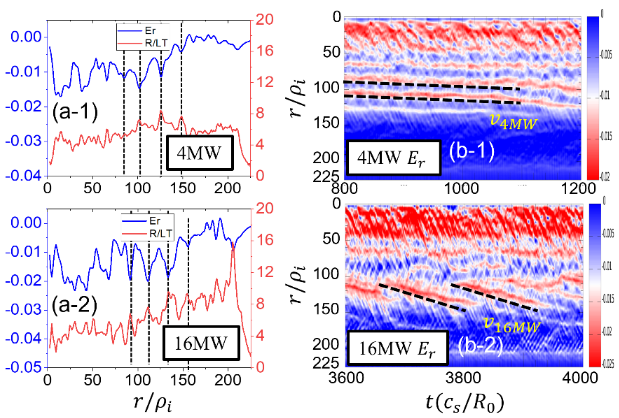

Fig. 1. (a) Profiles of E×B staircase with E_r field (blue lines) and reversed temperature scale length R/L_T (red lines), and time evolutions of (b) radial electric field E_r and (c) turbulent transport Q_{turb} with 4MW input power (case 1) and 16MW input power (case 2).

<u>Staircase long time-scale dynamics with different heat input configurations:</u> In figure 1(a), radial profiles of E×B staircase with 4MW and 16MW input power are shown. The spacing between staircase shear layers is about 15~20ρ_i, and almost constant under different input power. Through the profile of temperature reversed scale length (red lines), we also observed an increasement of the mean gradient in the E×B staircase region ($75\rho_i < r < 150\rho_i$), while keeping a similar level in the inner part ($r < 75\rho_i$), indicates a stiffness phenomenon in the power scan. A radially propagating type E×B staircase structure is observed, for which the speed varies depends on the input power. In the 4MW case, showing a quasi-stationary existence, i.e., a near-zero propagation velocity v_{4MW} as seen in figure 1(b-1). As input power increases to 16MW, the quasi-stationary staircase shows a radial propagation, coupled with a slow time scale weak avalanches as seen in figure 1(b-2). The propagation velocity can be estimated as v_{16MW}~$0.25(\rho_i/R)c_s$. This propagation is believed to be caused by the background mean flow shear which initialized from the radial force balance. The higher input power will cause larger temperature gradient and enhance the positive shear in this region.

References:

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