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準軸対称ヘリカル装置CFQSのダイバータ配位設計
Design of Dvertor Configuration for Quasi-axisymmetric Stellarator CFQS

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For a new quasi-axisymmetric stellarator CFQS, we designed a new divertor configuration which provides a sufficiently long connection length of magnetic field lines between the plasma boundary and the wall.

Figure 1 shows the punctual plots of the vacuum magnetic field lines (magnetic surfaces) produced with modular coils for CFQS. Red line shows the LCMS of the VMEC target configuration in the modular coil design. The magnetic field produced by the modular coils has many closed magnetic surfaces with a larger area beyond the target LCMS. In usual cases of designing modular coils for the advanced stellarator, it is very difficult to make larger closed magnetic surfaces beyond the target LCMS because the boundary area usually becomes stochastic.

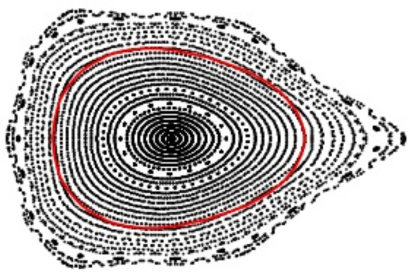

Fig. 1 Magnetic surface of CFQS stellarator

When we introduce the auxiliary toroidal coils to provide additional toroidal field to the stellarator field produced with modular coils, the magnetic configuration is changed to include large islands at the boundary of the core confinement region shown in Fig. 2. The quasi-axisymmetry is conserved with the additional toroidal field. Such a boundary structure is a typical magnetic configuration for any type of stellarator that has a rational value of the rotational transform near the boundary. However, essential differences between the configuration shown in Fig. 2 from many other cases are 1) large size of islands and 2) the completeness of the island magnetic surfaces. It is shown that clearly formed island bundle flux surrounds the core confinement region with a clearly defined interface of the magnetic field separatrix. The entire magnetic confinement area is clearly separated into two regions: hot plasma region in the core and cold plasma region in the periphery.

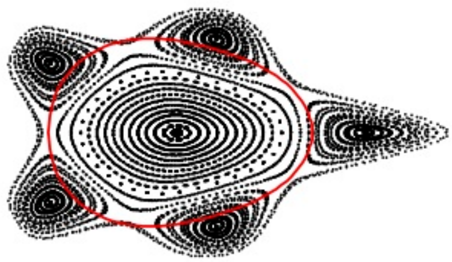

Fig. 2 Magnetic configuration of island bundle divertor

Figure 3 shows the divertor field line tracing with the wall target where the field line tracing is stopped, which is created in the following calculation procedures. We found first the LCMS of the core confinement region. Then we distributed many field line tracing starting points with a small deviation (5 mm for R=1 m torus) from the LCMS. The pattern of the magnetic field line punctual plots is very similar to the tokamak divertor structure. In fact, the transport of the magnetic field lines is exactly the same as tokamak divertor, where the peripheral regions of the divertor are connected to the core confinement region with a clear magnetic separatrix, and divertor magnetic field lines in divertor region have long connection length between the null point and the wall.

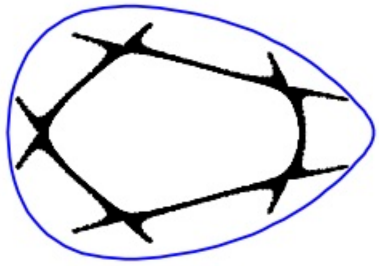

Fig. 3 Divertor field line tracing with divertor wall target