

RECENT RESULTS ON THE LARGE HELICAL DEVICE

Y. Nagayama, N. Ashikawa, M. Emoto, H. Funaba, P. Goncharov¹⁾, M. Goto, T. Hayashi, K. Ida, T. Ido, K. Ikeda, S. Inagaki, M. Isobe, H. Igami, D. Kalinina¹⁾, O. Kaneko, K. Kawahata, A. Komori, S. Kubo, R. Kumazawa, S. Masuzaki, J. Miyazawa, T. Morisaki, S. Morita, S. Muto, T. Mutoh, Y. Nakamura, H. Nakanishi, K. Narihara, Y. Narushima, K. Nishimura, M. Nishiura, A. Nishizawa, S. Ohdachi, N. Ohyabu, Y. Oka, M. Osakabe, T. Ozaki, R. O. Pavlichenko, B. J. Peterson, A. Sagara, K. Saito, S. Sakakibara, R. Sakamoto, K. Sato, T. Seki, T. Shimosuma, M. Shoji, S. Sudo, Y. Takeiri, N. Tamura, K. Tanaka, K. Toi, T. Tokuzawa, K. Tsumori, I. Yamada, M. Yokoyama, Y. Yoshimura, M. Yoshinuma, K. Y. Watanabe, T. Watari, O. Motojima, and LHD experimental group

National Institute for Fusion Science, 322-6 Oroshi, Toki-shi, 509-5292, Japan

¹⁾ Graduate University for Advanced Studies, Hayama, 240-0193, Japan
nagayama.yoshio@nifs.ac.jp

It has been considered that the critical issues in the development of a fusion reactor are as follows: (1) confinement, (2) disruption, (3) steady state operation, (4) economic feasibility and (5) wall damage. High beta operation is most effective to reduce the cost of fusion reactor. As the beta becomes higher, a tokamak plasma is more frequently disrupted. A helical system is advantageous in issues (2) and (3) since it is a current free confinement system in principle. The beta limit in helical systems has not been well understood. It has been considered that helical systems have weak points as follows: (a) the ripple transport enhances the high energy ion transport; (b) the magnetic island due to error field deteriorates the plasma confinement; (c) the beta is limited by the magnetic island structure.

This paper presents recent experimental results in the Large Helical Device (LHD), which is the world largest helical system ($R_{ax} \sim 3.6$ m, $a_{av} \sim 0.6$ m, $B_{ax} \sim 2.75$ T) and has the capability of steady state operation because of the super conducting magnets. LHD has confined a plasma with $T_{i0} \sim 2$ keV and $n_e \sim 0.8 \times 10^{19}$ m⁻³ for 1905 sec using ICRF heating. In this case, the total plasma heating energy was ~ 1.3 GJ. This suggests that high energy ions generated by ICRF are well confined. The magnetic island has been intensively investigated. The $n=1$ large magnetic island in the vacuum field, which is created by using the $n=1$ external vertical field, vanishes in plasma with higher temperature or with higher beta. This suggests that the error field would not be a critical problem in a helical reactor, which has a high temperature and high beta plasma. The obtained averaged beta is more than 4.3 % in LHD. In this case, the beta is not limited by the MHD events or magnetic island but is limited by the lack of heating power. Internal and external transport barriers also have been observed in LHD. By using the local island diverter and multiple ice pellet injection, an internal transport barrier in the density profile is observed in LHD. This indicates that the particle control is effective to generate the transport barrier.

The LHD experiment is accumulating evidence indicating that a helical fusion reactor could be realistic. Design activity for a steady state fusion reactor without disruption is being intensively pursued using the LHD configuration.