# 23P074-P

# Evaluation of MHD stability of weak shear configuration in LHD plasma
大型ヘリカル装置LHDにおける弱磁気シア配位でのMHD安定性の評価

Masaaki Okamoto, Kiyomasa Watanabe[1], Satoru Sakakibara[1], Satoshi Ohdachi[1], Yoshiro Narushima[1], Mikiro Yoshinuma[1], Katsumi Ida[1], Yoshihide Shibata[2], Noriyasu Ohno[2]
岡本征晃, 渡邊清政[1], 榊原悟[1], 大舘暁[1], 成嶋吉朗[1], 吉沼幹朗[1], 居田克巳[1], 柴田欣秀[2], 大野哲靖[2]

*Ishikawa National College Technology, Kitachujo, Tsubata, Kahoku-gun, Ishikawa, 929-0392 JAPAN*
石川工業高等専門学校, 〒929-0392　石川県河北郡津幡町北中条タ1
[1]*National Institite for Fision Science, Oroshi-cho, Toki, Gihu 509-5292, Japan*
[1]自然科学研究機構 核融合科学研究所, 〒509-5292　岐阜県土岐市下石町322-6
[2]*Graduate School of Engineering, Nagoya University, Furo-cho, Chikusa-ku, Nagoya, Aichi 464-8603, Japan*
[2]名古屋大学工学研究科, 〒464-8603　名古屋市千種区不老町

In Large Helical Device (LHD) experiments, the beta collapse phenomenon has been occurred by magneto-hydro dynamics (MHD) instability in the week shear configuration. We have evaluated the Mercier parameter about two discharges, which are with and without the beta collapse in the week shear configuration. The evaluation of the Mercier parameter is used the pressure and rotational transform profiles measured by Thomson scattering system and motional Stark effect diagnostic, respectively. We will clarify the threshold of the beta limit by the evaluation of the Mercier parameter.

## 1. Introduction

In toroidal magnetic confinement devices, the increase of the plasma beta value is one of the important issues for the achievement of the nuclear fusion plant. The plasma beta is limited by the plasma current and/or pressure driven MHD instabilities. The minor collapse and disruption are occurred by MHD instabilities in tokamak plasmas. In the LHD (one of the typical helical device) experiments, the beta collapse phenomenon has been also observed by MHD instability in the week shear configuration. This study's purpose is to clarify the threshold of the beta limit by the evaluation of the Mercier parameter $D_I$.

In this study, we have calculated the equilibrium of LHD plasmas with and without the beta collapse by using VMEC code [1]. We had already calculated the equilibrium by using the plasma pressure, which is measured by Thomson scattering system, and the rotational transform $\iota/2\pi$ profile assumed as uniform, parabolic and hollow current density profile. However the estimated $D_I$ had large scatter. So, it was found that the current density profile is important in order to precisely estimate $D_I$. Therefore, it is used for the calculation of the equilibrium that $\iota/2\pi$ profile was measured by motional Stark effect (MSE) diagnostic.

## 2. β collapse in week shear configuration

In order to form the week shear configuration, the plasma current is necessary in the LHD configuration. The plasma current $I_p$ was generated by unbalanced Neutral Beam (NB) injection. For example, over 100 kA of plasma current was observed by unbalanced NB injection in LHD device [2]. Figure 1 shows the temporal evolution of the port through power of NBI, ratio of $I_p$ and toroidal magnetic field $B_t$ and voluve averaged beta $<\beta_{dia}>$ measured by a diamagnetic loop. Because a

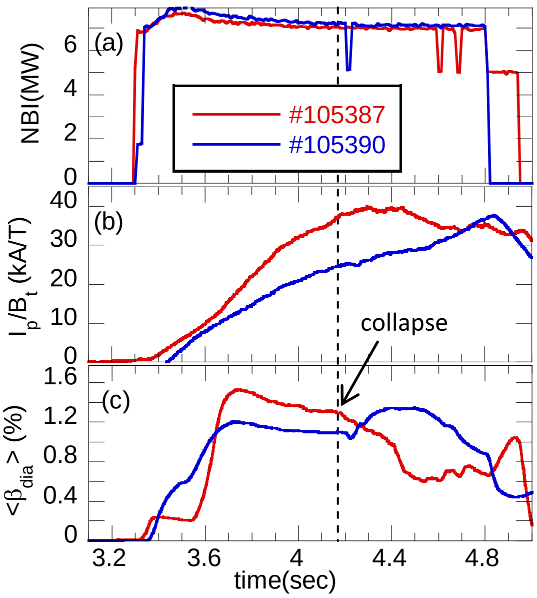


Fig.1. Time evolution of (a) the port through power of NBI, (b) ratio of plasma current $I_p$ and toroidal magnetic field $B_t$, and (c) volume averaged beta $<\beta_{dia}>$ measured by a diamagnetic loop.

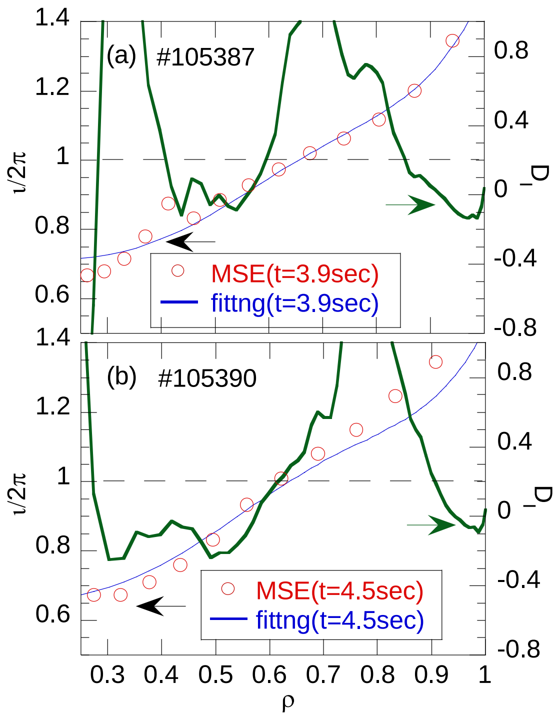


Fig.2. Profiles of rotational transform $\iota/2\pi$ and Mercier parameter $D_I$ of discharge (a) with collapse and (b) without collapse. Rotational transform profiles are measured by MSE diagnostic and calculated by the polynomial fitting of plasma current profile.

neon gas puff is applied at the discharge of #105387 to increase the ramp-up rate of $I_p$, the beta collapse is occurred at about $t$ = 4.17 sec, $I_p/B_t$ = 37.2 kA/T, and $\langle\beta_{\mathrm{dia}}\rangle$ = 1.29 %. On the other hand, the $I_p$ ramp-up rate of the discharge of #105390 is smaller than the rate of discharge with Ne gas puff. So, the discharge of #105390 cannot be observed the beta collapse. After $t$ = 4.5 sec, $\langle\beta_{\mathrm{dia}}\rangle$ is decreased with the electron density because hydrogen gas, which is the main discharge gas, puff is terminated at $t$ = 4.5 sec.

## 3. Calculation of equilibrium

Figure 2 shows profiles of $\iota/2\pi$ and $D_I$. In Fig.2 (a), opened circles indicate $\iota/2\pi$ profile measured by MSE diagnostic, which has time resolution of 0.3 sec, at $t$ = 3.9 sec. At $t$ = 3.9 sec, the plasma parameter is as follows, $\langle\beta_{\mathrm{dia}}\rangle$ = 1.40 % and $I_p/B_t$ = 28.2 kA/T. The fitting curve is $\iota/2\pi$ profile calculated by the polynomial fitting of plasma current profile. The curve of $D_I$ is evaluated by the measured pressure profile and fitting curve of $\iota/2\pi$. In Fig.2 (b), it shows profiles of $\iota/2\pi$ and $D_I$ at $t$ = 4.5 sec. At $t$ = 4.5 sec, the plasma parameter is as follows, $\langle\beta_{\mathrm{dia}}\rangle$ = 1.34 % and $I_p/B_t$ = 28.8 kA/T. From the measurement of $\iota/2\pi$ profile, it is found that magnetic shear of #105390 is larger than the shear of #105387 around the resonant surface of $m/n$ = 1/1 ($m$ and $n$ are the poloidal and toroidal mode number, respectively). And it is found that the $D_I$ of #105390 is smaller than $D_I$ of #105387 around the $m/n$ = 1/1 surface. These results are indicated that the discharge of #105387 is more unstable than #105390 and it is consistent with the experimental result of Fig. 1.

## 4. Summary

We indicate that $D_I$ could be evaluated at LHD plasma with and without the beta collapse by using MSE diagnostic. The result is obtained that $D_I$ of the discharge with collapse is larger than $D_I$ of the discharge without collapse. As the future works, we will evaluate the $D_I$ of other discharges and clarify the threshold of the beta limit by the $D_I$.

**References**

[1] S.P. Hirshman, W.I. Van Rije and P. Merkel, Comput. Phys. Commun. **43** (1986) 143.

[2] K.Y. Watanabe, et al., Controlled Fusion and Plasma Physics **24B** (2000) 1316.