PERTURBATED MAGNETIC FIELD THRESHOLD OF EDGE COHERENT OSCILLATION DURING ELM MITIGATION BY N = 1 AND N=2 RMP

Progress of ELM control experiments with RMP in HL-2A and HL-3 tokamak

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The ELM mitigation by applying an n = 1 compact in-vessel resonant magnetic perturbation (RMP) coils has been observed. The ELM frequency was increased by a factor of 2 and the ELM amplitude decreased, leading to a reduced heat load on the divertor plates. Clear ELM mitigation is achieved in a q_{95} window with q_{95} value range 3.55-3.85, which is explained in terms of the edge-peeling response, based on toroidal single fluid resistive plasma model MARS-F code with different assumption of toroidal flows[1]. The simulation results using the CLTx code show the footprints of strongly distorted magnetic field lines on the divertors are consistent with the energy deposit spots in the experiment [2].

An edge coherent oscillation (ECO) with a bursting feature was observed in the steep-gradient pedestal region of the H-mode plasmas, where the type-I ELMs were mitigated by application of the n = 1 RMP. It was found that the ECO with frequency of about 2 kHz is located at the edge pedestal region, and is excited by three-wave interaction of turbulence enhanced by the RMP field through the change of electron density gradient in the pedestal region because of pump-out effect. The oscillation providing a channel for a nearly continuous extra particle transport across the pedestal during the ELM mitigation by RMP. The RMP significantly enhances the power spectrum in the high frequency (50-150 kHz) range, whereas the peaked power spectrum around 100 kHz is substantially modified to a flat shape during the mitigation with ECO [3]. Nonlinear modelling of ELM mitigation, utilizing 3D magnetohydrodynamic (MHD) code JOREK, demonstrates that strong mode coupling among toroidal Fourier harmonics allows redistribution of the magnetic energy, which explains the ELM mitigation with modifying the edge magnetic topology and characteristics of the edge transport. A threshold value of around 4.5 kAt RMP coil current required for achieving the ELM mitigation. Modelling results utilizing the quasi-linear initial-value code MARS Q reveal that the electron neoclassical toroidal viscosity (NTV) due to three dimensional fields plays the key role of density pump-out with reduction of both the plasma density and toroidal flow speed [4].

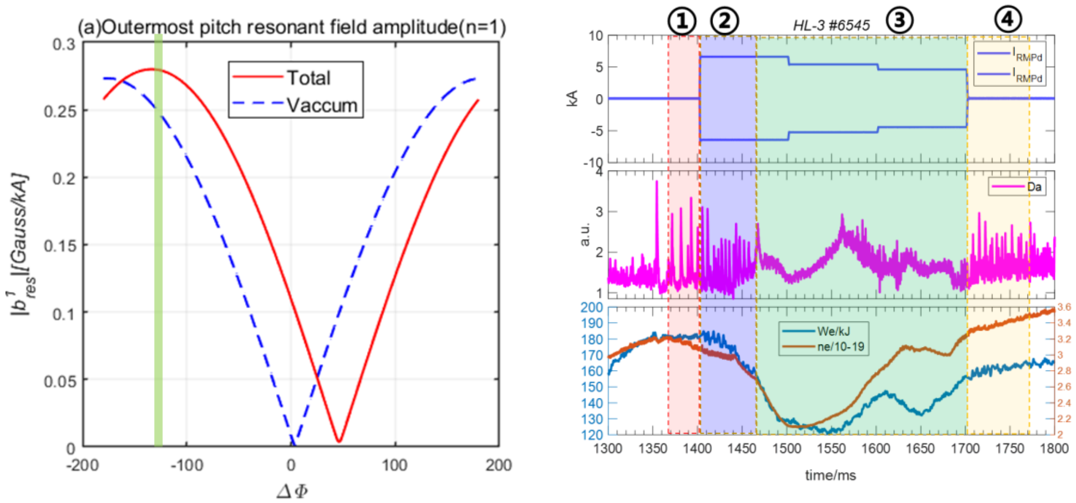

FIG.1 In the new machine HL-3 tokamak, the ELM control experiment is carried out with n =1 RMP.
The new result shows the process of the RMP making the ELM mitigated firstly and then induce H-L transition.

The threshold of ELM mitigation with ECO is found. During ELM H-mode, I_{RMP} with n=1 dominant spectrum varies from 3000At to 6.5kAt step by step with scanning plasma current Ip from 300 to 700 kA. The toroidal magnetic field Bt change from 1T to 1.5T to scan the q_{95} window of ELM mitigation. The threshold of mitigation is observed. The drop of core toroidal velocity measured by charge exchange recombination spectroscopy was always observed in ELM mitigation discharges correlated with density pumpout. And then I_{RMP} with n=2 dominant spectrum varies from 3000At to 6500At step by step.

RMP ELM mitigation with ECO effect on the compensation of density pump-out is cooperated with SMBI ELM mitigation. On JET, previous experiments have shown that the compensation of density pump-out effect, due to the n = 1 field, can be achieved by means of gas fuelling and pellet injection. ELM mitigation is identified by means of SMBI on HL-2A tokamak. The compensation of density pump-out experiments, due to the n = 1 field, is investigated by means of SMBI. During ECO, the density pump-out caused by RMP is mitigated by SMBI.

It is firstly described that the effect on ECO of SMBI technique for the compensation of the density pump out effect occurring during ELM control experiments with RMP fields on HL-3 tokamak. The RMP current window for ECO in HL-3 experiments is found.

1) The current (Magnetic field) threshold of ECO is discovered during ELM mitigation by n = 1 RMP on HL-3；

2）The current (Magnetic field) threshold of ECO is also discovered during ELM mitigation by n = 2 RMP on HL-3；

3) The current (Magnetic field) statistic window of ELM mitigation with ECO is found, after comparation of ELM mitigation n=1 and n=2 ELM;

4) The relation between frequency of ECO and RMP current.

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