§1. Numerical MHD Analysis of LHD Plasmas with Magnetic Axis Swing

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It is crucial to predict the MHD stability boundary in the design of future reactors. However, systematic procedure for the prediction has not been established in heliotron configurations. In LHD, experiments were carried out to find the stability boundary as a function of the horizontal position of the vacuum magnetic axis[1]. In these experiments, the background magnetic field is changed during each shot so that the corresponding vacuum magnetic axis position is shifted inwardly. A partial plasma temperature collapse happens during the shift of the magnetic axis. In the present work, we investigate the mechanism of this partial collapse with a numerical MHD approach[2]. To incorporate the change of the background field, we have to treat the time evolution of the equilibrium as well as the perturbations. Since the time scale of the equilibrium change is much longer than that of the perturbations, we utilize a multi-scale numerical scheme[3]. In the scheme, time-dependent nonlinear dynamics calculations and updates of a static equilibrium are iterated.

By applying the method to the LHD plasma, we identify the collapse mechanism. In the time evolution, a nonlinear saturation occurs after the linear growth of the perturbation. In the linear phase, the growth is accelerated by the real-time enhancement of the magnetic hill due to the change of the background magnetic field. The instability has the characteristic properties of an infernal mode as shown in Fig.1. At saturation, the core pressure is degraded in a short time as shown in Fig.2. The degradation is caused by the vortices of the infernal mode, which corresponds to the partial collapse observed in the experiments. We also compare the time evolutions with and without the change of the background magnetic field, and obtain that the plasma with the change is more unstable than that without the change. This tendency agrees with the experiments. Further extension of this simulation can reveal the key physics of the collapse onset, which will be necessary for the prediction of the stability boundary in the reactor design.

1) S.Sakakibara, et al., Proc. 23rd Fusion Energy Conf. Oct.11-16, 2010, Deajeon, EXS/P5-13.

2) K.Ichiguchi S.Sakakibara, S.Ohdachi and B.A.Carreras, submitted to Plasma Phys. Control. Fusion.

3) K.Ichiguchi, et al., Nucl. Fusion **43** (2003) 1101.

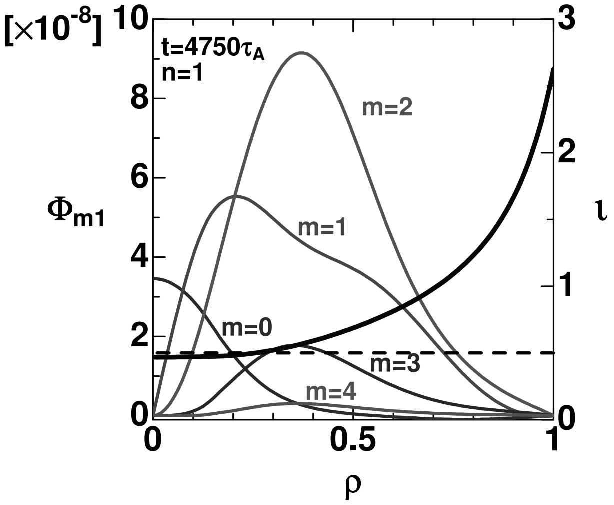

Fig. 1: Profiles of rotational transform (black solid line) and components of $n = 1$ stream function in the linear phase (other solid lines) in the change of the background field.

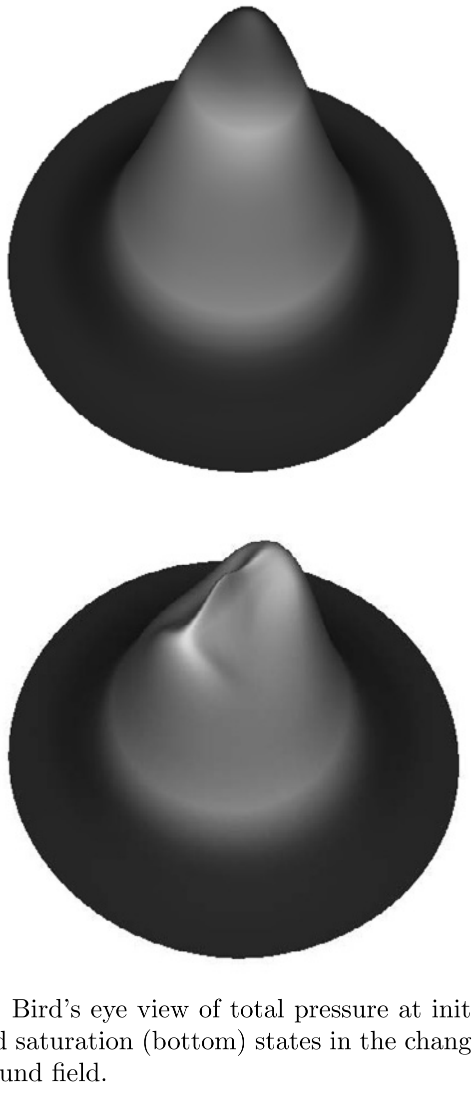

Fig. 2: Bird's eye view of total pressure at initial (upper) and saturation (bottom) states in the change of the background field.