## §1. Observation of Stabilization of Helically Trapped Energetic Ion Driven Resistive Interchange Mode During High Power Injection of the ECH

Du, X.D., Ohdachi, S., Osakabe, M., Nagaoka, K., Suzuki, Y., Toi, K., LHD Experiment Group

The resistive interchange mode (RIC) destabilized through resonant interaction with a characteristic motion of helically trapped energetic ions (EPs) are observed in Large Helical Device (LHD), called the EIC, exhibiting bursting character and rapid frequency chirping down and having m=1/n=1 mode structure (m, n: the poloidal and toroidal mode numbers, respectively) [1]. The initial frequency of the EIC is consistently explained by the mode-particle resonance condition in non-axisymmetric LHD plasma. In previous study, it is found that a certain threshold of helically trapped EP pressure exists to destabilize the EIC. The EIC also strongly impacts the confinement of helically trapped EPs and induces noticeable losses. The loss fraction from the plasma confinement region is crudely estimated to be ~30% from a diamagnetic loop [1]. Therefore, the study on the control of the EIC in LHD is crucial to reduce the losses of helically trapped EPs.

In recent experiment, the clear suppression of the EIC is found during the injection of the high power electron cyclotron heating (ECH). One typical example is shown in Fig. 1. In the so-called high Ti discharge of central electron density $n_{e0}$~$1\times10^{19}m^{-3}$ and temperature $T_{e0}$~$3keV$, the EIC bursts exhibits the 'fishbone'-shape oscillation in magnetic probes. However, during the time window from 4.65s to 4.85s when the high ECH power of 5.2MW is injected without changing the power of neutral beam injection perpendicular to magnetic field line (PERP-NBI), the strong bursting oscillations in magnetic probes disappear. Moreover, the EIC suppression phase even persists ~100ms after switching off the ECH, as seen from Fig. 1(a). The volume-averaged beam beta perpendicular to magnetic field line $\beta_{h\perp}$ is estimated by subtracting the bulk plasma beta $\beta_{bulk}$ evaluated from the YAG-laser Thomson Scattering system and charge exchange recombination spectroscopy system from the diamagnetic beta $\beta_{dia}$ obtained by a diamagnetic loop, shown in Fig. 1(b). During the injection of high ECH power phase, the clear reduction of $\beta_{h\perp}$ is revealed. This might be due to the decrease of the deposition power of PERP-NBI by the strong electron density pump-out induced by ECH, i.e., ~20% decrease of the electron density in this case. Since the destabilization of the EIC strongly correlates with the contents of helically trapped EPs in plasma, it may contribute to the suppression of the EIC, but it seems not to be appropriate to explain the sudden suppression of the EIC in the very beginning phase of ECH injection, in which the $\beta_{h\perp}$ does not reduce noticeably. That is, the suppression of the EIC by the ECH is rather fast compared with the slow decrease of the electron density by the density pump-out by the injection of ECH, shown in Fig. 1(c), indicating that the suppression of the EIC by ECH may not be simply explained by the reduction of deposition power of PERP-NBI in the very beginning phase of EIC suppression.

The details of deposition profile of PERP-NBI will be investigated numerically by the MORH code and the physics mechanism for the suppression of the EIC by the injection of high power ECH will be studied in the future.

[1] X.D. Du, K. Toi, M. Osakabe et al., Phys. Rev. Lett. **114**, 155003 (2015)

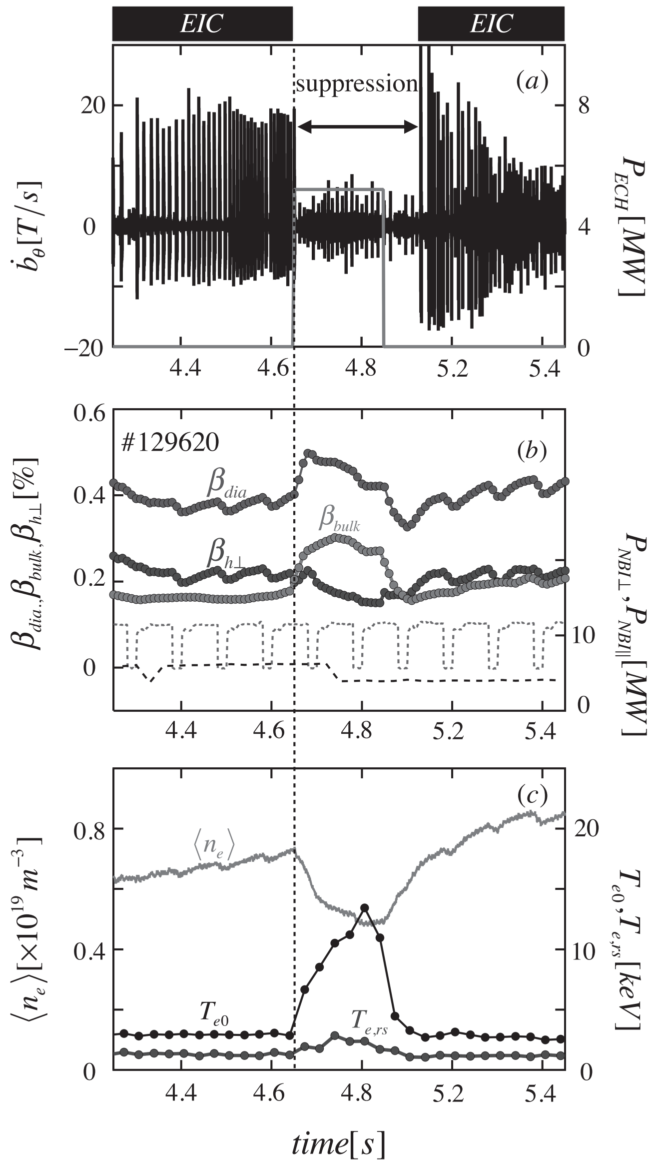


Fig. 1 Time evolutions of the magnetic fluctuations measured by a magnetic probe signal and injected ECH power (a), the volume-averaged bulk plasma beta ($\beta_{bulk}$), beam beta ($\beta_{h\perp}$) and diamagnetic beta ($\beta_{dia}$) (b) and the electron temperature at the plasma center ($T_{e0}$) and that at the mode rational surface ($T_{e,rs}$) together with a line-averaged electron density ($\langle n_e\rangle$) in (c).