Contribution ID: **846** Type: **Regular Poster**

3D nonlinear modeling of Resonant Magnetic Perturbation on EAST

Wednesday 12 May 2021 12:10 (20 minutes)

The 3D nonlinear equilibrium and its associated magnetic topology are investigated on EAST for the first time for future understanding on the mechanism of how the Resonant Magnetic Perturbation (RMP) mitigates or suppresses the Edge-Localized Mode (ELM). Recently, a nonlinear transition from mitigation to suppression of the ELM by using RMP on EAST is observed [1]. To understand the RMP mechanism in different ELM phases, the nonlinear 3D resistive equilibrium is studied by HINT code [2], and impacts of the plasma rotation on the magnetic topology are investigated. To suppress or mitigate ELM strongly, the deep penetration of RMP field or the relevant edge topological change resulting from nonlinear plasma response is supposed to be the key factor.

The ELMs control in the H-mode operation is a key issue in the future tokamak fusion reactor research like ITER, and one of the most effective proposals of type-I ELM control is RMP [3]. To investigate the RMP mechanism, the plasma parameter profile in the pedestal region and the edge magnetic topological change are the key points. The HINT code, directly solving the dynamic equations of the magnetic field and pressure based on the relaxation method, has the unique advantages of 3D MHD equilibrium with magnetic islands and stochastic edge field induced by RMP, which is maintained by NIFS group. Here we apply the HINT code to study 3D equilibrium with RMP on EAST and develop the plasma flow effect part to study the nonlinear interaction between RMP and plasma rotation effect on magnetic topology.

The nonlinear transition between ELM mitigation and suppression by scanning of the phase difference between upper and lower RMP coils $\delta\Phi_{UL}$ with n = 1 RMP on EAST is obtained [1]. In the EAST shot #55272, the ELM frequency behaves in a significantly different way at different phase. For ELM suppression or strong mitigation phase, the RMP field could penetrate deeply. While for the weak mitigation phase, the RMP field is shielded by plasma response. The 3D equilibrium is calculated for EAST shot #55272 in different ELM phase. Figure 1 (a) shows the pressure profile calculated by HINT for without RMP (t = 3.9 s), strong ELM mitigation phase (t = 4.2 s) and suppression phase (t = 4.5 s) when the RMP penetrates. The pressure profiles in the plasma core region for the different phases are almost identical while the profiles in the pedestal region are significantly different with RMP penetration, as figure 1 (b) shows. Or equivalently, as shown in figure 1 (c), the pressure gradient decreases in the pedestal region with significant 3D edge magnetic field topology change when the RMP penetrates. It can be inferred that the bootstrap current density will decrease with the pressure gradient degradation, resulting in ELM suppression or strong mitigation concerning peeling-ballooning mode. Here, the evidence of plasma pressure gradient degradation with RMP penetration is presented on EAST for the first time from the point of view of 3D nonlinear equilibrium.

Indico rendering error

```
Could not include image: Problem downloading image (https://workshop.nifs.ac.jp/fec2020/image/63-HUANG
```

The RMP penetration is a nonlinear process essentially. The nonlinear interaction between the RMP and plasma rotation is also the key point for the final 3D equilibrium. The RMP field could be shielded by plasma response, resulting in a weak ELM mitigation case. Based on the HINT model, the plasma response effect is simulated by introducing plasma flow in the evolution of magnetic field calculation. Since HINT employs a resistive model, the initial surface plasma flow cutting the RMP field can generate the electric field when RMP superposed, leading to the screening current by Ohm's law to shield the RMP field. In the meanwhile, the flow velocity is also changed by the momentum equation to keep its self-consistency. Or the nonlinear interaction between the RMP field and plasma rotation is treated as a nonlinear process of equilibrium with plasma flow in the modeling. As HINT is based on the single-fluid model, here we technically divide the plasma flow into two parts, the parallel flow and perpendicular flow concerning the initial 2D magnetic field line given by EFIT. Recently the module of parallel flow part is developed. Figure 2 shows the magnetic topology in the weak ELM mitigation phase for EAST shot #55272 calculated by HINT with or without parallel flow. The 3/1 magnetic island width becomes small when the parallel flow is taken into account. Since the main component of RMP field is the radial component $\vec{B}_r$, the parallel flow can generate the electric potential by $\vec{v}_{\parallel 0} \times \vec{B}_r$ term and change the current density profile according to Ohm's law in the nonlinear equilibrium calculation. The additional current component induced by the initial parallel flow could give rise to magnetic island healing topology, resulting in the reduction of the RMP field penetration depth. To model the plasma response more precisely, the perpendicular flow is important and will be included in the future work. Here, the plasma response effect with RMP is modeled by introducing the plasma flow in the 3D nonlinear equilibrium calculation and the magnetic island healing is presented with the parallel flow, which could give the interpretation of the RMP mechanism in weak ELM mitigation case.

Indico rendering error

```
Could not include image: Problem downloading image (https://workshop.nifs.ac.jp/fec2020/image/63-HUANG
```

Reference:
1 Y. Sun et al 2016 Phys. Rev. Lett. 117 115001
2 Y. Suzuki 2017 Plasma Phys. Controlled Fusion 59 054008
3 T. E. Evans et al 2006 Nat. Phys. 2 419

Country or International Organization

Japan

Affiliation

National Institute for Fusion Science

Authors: HUANG, JIE (National Institute for Fusion Science); SUZUKI, Yasuhiro (National Institute for Fusion Science); LIANG, Yunfeng (Forschungszentrum Jülich GmbH, Germany); SUN, Youwen (Institute of Plasma Physics, Chinese Academy of Scienses); Mrs JIA, Manni (Institute of Plasma Physics, Chinese Academy of Sciences); Mr CHU, Nan (Institute of Plasma Physics, Chinese Academy of Sciences); Mr WU, Muquan (Institute of Plasma Physics, Chinese Academy of Sciences)

Presenter: HUANG, JIE (National Institute for Fusion Science)

Session Classification: P3 Posters 3

Track Classification: Magnetic Fusion Theory and Modelling