§12. Compact Toroidal Magnetic Concepts in Mirror Magnetic Field

Yamazaki, K., Oishi, T., Arimoto, H. (Nagoya Univ.),
Ichimura, M. (Tsukuba Univ.),
Nagayama, Y.

In order to realize attractive fusion reactors, steady-state high-beta plasmas are required with efficient divertor, compact coil and simple reactor core systems. According to the reactor system analysis carried out by our PEC system code, to realize economic tokamak reactors, steady-state operation at high beta (>5%) should be achieved with high bootstrap current fraction (>70%) and efficient current drive methods. The plant availability factor should be larger than 70 %, which gives rise to the requirements of only one permissible major disruption during several years. For this purpose, reliable active disruption control is required. For compact and low-cost designs, low-aspect-ratio systems without disruptions might be created by some combinations among tokamak, helical and mirror field configurations. Moreover, easy maintenance of reactor system requires a simple coil system and enough plasma-coil space, which can be achieved using mirror field configurations.

Here, we continue bidirectional collaboration research program between Nagoya University and Tsukuba University on the toroidal plasma formation in mirror field configurations. Especially, the compact tokamak-stellarator hybrids (C-TOKASTAR) with mirror-type magnetic divertor configuration are investigated.

Historically, a lot of exotic confinement concepts have been proposed so far. One of the authors previously proposed the tokamak/stellarator hybrid called TOKASTAR in 1985 to improve the magnetic local shear near the bad curvature region and to get smooth transition from the first to the second stability regime.

As an extension of this TOKASTAR, we propose an N=2 compact coil system C-TOKASTAR (Compact Tokamak/ Stellarator Hybrid) [1]. This system has several advantages: (1) probable high-beta by strong magnetic well, (2) steady-state operation by helical coils, (3) no current disruption risk by external helical field, (4) enough divertor space by mirror-type magnetic divertor configuration, (5) compact economic system by spherical configuration, (6) easy maintenance by simple N=1 or N=2 coil system.

For the experimental demonstration of the original configuration concept, a Compact-TOKASTAR device (C-TOKASTAR) was constructed, and the existence of magnetic surfaces and the electron confinement are suggested using the stellarator diode method [2].

Recently new machine TOKASTAR-2 has been constructed [1,3] and the effect of helical filed on tokamak plasma discharge will be clarified in the near future.

1) Yamazaki, Y., Taira, U., Oishi, T., Arimoto, H., Shoji, T., *Analyses and Experiments of Compact Spherical Tokamak-Stellarator "TOKASTAR",* 14th International Congress on Plasma Physics (Fukuoka, Japan 2008/9/8-12)
2) Taira, Y., Yamazaki, K., Arimoto, H., Oishi, T., Shoji, T., *"Analysis of particle orbits in spherical tokamak-stellarator hybrid system (TOKASTAR) and experiments in Compact-TOKASTAR device"* The 18th International Toki Conference (ITC18) on Development of Physics and Technology of Stellarator/Heliotrons en route to DEMO (Toki, 9-12 December, 2008) P1-40
3) Okano, K., Tatematsu, M., Y., Yamazaki, K., Oishi, T., Arimoto, H., Shoji, T., *"Small Plasma Experiment of Tokamak-Helical Hybrid"* Plasma Science Symposium PSS-2009 (Nagoya Univ., Nagoya, Feb. 2-4, 2009)

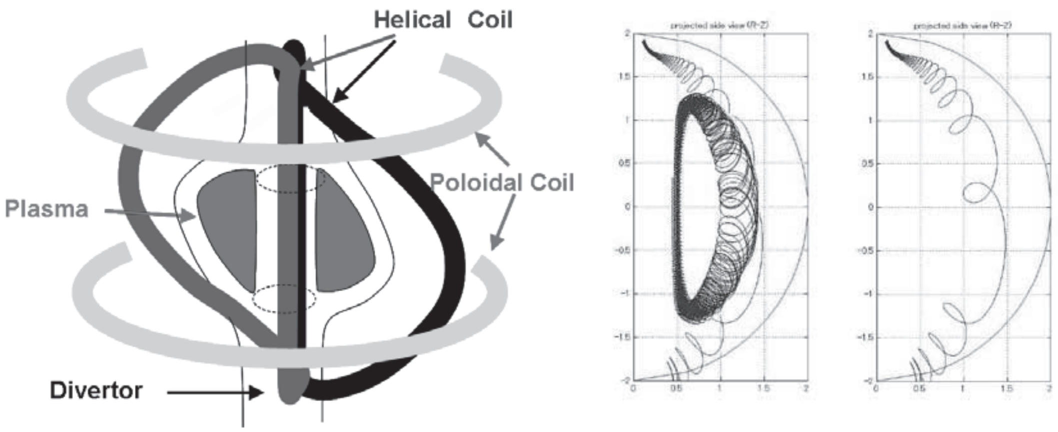

Fig. 1. Magnetic configuration concept of C-TOKASTAR (left) and typical magnetic surface and divertor filed trace (right).