ISSN 0915-633X

NATIONAL INSTITUTE FOR FUSION SCIENCE

Proposal of "MODULAR HELIOTRON": Advanced Modular Helical System Compatible with Closed Helical Divertor

K. Yamazaki

(Received – Nov. 9, 1993)

NIFS-261 Nov. 1993

RESEARCH REPORT
NIFS Series

NAGOYA, JAPAN

Proposal of " MODULAR HELIOTRON " :

Advanced Modular Helical System

Compatible with Closed Helical Divertor

Kozo Yamazaki

National Institute for Fusion Science,
Chikusa-ku, Nagoya 464-01, Japan

Abstract

A new modular helical configuration named "Modular Heliotron" with clean and efficient helical magnetic divertor is proposed as an extension of the present conventional design of the continuous helical coil system. The sectored helical coils on one plane of the torus and the sectored returning vertical field coils on the other plane are combined. This coil system produces magnetic surfaces nearly equivalent to those of the $\ell=2$ helical system with one-pair poloidal coils, and overcomes the defects of construction and maintenance difficulties of the continuous coil systems. This concept satisfies the compatibility between the coil modularity and the sufficient divertor-space utilization, different from previous modular coil designs. The allowable length of the gap between each modular coil is clarified to keep good magnetic surfaces. Typical examples of the reactor coil configuration are described as an extension of the LHD (Large Helical Device) configuration.

Keywords: modular coils, helical system, helical divertor, magnetic surface, heliotron/torsatron, stellarator

1. Introduction

Helical confinement configurations have remarkable advantages in demonstrating steady-state operations of fusion reactors [1]. From this viewpoint the helical systems are superior to the tokamak systems that might suffer from serious plasma current disruptions. This will be demonstrated in the LHD (Large Helical Device) [2] in the near future.

Helical systems are presently suffering from the anomalous plasma energy loss as well as tokamak systems. As has been demonstrated in tokamaks, clean divertor configurations for recycling controls are important to improve plasma confinement like H-mode. Even in helical systems an H-mode transition requires clean magnetic separatrix [3]. Moreover, impurity and ash exhaust controls in the reactor require efficient divertor pumping. This clean and efficient divertor concept with helical magnetic separatrix will be demonstrated in the LHD with continuous helical coil systems. However, the continuous coil system requires sophisticated SC joint concept [4] to keep modularity, otherwise, it might become quite difficult to construct and repair this coil system.

To keep easy maintenance and reliable modularity in the helical system the W7-X modular stellarator project is proposed [5]. Especially, plasma shapes are optimized for high-beta and good confinement with sophisticated modular coils. However, this is not optimized for magnetic separatrix configurations outside the outer-most surface, and therefore will utilize the local bundle divertor, ergodic divertor or island divertor, instead of helical divertor with larger and efficient divertor chamber space.

Until today, a lot of modular coil systems based on the stellarator concept are proposed [6-9]. The modular coil design based on heliotron/torsatron system is also discussed [10]. However, there is no proposal for the coil configuration compatible between the helical divertor and the coil modularity.

Both clean divertor and coil modularity are essential for the achievement of reliable helical reactor systems. This paper proposes an advance modular helical system named "Modular Heliotron" that is compatible with closed helical divertor. This is based on the LHD configuration [11] with ℓ=2 and m=10 coil system which was optimized for high-beta achievement, particle orbit confinement, divertor space utilization and transport scaling. The effects of gaps between each modular coil on the magnetic surfaces are also surveyed in this paper.

2. Modular coil configurations

The clean divertor concept and the coil modularity scheme are essential for the achievement of good plasma confinement and reliable engineering reactor systems. By using continuous helical coil systems, helical divertor separatrix can be potentially formed. Especially, the heliotron/torsatron system is superior to the classical stellarator requiring a pair of plus-minus helical coil currents, because the larger space for helical divertor chamber can be utilized and the medium or strong magnetic shear can help good confinement. Within heliotron/torsatron systems an ℓ=2 system is better than ℓ=1 or more than 3 because of enough experimental data-base and the existence of magnetic rotational transform near the plasma center. This is the basic reason why the ℓ=2 heliotron configuration has been chosen for LHD [11]. However, this continuous coil system is not preferable as a reactor with respect to the easy construction and maintenance of the machine, as summarized in Table 1.

As an extension of this LHD configuration to the reactor, one way is to use this continuous coil system with superconducting joint [4] for easy maintenance. Another way is to consider modular coil systems, however, the previously proposed modular heliotron/torsatron system, for example "Symmotron" [10], is not appropriate to install efficient divertor pumping chamber. In a similar manner, the present advanced modular helical systems, for example Wendelstein-7X configurations [5], are not appropriate for producing clean magnetic surface near the plasma edge and for keeping enough space for closed divertor chamber.

As an extension of the present continuous coil configuration, we can propose new modular coil design for the heliotron/torsatron and the stellarator as shown in Fig. 1(a) and (b). The essential difference between the present proposal and the well-known previous modular coil systems is whether the closed helical divertor can be installed or not. The improvements of the plasma properties in the continuous coil systems are realized by the plasma shifting, cross-sectional shaping and/or coil pitch modulations. The same technique might be used even in these modular systems by adding flexible coil systems as shown in Fig. 2 (a) and (b). This concept can be applied to the $\ell=1$ or $\ell=3$ helical systems, too.

These modular concepts can ensure the compatibility between the sufficient ash exhaust though the helical divertor and the easy reactor maintenance due to modular coil properties (Table 1). Clean magnetic separatrix will also help confinement improvement as suggested in the W7-AS experiment [3].

3. Plasma shaping, magnetic energy and leakage field

We would like to consider one of simplest modular coil systems as shown in Fig. 1(a), instead of Fig. 2(a). The constraints used here on the continuous helical coil (HC) with one-pair poloidal coil (PC) are based on the LHD design described by;

(1) helical coil polarity $\ell = 2$,

(2) helical coil period number m = 10,

(3) pitch parameter gamma $\gamma = 1.25$,

(4) pitch modulation alpha $\alpha = 0.0$, and

(5) position of magnetic axis Δ=-0.15m at R_0=4m.

Here, the winding law of the helical coil with the major radius R_0 and the minor radius r_{HC} is given by

$$\theta = (m\phi / \ell) + \alpha \sin (m\phi/\ell),$$

$$\gamma = (m r_{HC})/(\ell R_0),$$

where θ and ϕ are the poroidal and toroidal co-ordinates, respectively. The final LHD design parameters ($\alpha = 0.1, R_0=3.9$m) are slightly different from the above parameters. All these parameters of LHD are determined by the trade-off among the following issues [2,11];

(1) physics design (orbit loss-cone, high-beta achievement, divertor clearance and confinement scaling),

(2) scenarios for plasma axis shift and plasma shaping,

(3) reduction of leakage magnetic field, and

(4) minimization of magnetic energy.

Here, we will focus on the advanced modular coil design extended from the above LHD helical coil. The other shape of this modular coil system is defined by

(1) location of return coil current (r_{PC}/r_{HC}, θ_{PC}), and

(2) gap between modular coils (Δgap),

as shown in Fig. 3.

Figure 4(a) shows the effects of the location of one-pair poloidal coil (PC) system with continuous helical coil (HC) on the plasma shaping, plasma axis, and magnetic energy. The poloidal angle of PC is fixed to 45° in this figure. The increase in r_{PC} gives rise to the increase in the required poloidal coil current I_{PC} and total magnetic energy W_{PC} normalized by helical coil energy W_{HC}. The leakage magnetic field B_l at $R_l = 4R_0$ becomes nearly zero at $r_{PC}=2\,r_{PC}$. The quadrupole component of poloidal coil normalized by that of helical coil, B_Q, is almost constant because of fixed angle θ_{PC}. The condition that the I_{PC} value coincides with the I_{HC} is realized at r_{PC}/r_{HC} = 3.5, and leads to the possibility of simple modular heliotron without PC systems.

The dependence of these parameters on the angular position of one-pair PC system is shown in Fig. 4(b). The magnetic energy and the leakage magnetic field remain almost constant because of fixed r_{PC}/r_{HC}, while the B_Q vale increases as θ_{PC} is raised. The typical configuration of $I_{PC}=I_{HC}$ is r_{PC}/r_{HC} = 3 and θ_{PC}. = 55°. Figure 5 shows this coil configuration of continuous HC and one-pair PC system and its magnetic surface. Using these results, we might construct a " Modular Heliotron " as an advanced modular system with helical divertor.

4. Effects of coil gap on magnetic configurations

The irregular magnetic field will easily destroy the clean magnetic surfaces of helical confinement configurations. In the present proposed modular coil system the gaps between each modular coil will make bad effects on the plasma confinements. These wide gaps are important for reducing the electromagnetic forces, and for easy maintenance of modules.

Figure 6 shows the variations of magnetic surfaces due to the coil gap (Δgap). The calculations are carried out using single filament model for simplicity, but the characteristics of the effects of the gap might be maintained. Without gaps the same magnetic field configurations are obtained, while the existence of $\geq 6°$ gap between two $18°$ periodic modules is not acceptable because of the strange shape of plasma cross-section and the unfavorable existence of the pitch minimum. The gap less than $4°$ is acceptable, which is equivalent to 0.7 m distance for R_0=10 m machine. Since the magnetic field strength of ~ 6 T (the coil current of ~ 30 MA) is required for ignition in this machine, the width of the rectangular coil is estimated less than 0.55 m in the case of coil current density of ~ 100 A/mm^2, which is within the above-stated permissible gap of 0.7m.

By changing the position of return module current and/or adding supplementary PC systems, we might enlarge the modular gap without sacrificing the magnetic surfaces. More optimized coil configurations will be investigated in the near future.

5. Discussions and summary

In summary, we proposed new modular helical coil systems compatible with the closed helical divertor operations as an extension of the present continuous coil concept. Generally we can produce nearly same magnetic surfaces by this modular system as those obtained by the equivalent continuous coil design. We studied the effect of the gap between each module on the magnetic surfaces and clarified the effectiveness of this new modular helical system (called "Modular Heliotron") as a reactor system (Fig. 7).

The remaining items relevant to this modular coil system is as follows:

(1) analysis of magnetic surfaces and separatrix using finite-sized coils,

(2) possible utilization of pitch-modulated and non-circular helical coil windings for configuration optimization,

(3) reduction of electromagnetic forces on the modular coils, and

(4) stability and transport analyses as a function of the gap length.

These issues are now under investigation and will be published in the near future.

References

[1] J.F.Lyon, *Fusion Technol.*, **17**,19 (1990).

[2] A. Iiyoshi, M. Fujiwara, O. Motojima, N. Ohyabu and K. Yamazaki, *Fusion Technol.*, **17**, 169 (1991).

[3] V. Erckmann, F. Wagner et al., *Phys. Rev. Lett.*, **70**, 2086 (1993).

[4] K. Uo, O. Motojima, T. Horiuchi, Y. Monju and M. Hamada, *Proc. 14 th Sympo. Fusion Technology* , Avignon, 1986, Vol.2 p.1727(1986).

[5] C. Beidler, G. Grieger, F. Herrnegger, E. Harmeyer, J. Kisslinger et al., *Fusion Technol.*, **17**,148 (1990).

[6] H.Wobig and S. Rehker, *Proc. 7 th Sympo. Fusion Technology*, Grenoble, 1972, p.345.

[7] D. T. Anderson, J. A. Derr and J.L. Shohet, , *IEEE Transaction on Plasma Science* **PS-9**, 212 (1981).

[8] R. Chodra et al., *IEEE Transaction on Plasma Science* **PS-9**, 221(1981).

[9] T. K. Chu et al., *IEEE Transaction on Plasma Science* **PS-9**, 228(1981).

[10] J. F. Lyon, B. A. Carreras, R. A. Dory, S. P. Hirshman et al, "Stellarator Physis Evaluation Studies", Internal Report of Oak Ridge National Laboratory ORNL/TM-8496 (1983)

[11] K. Yamazaki et al., *Proc. 13th Int. Conf. Plasma Physics and Controlled Nuclear Fusion Research*, Washington, USA, 1990, Vol. 2, p.709, International Atomic Energy Agency (1991).

Figure Captions

Fig. 1 Modular Coils for Helical Configurations.
(a) Modular Heliotron
(b) Modular Stellarator

Fig. 2 Flexible modular systems
(a) addition of modular poloidal field coils
(b) addition of modular toroidal field coils

Fig. 3 Configuration of $\ell=2$ Modular Heliotron

Fig. 4 Position of the return coil vs. coil current, quadrupole field component and magnetic energy for $\ell=2$ Modular Heliotron.
(a) effects of radial position,
(b) effects of angular position.

Fig. 5 Magnetic configurations with one-pair poloidal coils
(a) $\ell=2$, m=10 continuous coil system at $r_{PC}/r_{HC}=3$, $\theta_{PC}=55°$,
(b) magnetic surfaces.

Fig. 6 Magnetic configurations by modular helical coils.
(a) $\ell=2$, m=10 modular coil system with $\Delta_{gap} = 4°$, $r_{PC}/r_{HC}=3$ and $\theta_{PC}=55°$,
(b) effects of Δ_{gap} on magnetic surfaces,
(c) effects of Δ_{gap} on rotational transform .

Fig. 7 Modular Heliotron Reactor Concept.
(a) single reactor module,
(b) schematic cross-sectional view of Modular Heliotron Reactor.

Table. 1 Comparisons among Helical Configurations

	Continuous Coil (LHD)	Modular Coil (W7X)	Advanced Modular System (Present ProposaL)
Modularity	△ (SC Joint)	○	○
Helical Divertor	○	△ (Island Divertor)	○

Table 1
Kozo Yamazaki

Modular Heliotron

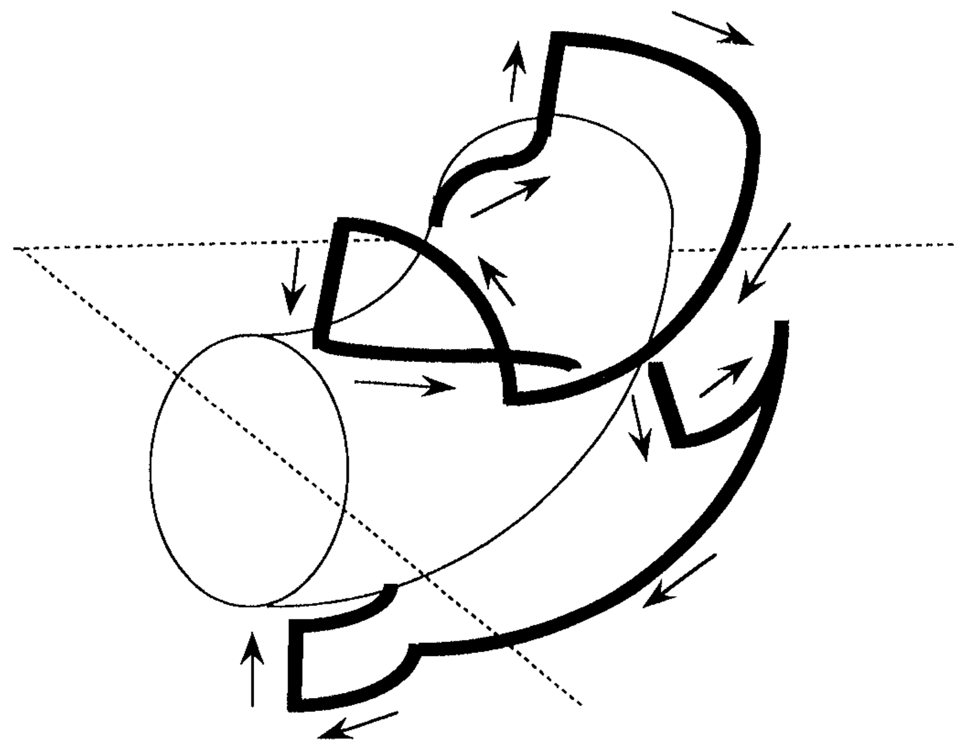

Fig. 1(a)
Kozo Yamazaki

Modular Stellarator

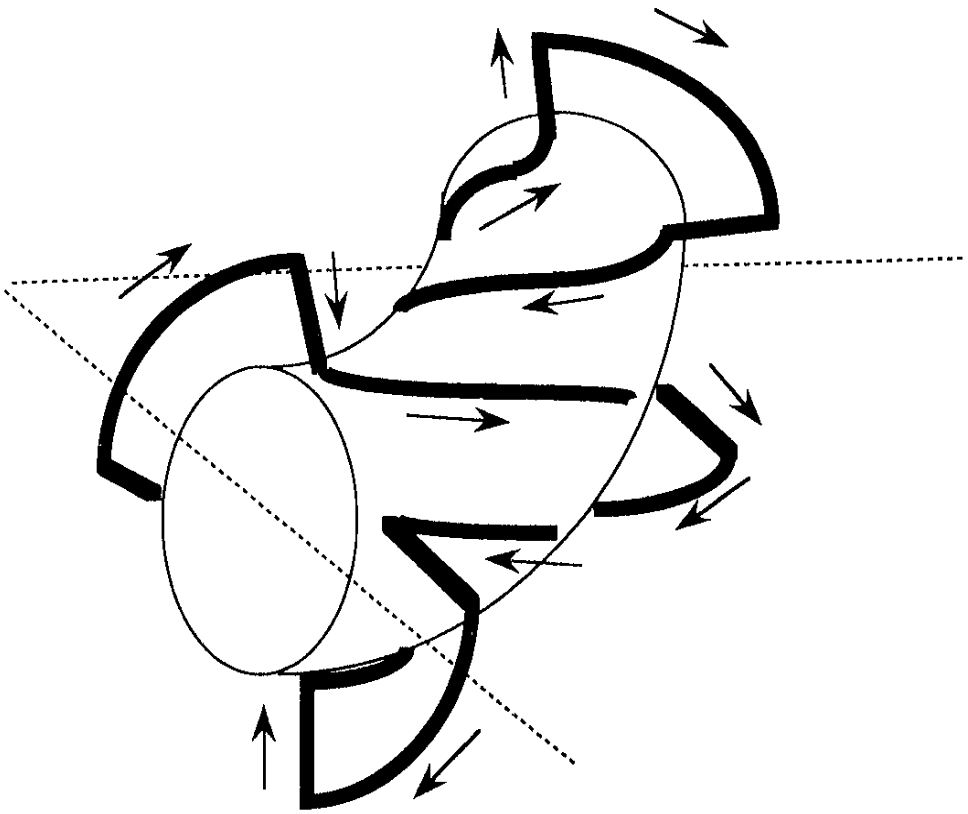

Fig. 1(b)
Kozo Yamazaki

Modular
Heliotron
or
Modular
Stellarator

+

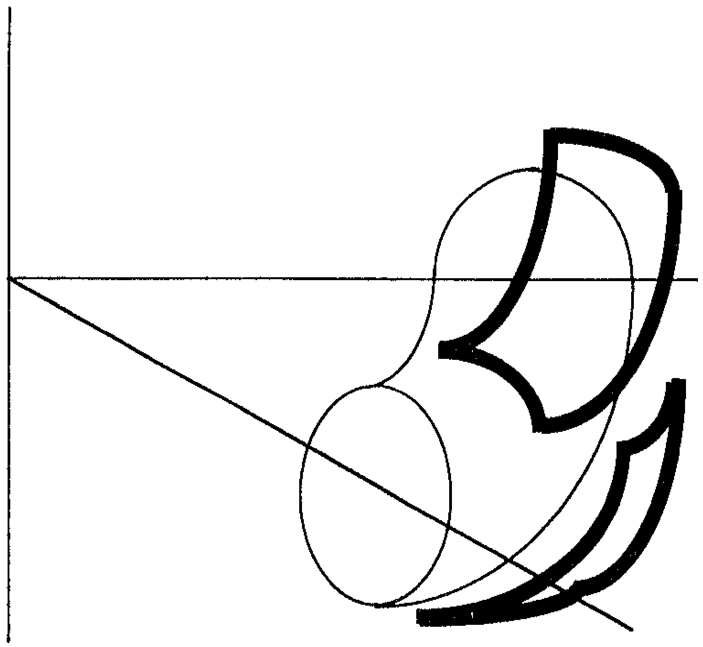

Fig. 2(a)
Kozo Yamazaki

Modular
Heliotron
or
Modular
Stellarator

+

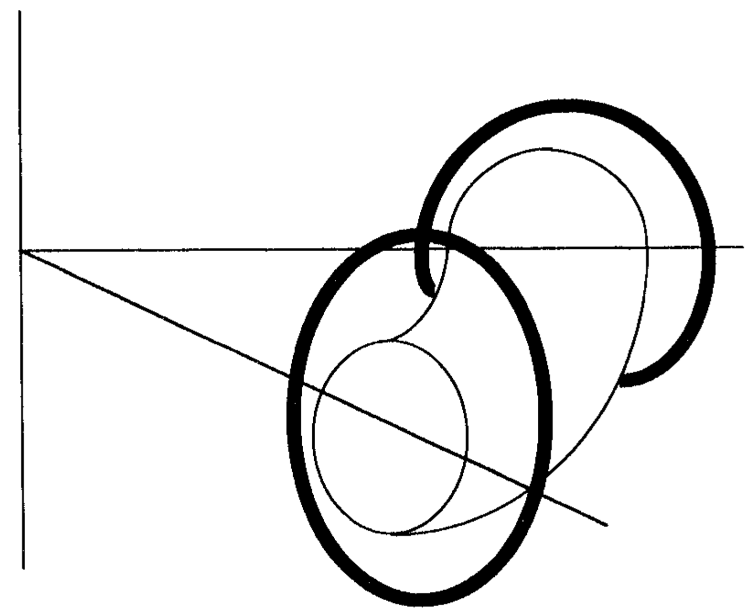

Fig. 2(b)
Kozo Yamazaki

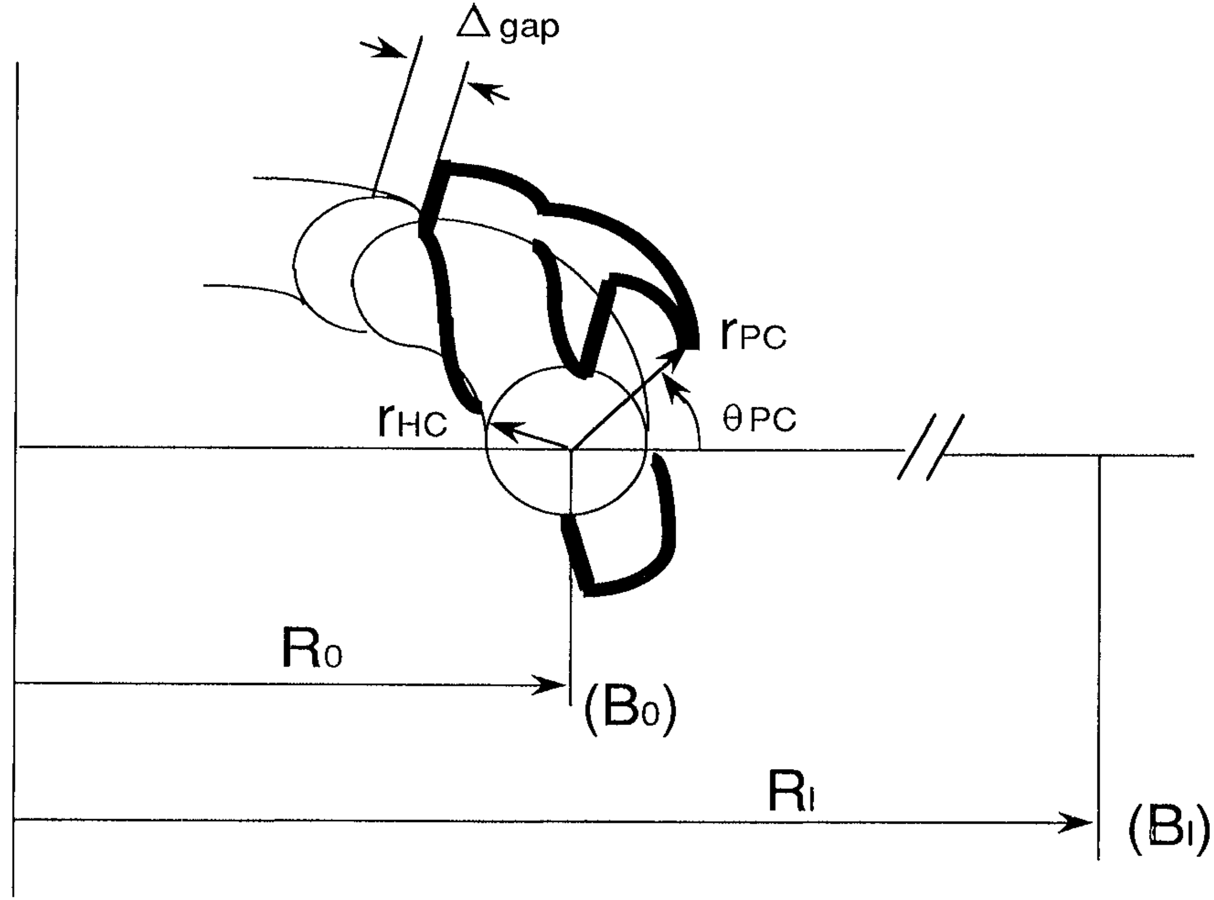

Fig. 3
Kozo Yamazaki

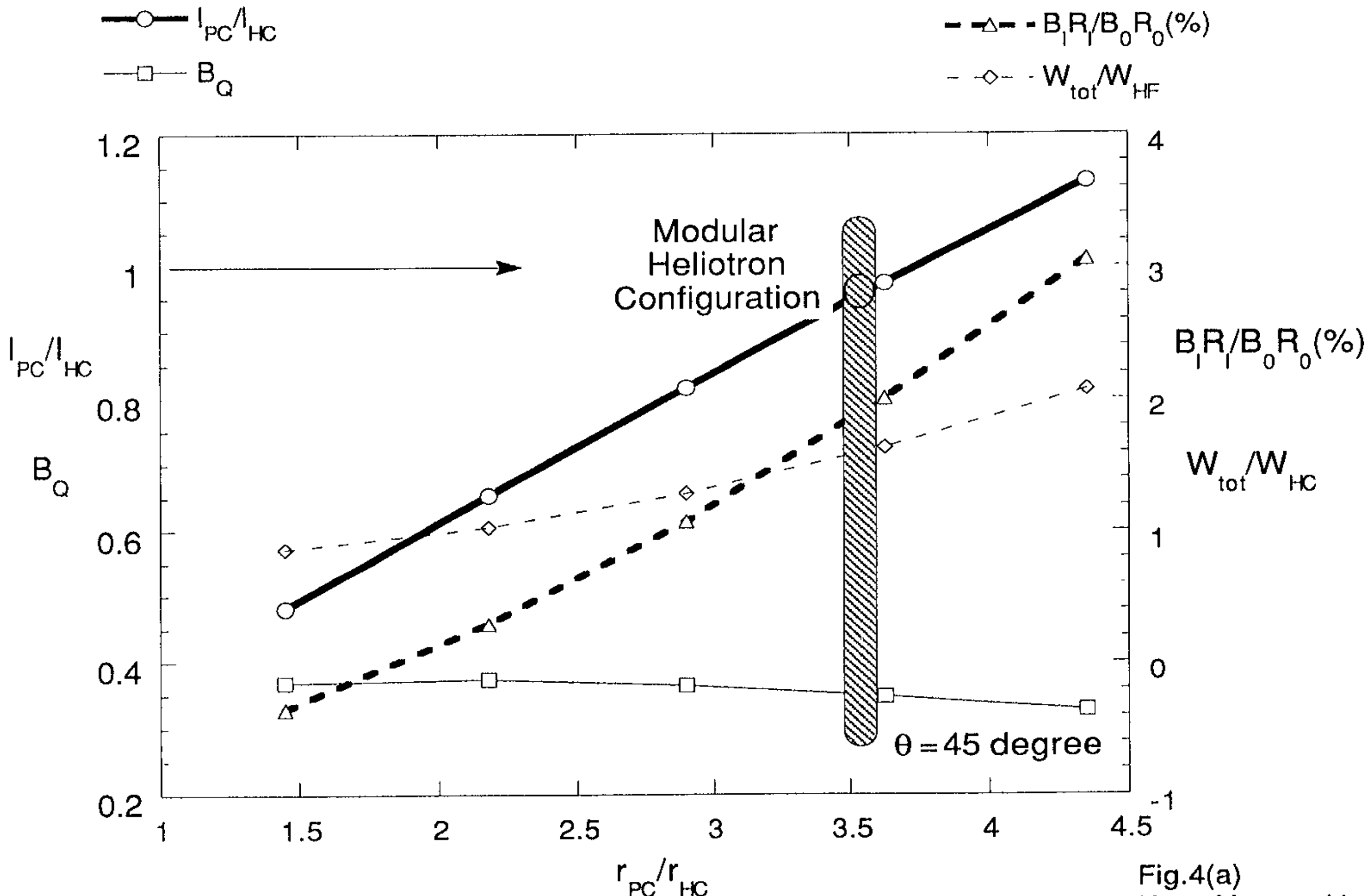

Fig.4(a)
Kozo Yamazaki

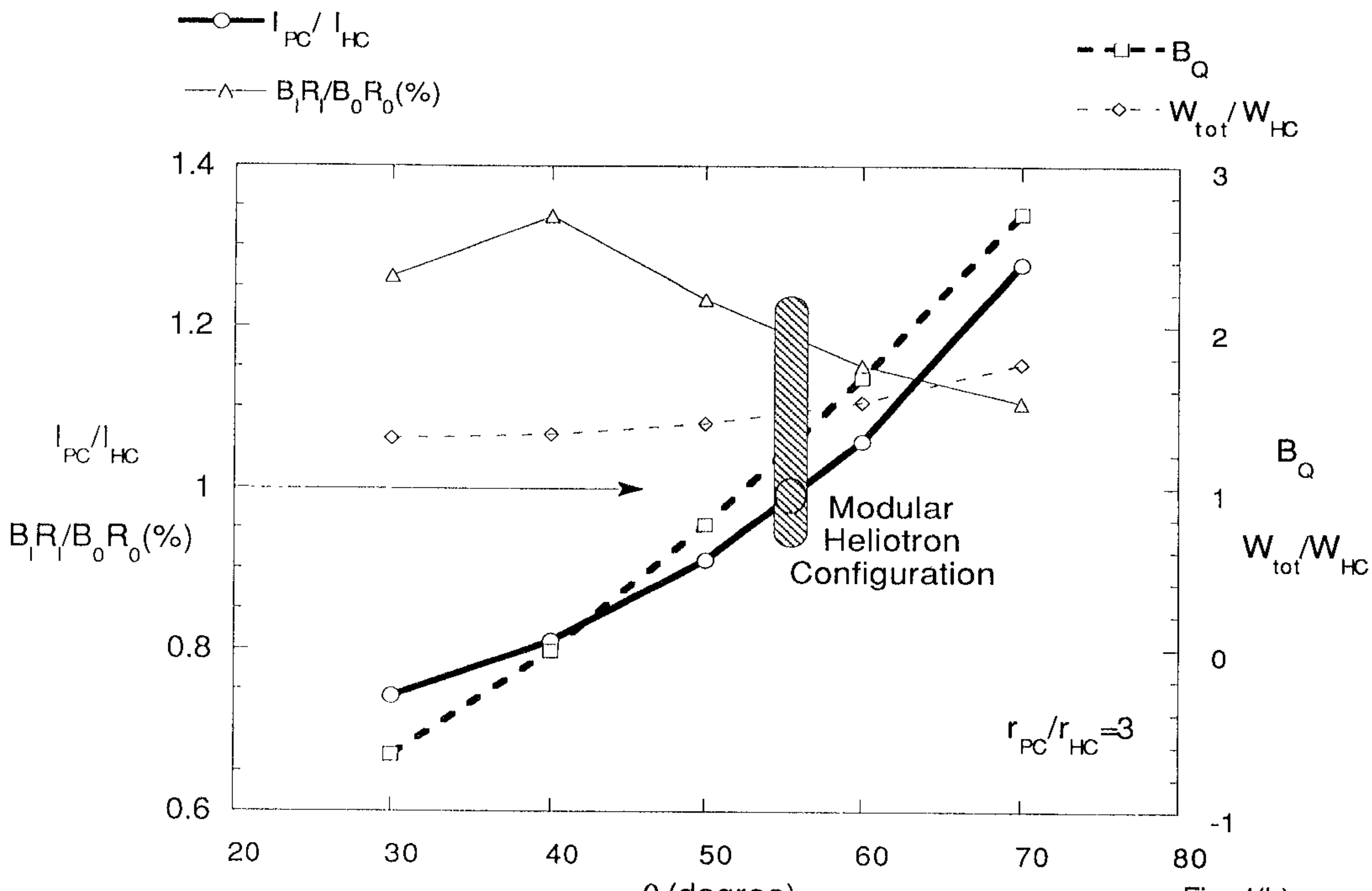

Fig. 4(b)
Kozo Yamazaki

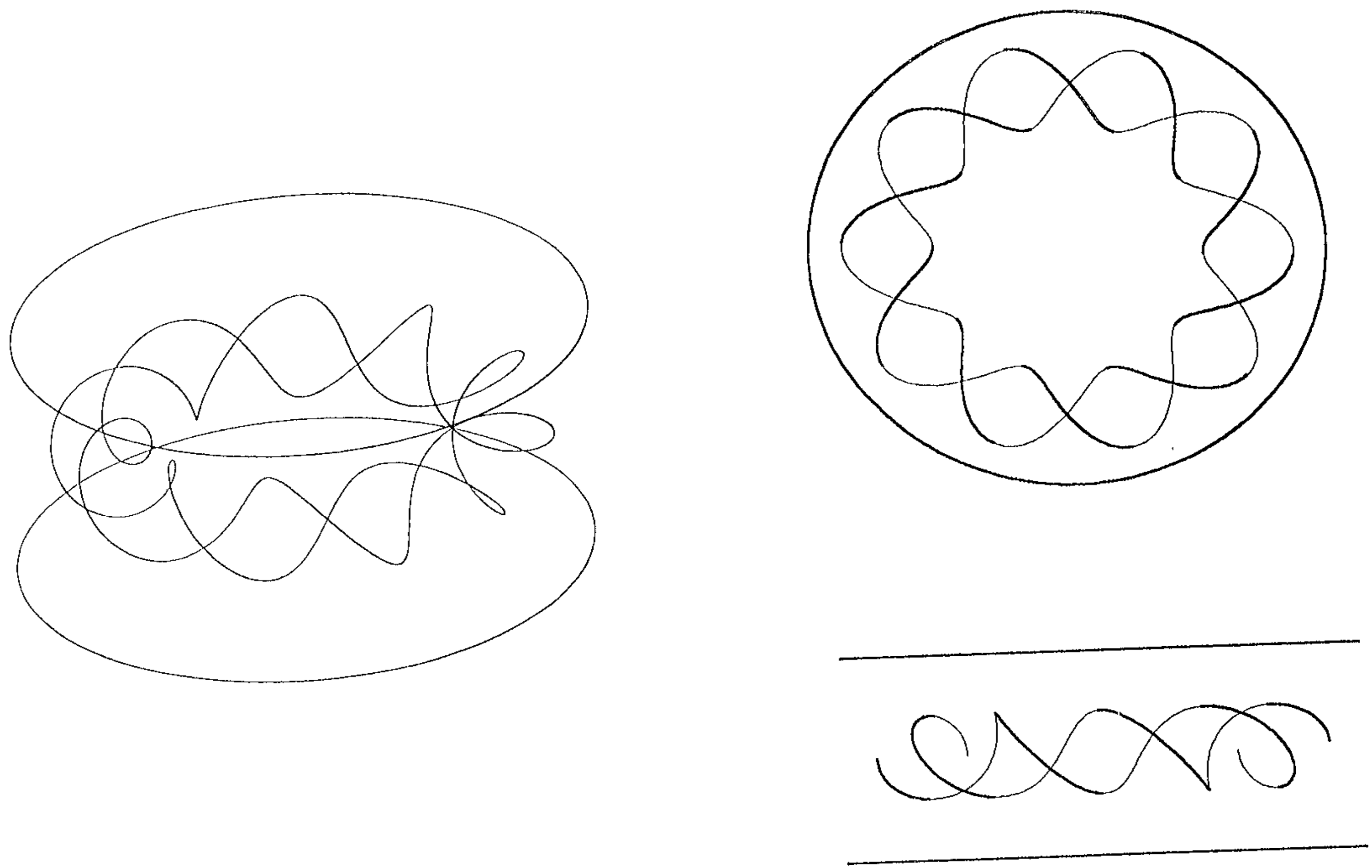

Fig. 5(a)
Kozo Yamazaki

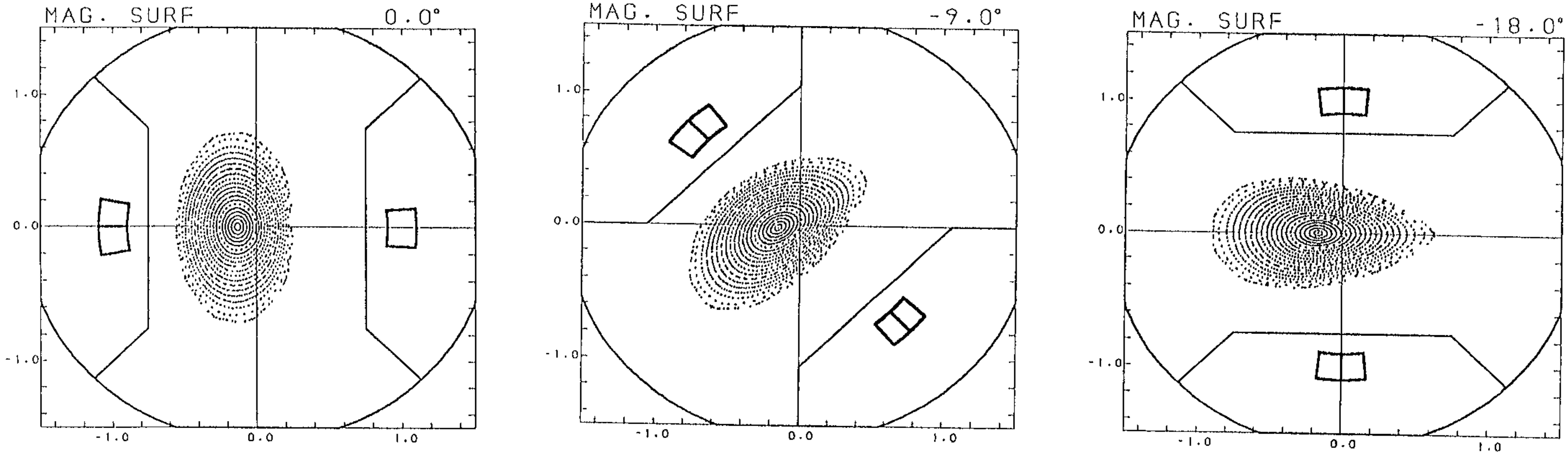

Fig. 5(b)
Kozo Yamazaki

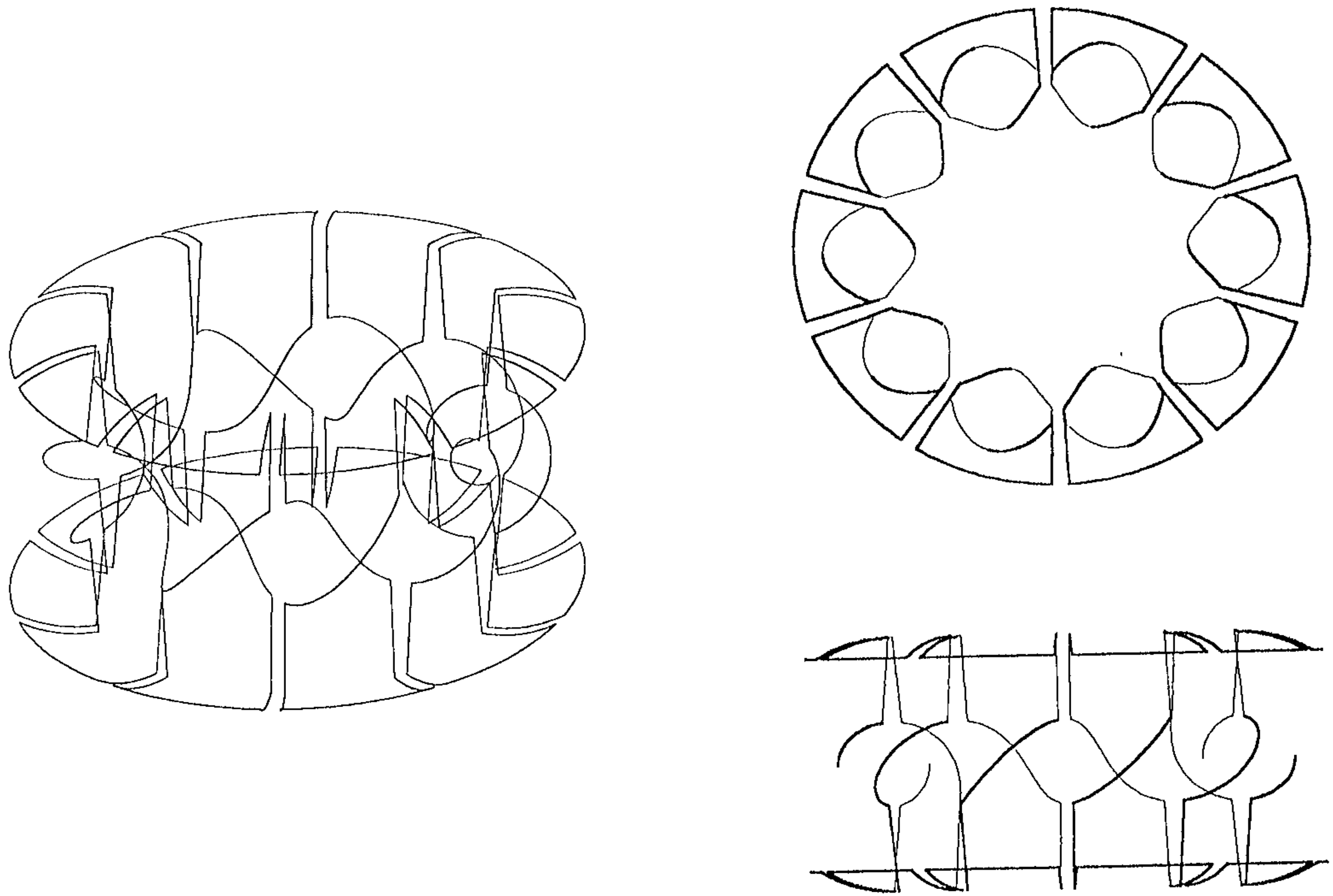

Fig. 6(a)
Kozo Yamazaki

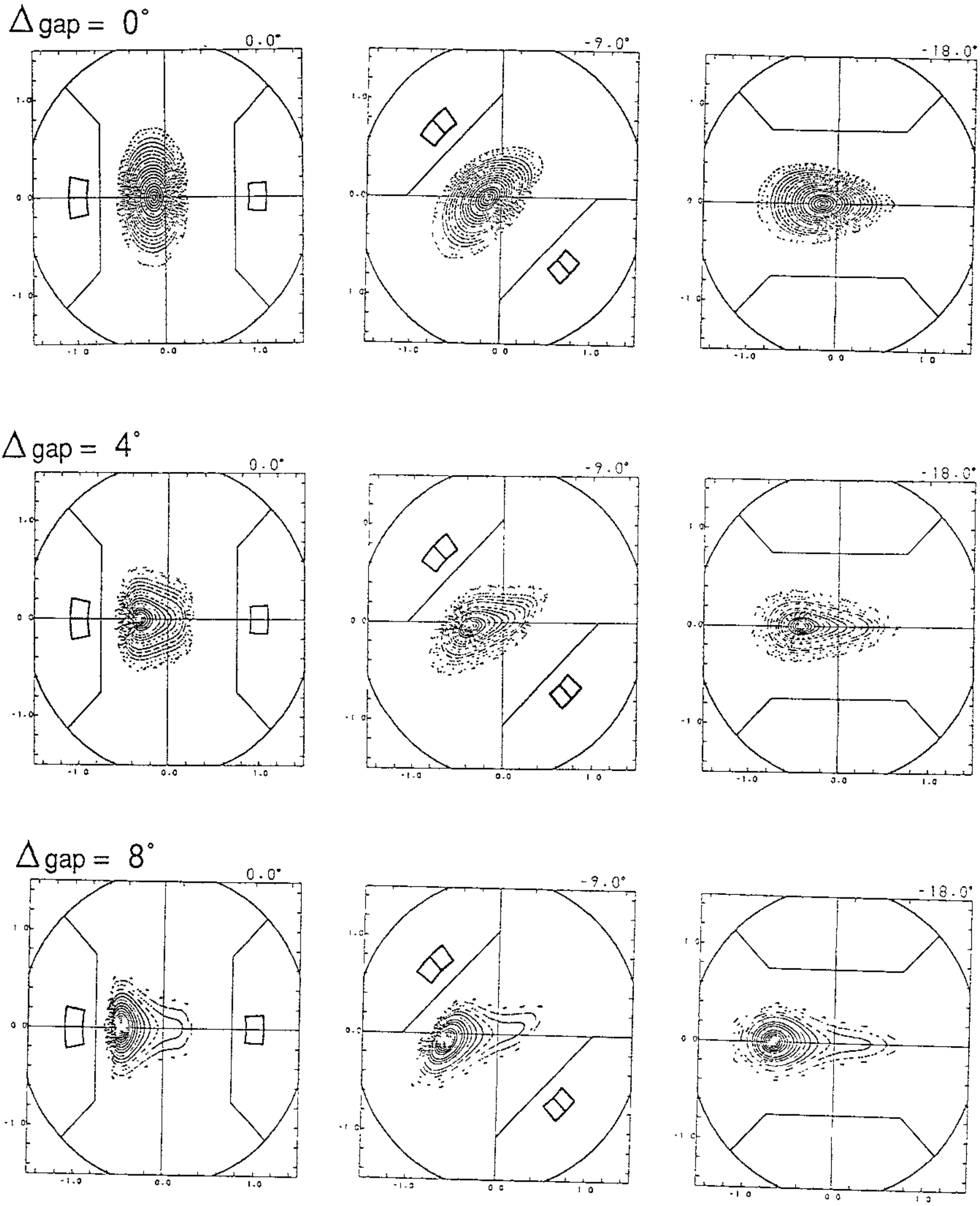

Fig. 6(b)
Kozo Yamazaki

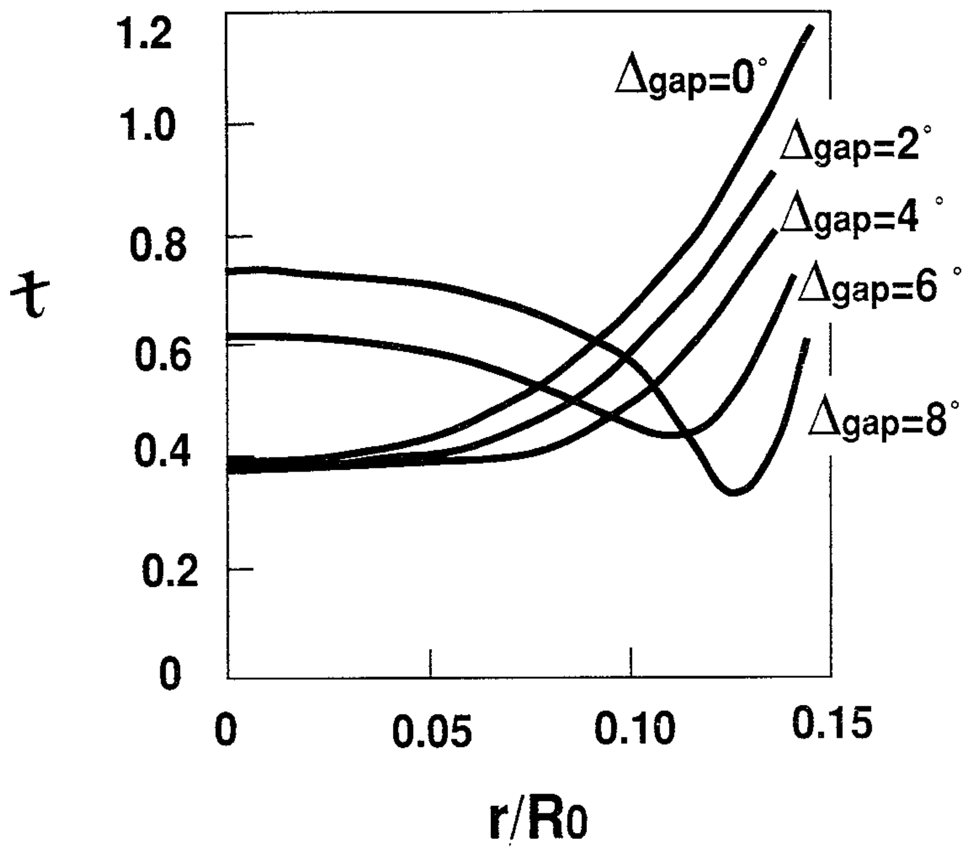

Fig. 6(c)
Kozo Yamazaki

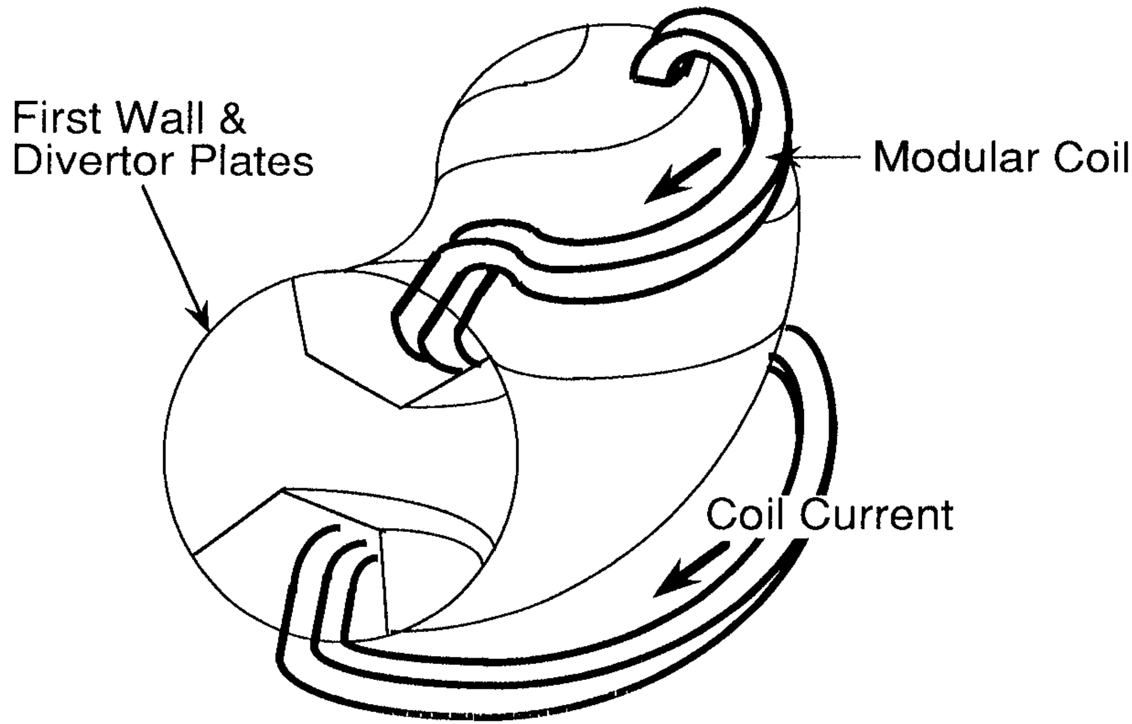

Fig. 7(a)
Kozo Yamazaki

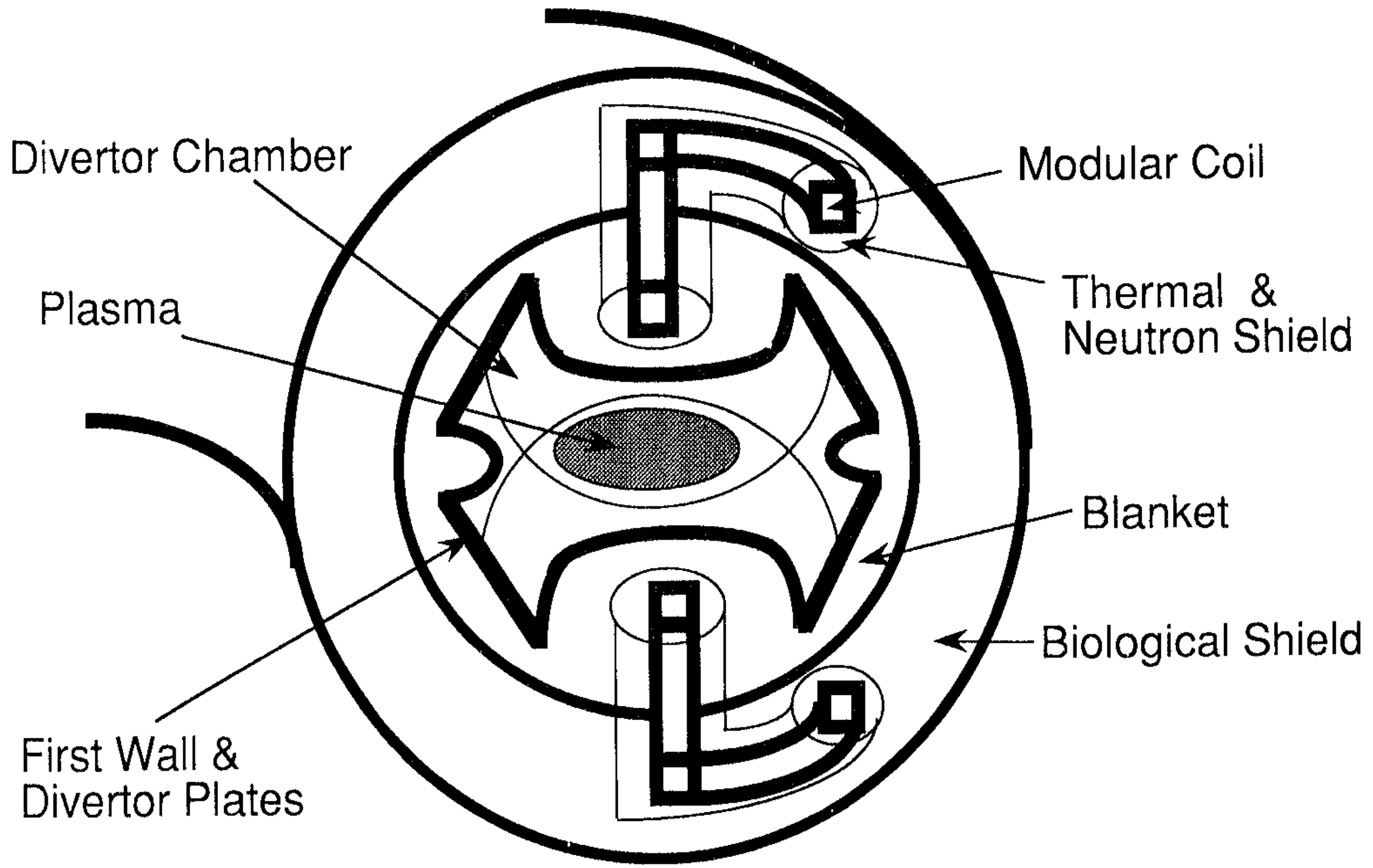

Fig. 7(b)
Kozo Yamazaki

Recent Issues of NIFS Series

NIFS-210 K. Ohkubo, M. Hosokawa, S. Kubo, M. Sato, Y. Takita and T. Kuroda, *R&D of Transmission Lines for ECH System* ; Feb. 1993

NIFS-211 A. A. Shishkin, K. Y. Watanabe, K. Yamazaki, O. Motojima, D. L. Grekov, M. S. Smirnova and A. V. Zolotukhin, *Some Features of Particle Orbit Behavior in LHD Configurations*; Mar. 1993

NIFS-212 Y. Kondoh, Y. Hosaka and J.-L. Liang, *Demonstration for Novel Self-organization Theory by Three-Dimensional Magnetohydrodynamic Simulation*; Mar. 1993

NIFS-213 K. Itoh, H. Sanuki and S.-I. Itoh, *Thermal and Electric Oscillation Driven by Orbit Loss in Helical Systems*; Mar. 1993

NIFS-214 T. Yamagishi, *Effect of Continuous Eigenvalue Spectrum on Plasma Transport in Toroidal Systems*; Mar. 1993

NIFS-215 K. Ida, K. Itoh, S.-I.Itoh, Y. Miura, JFT-2M Group and A. Fukuyama, *Thickness of the Layer of Strong Radial Electric Field in JFT-2M H-mode Plasmas*; Apr. 1993

NIFS-216 M. Yagi, K. Itoh, S.-I. Itoh, A. Fukuyama and M. Azumi, *Analysis of Current Diffusive Ballooning Mode*; Apr. 1993

NIFS-217 J. Guasp, K. Yamazaki and O. Motojima, *Particle Orbit Analysis for LHD Helical Axis Configurations* ; Apr. 1993

NIFS-218 T. Yabe, T. Ito and M. Okazaki, *Holography Machine HORN-1 for Computer-aided Retrieve of Virtual Three-dimensional Image* ; Apr. 1993

NIFS-219 K. Itoh, S.-I. Itoh, A. Fukuyama, M. Yagi and M. Azumi, *Self-sustained Turbulence and L-Mode Confinement in Toroidal Plasmas* ; Apr. 1993

NIFS-220 T. Watari, R. Kumazawa, T. Mutoh, T. Seki, K. Nishimura and F. Shimpo, *Applications of Non-resonant RF Forces to Improvement of Tokamak Reactor Performances Part I: Application of Ponderomotive Force* ; May 1993

NIFS-221 S.-I. Itoh, K. Itoh, and A. Fukuyama, *ELMy-H mode as Limit Cycle and Transient Responses of H-modes in Tokamaks* ; May 1993

NIFS-222 H. Hojo, M. Inutake, M. Ichimura, R. Katsumata and T. Watanabe, *Interchange Stability Criteria for Anisotropic Central-Cell Plasmas in the Tandem Mirror GAMMA 10 ;* May 1993

NIFS-223 K. Itoh, S.-I. Itoh, M. Yagi, A. Fukuyama and M. Azumi, *Theory of Pseudo-Classical Confinement and Transmutation to L-Mode;* May 1993

NIFS-224 M. Tanaka, *HIDENEK: An Implicit Particle Simulation of Kinetic-MHD Phenomena in Three-Dimensional Plasmas;* May 1993

NIFS-225 H. Hojo and T. Hatori, *Bounce Resonance Heating and Transport in a Magnetic Mirror;* May 1993

NIFS-226 S.-I. Iton, K. Itoh, A. Fukuyama, M. Yagi, *Theory of Anomalous Transport in H-Mode Plasmas;* May 1993

NIFS-227 T. Yamagishi, *Anomalous Cross Field Flux in CHS ;* May 1993

NIFS-228 Y. Ohkouchi, S. Sasaki, S. Takamura, T. Kato, *Effective Emission and Ionization Rate Coefficients of Atomic Carbons in Plasmas;* June 1993

NIFS-229 K. Itoh, M. Yagi, A. Fukuyama, S.-I. Itoh and M. Azumi, *Comment on 'A Mean Field Ohm's Law for Collisionless Plasmas;* June 1993

NIFS-230 H. Idei, K. Ida, H. Sanuki, H. Yamada, H. Iguchi, S. Kubo, R. Akiyama, H. Arimoto, M. Fujiwara, M. Hosokawa, K. Matsuoka, S. Morita, K. Nishimura, K. Ohkubo, S. Okamura, S. Sakakibara, C. Takahashi, Y. Takita, K. Tsumori and I. Yamada, *Transition of Radial Electric Field by Electron Cyclotron Heating in Stellarator Plasmas;* June 1993

NIFS-231 H.J. Gardner and K. Ichiguchi, *Free-Boundary Equilibrium Studies for the Large Helical Device,* June 1993

NIFS-232 K. Itoh, S.-I. Itoh, A. Fukuyama, H. Sanuki and M. Yagi, *Confinement Improvement in H-Mode-Like Plasmas in Helical Systems,* June 1993

NIFS-233 R. Horiuchi and T. Sato, *Collisionless Driven Magnetic Reconnection,* June 1993

NIFS-234 K. Itoh, S.-I. Itoh, A. Fukuyama, M. Yagi and M. *Azumi, Prandtl Number of Toroidal Plasmas;* June 1993

NIFS-235 S. Kawata, S. Kato and S. Kiyokawa , *Screening Constants for Plasma;* June 1993

NIFS-236 A. Fujisawa and Y. Hamada, *Theoretical Study of Cylindrical Energy Analyzers for MeV Range Heavy Ion Beam Probes;* July 1993

NIFS-237 N. Ohyabu, A. Sagara, T. Ono, T. Kawamura and O. Motojima, *Carbon Sheet Pumping;* July 1993

NIFS-238 K. Watanabe, T. Sato and Y. Nakayama, *Q-profile Flattening due to Nonlinear Development of Resistive Kink Mode and Ensuing Fast Crash in Sawtooth Oscillations;* July 1993

NIFS-239 N. Ohyabu, T. Watanabe, Hantao Ji, H. Akao, T. Ono, T. Kawamura, K. Yamazaki, K. Akaishi, N. Inoue, A. Komori, Y. Kubota, N. Noda, A. Sagara, H. Suzuki, O. Motojima, M. Fujiwara, A. Iiyoshi, *LHD Helical Divertor;* July 1993

NIFS-240 Y. Miura, F. Okano, N. Suzuki, M. Mori, K. Hoshino, H. Maeda, T. Takizuka, JFT-2M Group, K. Itoh and S.-I. Itoh, *Ion Heat Pulse after Sawtooth Crash in the JFT-2M Tokamak;* Aug. 1993

NIFS-241 K. Ida, Y.Miura, T. Matsuda, K. Itoh and JFT-2M Group, *Observation of non Diffusive Term of Toroidal Momentum Transport in the JFT-2M Tokamak;* Aug. 1993

NIFS-242 O.J.W.F. Kardaun, S.-I. Itoh, K. Itoh and J.W.P.F. Kardaun, *Discriminant Analysis to Predict the Occurrence of ELMS in H-Mode Discharges;* Aug. 1993

NIFS-243 K. Itoh, S.-I. Itoh, A. Fukuyama, *Modelling of Transport Phenomena;* Sep. 1993

NIFS-244 J. Todoroki, *Averaged Resistive MHD Equations;* Sep. 1993

NIFS-245 M. Tanaka, *The Origin of Collisionless Dissipation in Magnetic Reconnection;* Sep. 1993

NIFS-246 M. Yagi, K. Itoh, S.-I. Itoh, A. Fukuyama and M. Azumi, *Current Diffusive Ballooning Mode in Seecond Stability Region of Tokamaks;* Sep. 1993

NIFS-247 T. Yamagishi, *Trapped Electron Instabilities due to Electron Temperature Gradient and Anomalous Transport;* Oct. 1993

NIFS-248 Y. Kondoh, *Attractors of Dissipative Structure in Three Disspative Fluids;* Oct. 1993

NIFS-249 S. Murakami, M. Okamoto, N. Nakajima, M. Ohnishi, H. Okada, *Monte Carlo Simulation Study of the ICRF Minority Heating in the Large Helical Device;* Oct. 1993

NIFS-250 A. Iiyoshi, H. Momota, O. Motojima, M. Okamoto, S. Sudo, Y. Tomita, S. Yamaguchi, M. Ohnishi, M. Onozuka, C. Uenosono,
Innovative Energy Production in Fusion Reactors; Oct. 1993

NIFS-251 H. Momota, O. Motojima, M. Okamoto, S. Sudo, Y. Tomita, S. Yamaguchi, A. Iiyoshi, M. Onozuka, M. Ohnishi, C. Uenosono,
Characteristics of D-^{3}He Fueled FRC Reactor: ARTEMIS-L, Nov. 1993

NIFS-252 Y. Tomita, L.Y. Shu, H. Momota,
Direct Energy Conversion System for D-^{3}He Fusion, Nov. 1993

NIFS-253 S. Sudo, Y. Tomita, S. Yamaguchi, A. Iiyoshi, H. Momota, O. Motojima, M. Okamoto, M. Ohnishi, M. Onozuka, C. Uenosono,
Hydrogen Production in Fusion Reactors, Nov. 1993

NIFS-254 S. Yamaguchi, A. Iiyoshi, O. Motojima, M. Okamoto, S. Sudo, M. Ohnishi, M. Onozuka, C. Uenosono,
Direct Energy Conversion of Radiation Energy in Fusion Reactor, Nov. 1993

NIFS-255 S. Sudo, M. Kanno, H. Kaneko, S. Saka, T. Shirai, T. Baba,
Proposed High Speed Pellet Injection System "HIPEL" for Large Helical Device
Nov. 1993

NIFS-256 S. Yamada, H. Chikaraishi, S. Tanahashi, T. Mito, K. Takahata, N. Yanagi, M. Sakamoto, A. Nishimura, O. Motojima, J. Yamamoto, Y. Yonenaga, R. Watanabe,
Improvement of a High Current DC Power Supply System for Testing the Large Scaled Superconducting Cables and Magnets; Nov. 1993

NIFS-257 S. Sasaki, Y. Uesugi, S. Takamura, H. Sanuki, K. Kadota,
Temporal Behavior of the Electron Density Profile During Limiter Biasing in the HYBTOK-II Tokamak; Nov. 1993

NIFS-258 K. Yamazaki, H. Kaneko, S. Yamaguchi, K.Y. Watanabe, Y.Taniguchi, O.Motojima, LHD Group,
Design of Central Control System for Large Helical Device (LHD); Nov. 1993

NIFS-259 K. Yamazaki, H. Kaneko, S. Yamaguchi, K.Y. Watanabe, Y.Taniguchi, O.Motojima, LHD Group,
Design of Central Control System for Large Helical Device (LHD); Nov. 1993

NIFS-260 B.V.Kuteev,
Pellet Ablation in Large Helical Device; Nov. 1993