# A mechanism to trigger edge localized mode crash due to a threshold of magnetic perturbation driven by peeling-ballooning mode

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Edge localized mode (ELM) crash triggered by a threshold of magnetic perturbation associated with stochastic field, driven by Peeling-Ballooning (P-B) modes, is presented. Prior to the ELM crash, a clear magnetic precursor has been observed in Mirnov signal in the HL-2A tokamak, whose threshold characteristics indicate that magnetic perturbation may trigger the pedestal collapse and result in an ELM crash. The Mirnov signal sustains for 6~7 ms with frequency $f$ ~ 18 kHz before an ELM crash. The amplitude of precursor grows until a critical threshold to induce an ELM crash. The precursor threshold indicates magnetic perturbation that triggers the pedestal collapse and results in an ELMs crash, as shown in figure 1.

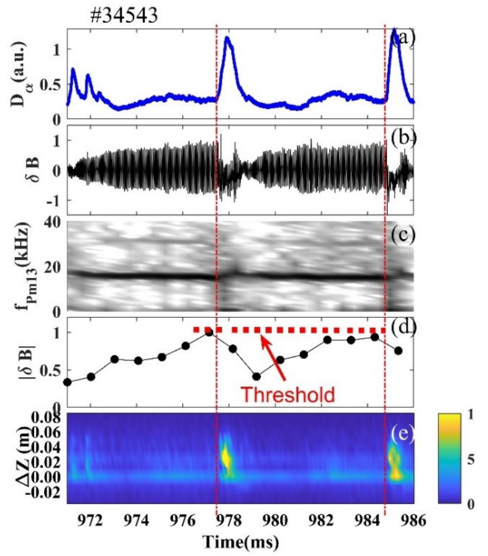


**Figure** 1. The zoom-in time trace of precursor perturbations in 972~986 ms. $D_\alpha$ emission (a), Mirnov signal (b), its frequency spectrum (c) and amplitude (d), and the distribution of the saturation ion current density on the outer divertor target (e).

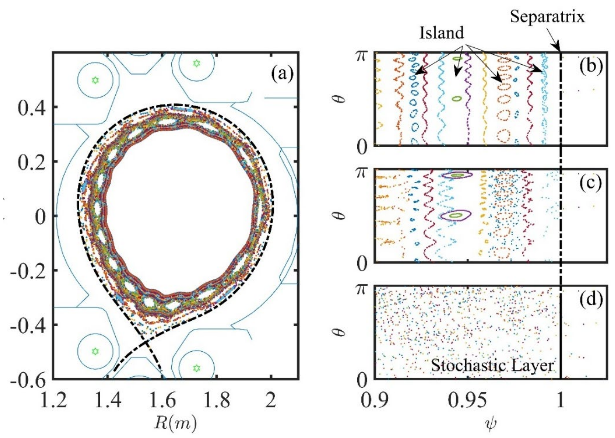


**Figure** 2. Poincare plots of the magnetic field with resistive P-B modes in the HL-2A poloidal section (a), and a zoom-in configuration near boundary region ψ= [0.9 1.025] in PEST coordinate at time slices 383 $\tau_A$ (b), 400 $\tau_A$ (c), and 487 $\tau_A$ (d).

Nonlinear MHD simulations, using CLT code, demonstrate that stochastic layer is generated by magnetic reconnections process of resistive Peeling-Ballooning (P-B) modes. The non-axisymmetric magnetic perturbation, derived from P-B modes, creates the magnetic islands and then stochastic layer, as shown in figure 2. The formation of edge stochastic magnetic field greatly enhances radial particle transport along magnetic field lines, which results in collapse of the pedestal pressure and an ELM crash. Especially, there is also a threshold of magnetic perturbation leading in connection length ($L_C$) abruptly changes, which responds for the sudden ELM crash, as shown in figure 3. From the Poincaré plot of escaped magnetic field lines, there are footprints, derived by P-B modes, which are useful to dissipate the peak heat loading during an ELM crash. The footprints have been proven to be a good indicator of the heat flux distribution on the divertor plates in experiments. In order to study the heat

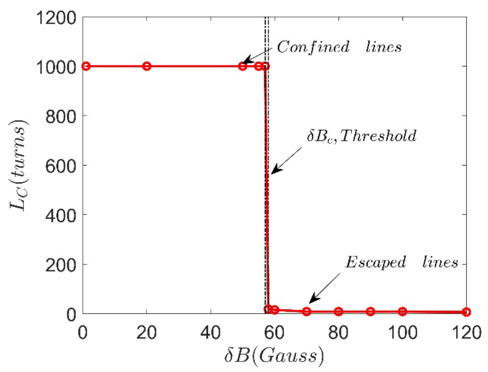


**Figure** 3. Connection length or turn number of toroidal rotation (LC) of the field lines against different perturbation amplitudes (δB) at X point.

flux loss during an ELM crash, a gyro-center particle (GCP) code has been developed. The simulation heat flux distribution with stochastic field is also good agreement with double-peaked experimental distribution of the heat flux and temporal evolution of ELM crash event, as shown in figure 4 and 5.

These results clearly prove that a threshold of magnetic perturbation, associated with stochastic field, driven by P-B mode, may cause an ELM crash.

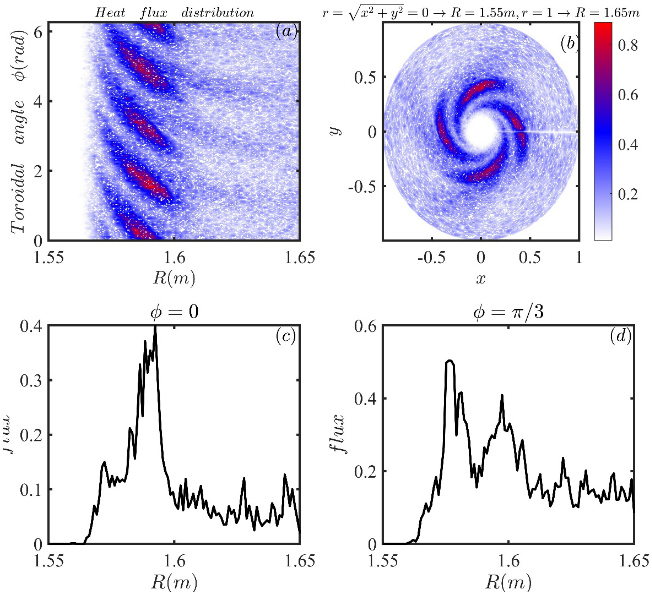


**Figure** 4. The simulation heat flux distribution with stochastic field in divertor region. The simulation heat flux distribution on R-ϕ plane(a) and (b). The double-peaked distribution of the heat flux at ϕ =0(c) and π/3(d).

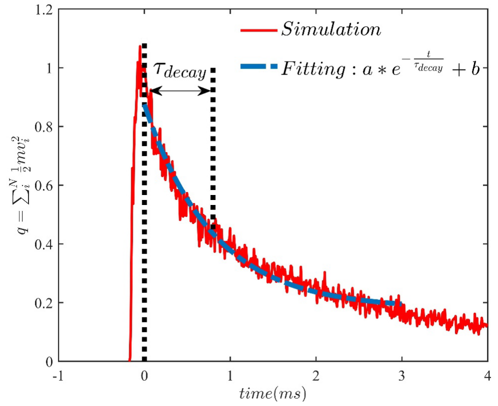


**Figure** 5. The simulation temporal evolution of ELM crash event with stochastic field. The decay time is estimated about 800 μs, which is consistent with experimental statistics.