§3. Compact Toroidal Magnetic Confinement Concepts in Mirror Magnetic Field

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We proposed a compact tokamak-stellarator hybrid system TOKASTAR [1] which is an extension of old crescent-shaped tokamak-stellarator hybrid (proposed in 1985) with outer helical grooves stabilizing ballooning modes. The simple coil configuration with one or two helical coils and a pair of poloidal field coils is adopted to generate confinement magnetic surfaces (Fig.1).

In the configuration analysis, magnetic field tracing code HSD is used to define vacuum magnetic surfaces and divertor configuration, and the DESCUR code is used for Fourier mode analysis of the vacuum last closed surface. The finite-beta 3-dimensional equilibrium was solved by the VMEC code, and the effects of current-free or flux-conserving high-beta plasmas configuration were evaluated. The particle orbit analyses (Fig. 2) are also carried out usin guiding-center approximation. The aspect ratio of the TOKASTAR plasma is 1.2, and the ellipticity is around 2.0. The local rotational transform is large on the outboard side, but small on the inboard side. By adding the plasma current, the average rotational transport increases and the finite-beta radial-shift of the equilibrium is suppressed.

The relevant miniature experimental device C-TOKASTAR (major radius = 2 cm) was constructed to demonstrate the concept of this compact tokamak-stellarator hybrid configuration. We also constructed a slightly larger machine TOKSATAR-2 [1-4] (major radius = 10 cm) with possible pure tokamak mode.

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 with mirror-type magnetic divertor configuration are investigated. Using the C-TOKASTAR machine, the existence of magnetic surfaces and the electron confinement are suggested using the stellarator diode method [1].

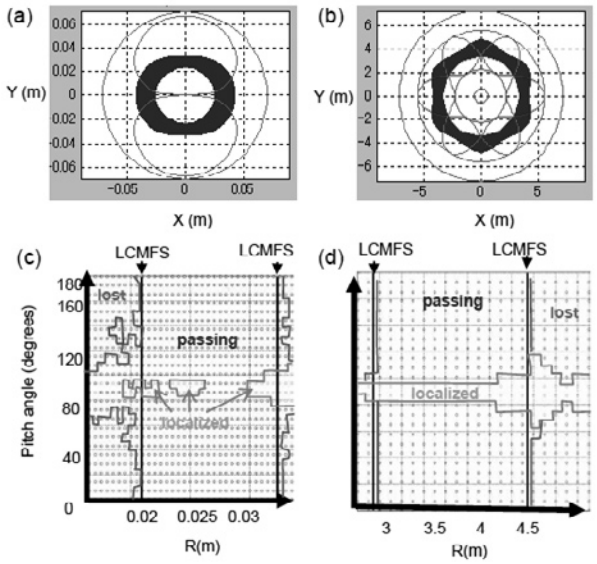

Fig.2 Particle orbit traces ((a) and (b)) and lost particle identification ((c) and (d)) from the coil boundary. LCMFS denotes last closed magnetic flux surface. (a) ,(c):TOKASTAR with N=2 spherical coil system, (b),(d) :N=6 standard Heliotron configuration with circular coil system.

1) K. Yamazaki, Y. Taira, T. Oishi, H. Arimoto and T. Shoji, Journal of Plasma and Fusion Research SERIES Volume 8 (2009) 1044-1047.
2) K. Baba, K. Yamazaki, H. Arimoto, T. Oishi, K. Okano, M. Hasegawa, T. Shoji, The 19th International, Toki Conference (ITC19) on Advanced Physics in Plasma and Fusion Research (Toki, 8-11 December 2009) P2-8.
3) K. Okano, K. Yamazaki, H. Arimoto, T. Oishi, K. Baba, M. Hasegawa, T. Shoji, 19th International Toki Conference (ITC19) on Advanced Physics in Plasma and Fusion Research (Toki, 8-11 December 2009) P2-9.
4) T. Oishi, K. Yamazaki, K. Okano, H. Arimoto, K. Baba, M. Hasegawa, T. Shoji, The 7th General Scientific Assembly of the Asia Plasma and Fusion Association (APFA2009) and the Asia-Pacific Plasma Theory Conference (APPTC2009) Aomori, Japan, October 27-30 2009.

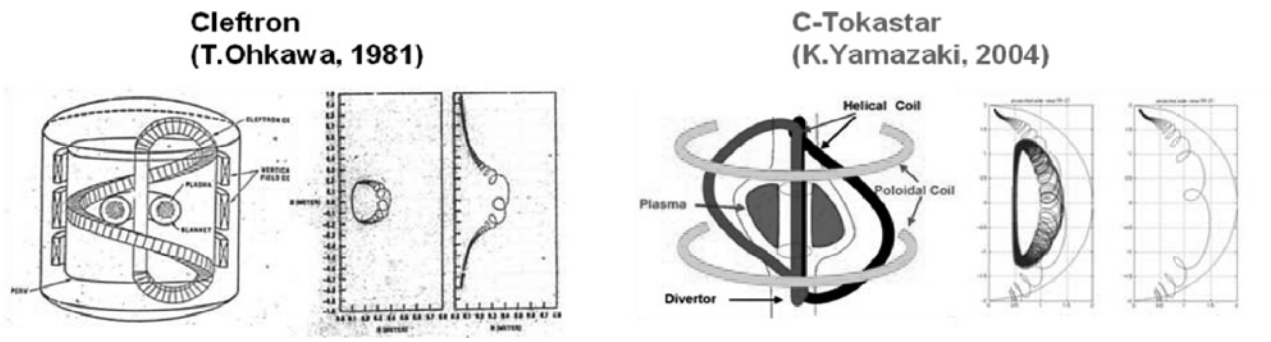

Fig.1 Compact helical field configurations formed in mirror-type field.
(left) Proposal of CLEFTRON by T. Ohkawa, (right) Proposal of C-TOKASTAR by the author
Original TOKASTAR proposal was done in 1985.