ℓ=1 Helical Axis Heliotron Device in Kyoto University

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Helical systems are an attractive candidate for magnetic fusion reactor. Recently, there has been great progress in theoretical research of three dimensional magnetic field structures, resulting in several kinds of confinement optimization being proposed for toroidal magnetic confinement system. For example, some sophisticated ideas have appeared on stage such as quasi-helical symmetry and quasi-isodynamic system. To find experimentally which way is the best optimization, a new helical axis heliotron device, so called "Heliotron J", is under construction in the Institute of Advanced Energy, Kyoto University, Japan. In this conference, the basic concept and the present status will be presented. Detail study of Heliotron J is given in Ref. [1].

In the conventional plane axis helical system, it was difficult to have both good particle confinement and good MHD stability simultaneously. The goal of Heliotron J project is to clarify their compatibility in the spatial axis toroidal device. The best way for optimizing the helical magnetic field configuration will be explored by investigating the plasma response to the change in the field components. The main subjects for plasma experiment are

(1) demonstration of the existence of good magnetic flux surfaces
(2) reduction of neoclassical transport in collisionless regime
(3) MHD stabilization in high β plasma
(4) controllability of bootstrap current
(5) good confinement of high energy particles.

Figure 1 shows the coils and vacuum chamber for Heliotron J. The coil system consists of one helical coil, 16 toroidal coils, and 6 poloidal coils. Separate control of helical coil, toroidal coils and vertical coils makes it possible to control the plasma volume, magnetic axis position, rotational transform, well depth, bumpiness and edge magnetic field structure. The typical device parameters are as follows; major radius, 1.2m, minor radius, 0.18m, volume, 0.82m^3, magnetic field, 1.5T, pulse length, 0.5sec, and toroidal pitch number, 4.

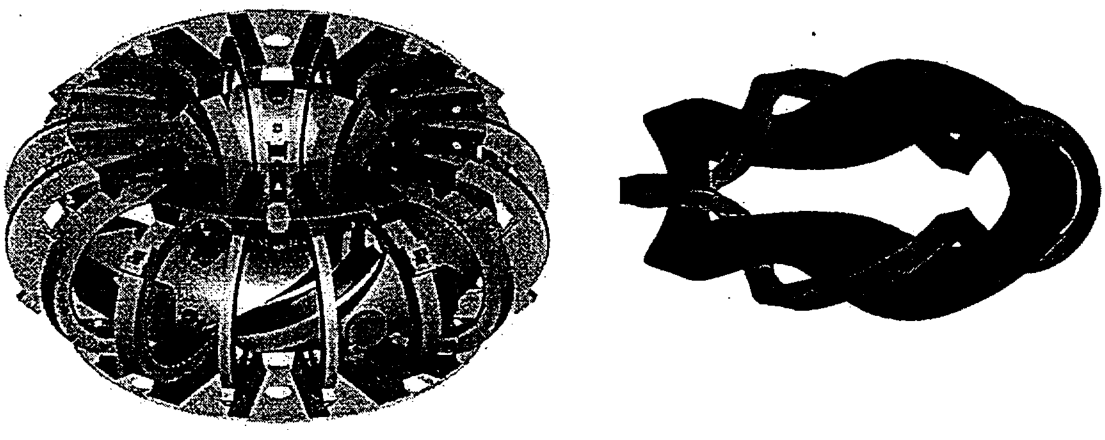

Fig. 1 Heliotron J Device

A continuous helical coil is chosen so as to control the magnetic field configurations flexibly and to make it easy to access the plasma for heating and diagnostics, compared to the stellarator with modular coils. Figure 2 shows the example of magnetic surfaces. The magnetic field structure is optimized for high energy particle confinement. The quasi-straight magnetic axis is formed at minimum B, which minimizes the ∇B drift and the curvature drift. The deviation of trapped particles from the magnetic surface would be suppressed. According to the theoretical study, the bumpy field component has an important role on the neoclassical diffusion in the collisionless regime. Two types of toroidal coils are assembled, which enables us to control the bumpy field components. The improvement of the global confinement will be investigated. It can also provide enough flexibility to control the bootstrap current.

The magnetic well is generated by the three dimensional magnetic axis structures. Due to the enhancement of the magnetic well through the Shafranov shift, the MHD interchange instabilities can be stabilized up to the equilibrium beta limit 4.5%, although the ballooning limit is still left for study. Since the magnetic well can be formed all in the confinement region, it can be expected that the MHD stabilization is compatible with the high energy particle confinement.

The power supply, heating system and diagnostics, which were utilized for Heliotron E, will be applied. The heating system is 0.4MW ECH, 2.5MW ICH and 1.5MW NBI. Currentless plasmas can be produced by ECH without ohmic heating, and then NBI and/or ICH are additionally applied. The toroidal coil and vacuum chamber have already been manufactured (See Fig. 3). Heliotron J is planned to start its plasma experiment in late 1999.

[1] F. Sano, et al., 16th IAEA Fusion Energy Conference, 1998, Yokohama, Japan, IAEA-F1-CN-69 ICP/08

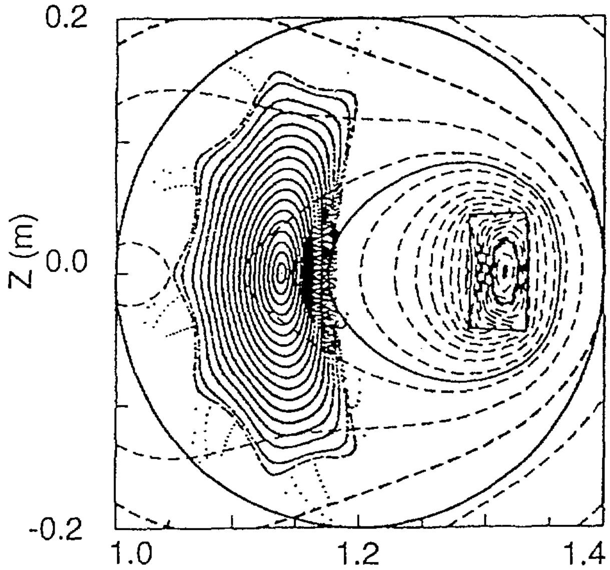

Fig.2 Magnetic surfaces

Fig. 3 Vacuum chamber