## §4. Study of Plasma Responses to Magnetic Perturbations in Two and Three Dimensional Tori

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This collaborative research aims at getting comprehensive understanding of interaction between resonant/non-resonant magnetic perturbations (RMPs/ NRMPs) and two types of toroidal plasmas in LATE and LHD. As applied perturbations, "stationary" and "alternating" perturbations are possible. Effects of stationary magnetic perturbations on plasma confinement are interesting research targets. They are closely related to suppression of edge localized modes (ELMs) in H-mode. The other is to develop a system using alternating magnetic perturbations for measurement of the safety factor in the current startup phase on LATE.

In many tokamaks including spherical tokamaks, suppression of ELMs is attempted by applying RMPs and/or NRMPs to the plasma edge region. In DIII-D, ELMs were successfully suppressed by RMPs without degradation of bulk plasma confinement [1]. However, RMPs did not suppress ELMs in NSTX and even excite them[2]. Moreover, ELM amplitude was reduced by NRMPs in JET, but the complete suppression was not achieved[3]. Based on the DIII-D results, installation of ELM suppression coils is being planned for ITER. However, interaction between RMPs/NRMPs and plasma edge is not fully understood even in tokamak plasmas. In particular, these magnetic perturbations applied to plasma edge enhance particle transport dominantly instead of noticeably enhanced electron heat diffusion.

In LHD, it is inferred that edge region is filled with ergodic or stochastic field zone because of breaking of axisymmetry in the magnetic configuration. Moreover, the thickness of edgodic layer and the size of m/n=1/1 magnetic island in the edge can be increased or decreased by RMPs having m/n=1/1 Fourier component, of which perturbations are generated by so-called local island divertor (LID) coils. The effects on edge transport barrier (ETB) were studied by application of the LID field. The transition to ETB formation occured at the lower electron density than that without the LID field [4]. Recently, giant ELMs were observed in outward-shifted LHD plasmas, as shown in Fig.1. This type of ELM appears during the strong density rise phase and stops the density rise suddenly. Density control by the LID field is being planned in the next experimental campaign of LHD.

In the LATE plasma which is sustained by energetic electrons produced by injected micro waves, resonant or non-resonant magnetic perturbations would affect the orbit of such electrons strongly. Enhanced loss of energetic electrons by these magnetic perturbations may modify plasma potential profile and then may affect bulk electron confinement. During the current startup on LATE, large amount of energetic electrons is generated. These electrons which are in passing and also in trapped orbits

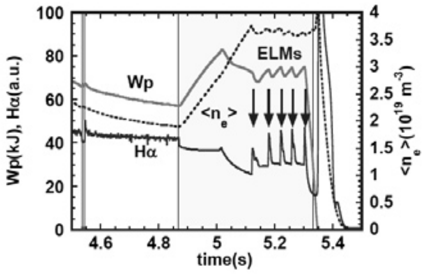
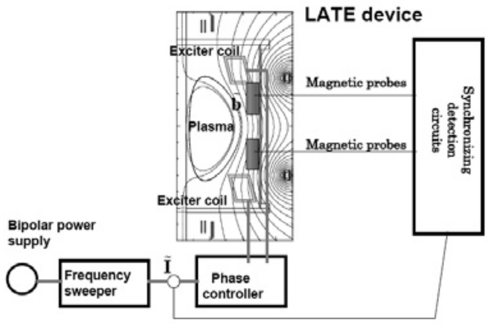



Fig.1 Giant ELMs excited after the ELM free phase in an H-mode of LHD. The ELM free H-phase stars from t=4.86s.

carry toroidal plasma current[5]. Effects of RMPs/NRMPs on current startup are interesting topic, because these magnetic perturbations may have a potentiality to control the amount of the trapped energetic electrons more effectively. In the LATE experiments using 2.45 GHz microwaves, the toroidal field strength is less than 0.1 T. Accordingly, necessary strength of magnetic perturbations is in the order of 10 G. Effects of these perturbations on bulk plasma can be monitored with soft and ultra soft X-ray detector arrays. A hard X-ray detector array may get information on the effects on energetic electrons.

Plasma responses to alternating magnetic perturbations in the frequency range of Alfvén eigenmodes(AEs) provide the information of the safety factor in the case that ion density profile is known. This method was applied to CHS plasmas and the stability of AEs was investigated [6, 7]. The method can be applied to the LATE plasma to get the information of the safety factor on the nested magnetic surfaces generated during current startup. A schematic drawing of a possible system is shown in Fig.2. For this purpose, a set of small exciter coil is necessary to install inside the vacuum vessel. The responses can be obtained with magnetic probe arrays.




Fig,2 Plan of an AE-sensing system in LATE.

[1] T.E. Evans et al., Phys. Rev. Lett. **92**, 235003-1 (2004).
[2] J.M. Canik et al., 4th Int. Workshop on Stochasticity in Fusion Plasmas, 2-4 March, 2009, Julich, Germany.
[3] Y. Liang et al., Phys. Rev. Lett. **98**, 265004 (2007).
[4] K. Toi et al., to be published in Fusion Sci. Technol.
[5] T. Yoshinaga et al., Phys. Rev. Lett. **96**, 125005 (2006).
[6]G. Matsunaga et al., Phys. Rev. Lett. **94**, 225005 (2005).
[7] T. Ito et al., Phys. Plasmas **16**, 092105 (2009).