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The Impact of Different External Source Input on Pedestal Turbulence During ELM Mitigation on HL-2A Tokamak

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Different techniques have been applied for active control of ELMs in HL-2A tokamak, such as supersonic molecular beam injection (SMBI)[1], impurity mixture gas SMBI[2], laser blow-off (LBO) impurity seeding[3] and lower hybrid current drive (LHCD)[4]. In the ELM mitigation experiment with LHCD, it is observed that the ion pressure gradient profile (the ion diamagnetic term $\nabla E_r^{\nabla P_i}$ of the $\gamma_{E\times B}$) is strongly medicated, possibly due to the non-resonant collisional absorption of the high $N_{//}$ components of lower hybrid wave at the plasma edge. The poloidal and toroidal velocity term contributes little to the reduction of velocity shear rate $\gamma_{E\times B}$, comparing to the ion diamagnetic term. However, in the ELM mitigation experiment with particle source input such as LBO impurity seeding and SMBI, the poloidal velocity component $\nabla E_r^{V\theta}$ and the toroidal velocity component $\nabla E_r^{V\varphi}$ changes dramatically due to the localized cooling effect.

Different external source input would reduce the E×B velocity shear though may due to different paradigm. Afterwards, the turbulence evolves in a similar way: the change of $\gamma_{E\times B}$ would induce the turbulence spectral shifting to zero direction, reducing the dissipation term ($\sim k_x^2$) and increasing the turbulence intensity with a time delay. This time delay strongly depends on the external source in both experimental result and simulation . A critical growth rate (CGR) γ_0 has been identified to play an important role during this turbulence enhancement process. It does not relate to plasma parameters such as diffusion coefficient D, density parameter α but only have strong relation with the amplitude of the maximum linear growth rate of the most unstable mode A, and the poloidal wavenumber k_y in a limited area. It has also been found that this critical growth rate has linear relation with the threshold of the external source input, which may provide the basis for turbulence regulation via the external source input in experiment study. Finally, the turbulence enhancement induced by the external source input might result in changing the ELM behavior via non-linear interaction to achieve ELM mitigation. Figure 1 shows the quantitive comparison between the experimental result and simulations on turbulence variation during an ELM mitigation experiment with LHCD. The ELM mitigation experiment with different external source inputs on HL-2A indicate that these techniques have much in mitigating ELMs and might be concluded by a similar paradigm.

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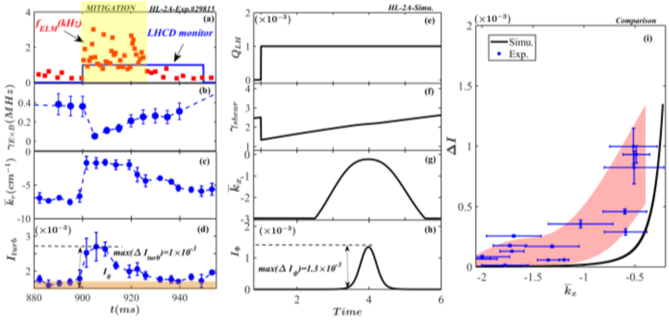

Figure 1. Quantitative comparison between the experimental results and the simulation results on turbulence variation