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The impact of peeling-ballooning turbulence on ELMs[1]

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Although the onset of ELMs has possibly been determined by linear peeling-ballooning (P-B) instabilities and, the nonlinear BOUT++ simulations show that nonlinear mode coupling starts before the onset of ELMs, which can lead to finite amplitude peeling-ballooning (P-B) turbulence at the H-mode pedestal and play a crucial role in ELM dynamics in two aspects: (1) since the P-B turbulence can suppress ELM crash, for a given power input, pedestal can keep evolving to a state with larger pedestal pressure and current gradients. Accordingly, the drives of P-B modes also keep increasing. Therefore the onset of ELM is determined by the competition between linear drive and nonlinear mode coupling. We find that only when a single mode can overcome the nonlinear damping to become dominant, an ELM crash is triggered by this mode. This means with the P-B turbulence, the onset of ELM is determined by a nonlinear criterion $\gamma > \gamma_c$ rather than the previous linear criterion$\gamma > 0$, where $\gamma_{\rm c}$ is the critical growth rate which depends on the P-B turbulence. (2) We find that the P-B turbulence can generate enough self-constant hyper-resistivity needed in ELM simulations when electron inertial is included in Ohm's law. This hyper-resistivity represents anomalous current transport and can set the limit of the narrow current layer width resolved in the simulations. Except the P-B turbulence, the impact of other micro-turbulence, such as KBM turbulence, will be presented via a newly developed electro-magnetic Gyro-Landau-Fluid extension of BOUT++ code.

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[2]In collaboration with X. Q. Xu, and P.H. Diamond.