# § 19. Edge Plasma Simulation of Stellarator System with UEDGE

Takayama, A., Tomita, Y.
Pigarov, A.Yu., Krasheninnikov (UCSD), Rognlien, T.D. (LLNL)

Magnetic configuration at the edge of a stellarator is very complex and contains a mixture of closed flux surfaces and stochastic field lines. At present, there is no plasma transport code that can handle highly complicated case. Moreover, it is even not very clear what kind of set of transport equations can be used for these purposes. At the same time, it is feasible that due to a strong anomalous cross-field plasma transport and convective plasma flows, rather detailed features of stellarator magnetic topology do not matter much for averaged plasma parameters. Therefore, it is worth to try a simple approach to the modeling of stellarator edge plasma based on "averaging" of edge plasma parameters along the magnetic axis and introducing effective two-dimensional flux surfaces. In this sense, we substitute the stellarator edge with that what can be called a stellarator-equivalent tokamak (SET) edge. We apply this approach to edge plasma modeling for Large Helical Device (LHD). We simulate the LHD-stellarator-equivalent tokamak with 2D edge plasma transport code UEDGE[1].

The magnetic configuration of LHD stellartor-equivalent tokamak is defined as follows. It is double null (bottom and top X-points) configuration, which has the same large aspect ratio and plasma cross-section elongation as the LHD. It reproduces the same position of X-points, striking points at the divertor plates, and plasma axis point. Furthermore, the equivalent tokamak keeps the same radial gradient of magnetic flux in the core region adjacent to separatrix and the same compression factor for the edge magnetic flux tube. In the SET configuration, the characteristic connection length $L_{SOL}$ of magnetic field lines from the SOL mid-plane to the divertor plates is typically set equal to the characteristic connection length in the real stellarator configuration calculated with 3D magnetic field line tracing code and averaged over a certain part of the "SOL".

We started the construction of a LHD-SET with adapting the EFIT code[2]. This code solves Grad-Shafranov equilibrium for the fix boundary problem. We, however, failed to obtain equilibrium solution for so elongated plasma at so large aspect ratio. Thus we use a more simple approach to calculate the SET configuration. Since our goal is only the edge plasma modeling, we assume that along with usual external coils the vacuum magnetic field is also created with shaping coils located near the plasma axis. Following this approach, we can easily handle largely elongated plasmas as well as various separatirx configurations. A typical SET configuration is shown in figure 1.

The UEDGE code solves in 2D the fluid equations for plasma transport and reduced set of Navier-Stokes equations for neutral particle transport. The plasma sources are the ionization of recycling atoms and flux from NBI-fuelled core plasma. Plasma is neutralized at the divertor plates and walls and the corresponding boundary condtions are similar to that in tokamaks[1]. The combied effect of small-scale magnetic islands, stochastic magnetic field layers as well as of intermittency (infrequent but large-scale transport events) on cross-field plasma transport is modeled in UEDGE by prescribing the 2D profiles anomalous convective velocity $V_{conv}$ and anomalous diffusivities ($D_\perp$, $\chi_\perp$) and by adjusting these profiles in order to match the experimental plasma profiles and recycling data[3].

Figure 2 shows the plasma density profile for a typical parameter case. A bump of dense and cold plasma is predicted by UEDGE in the private flux region and, so far, the simulated radial profiles of plasma temperature are steeper than the measured profile. Nevertheless, the UEDGE simulation based on SET approach is useful in the study of the "helical-axis averaged" plasma parameters and particle recycling in the edge region and more work is required to validate this approach.

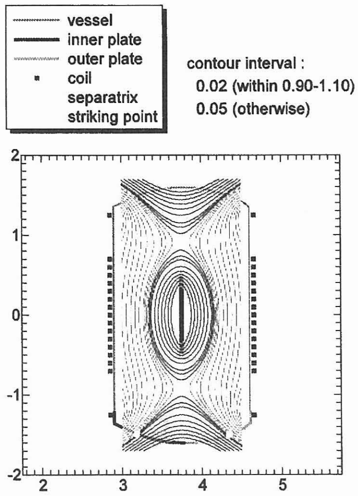


Fig. 1. Magnetic configuration of LHD-SET

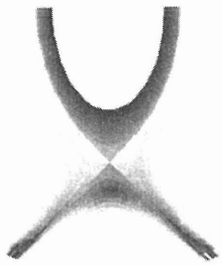

Fig. 2. Plasma density profile for a typical case

**References**

1) Rognlien, T.D. *et al.*, J.Nucl.Mater. **196** (1992) 345.
2) Lao, L. *et al.*, Nucl. Fusion **30** (1990) 1035.
3) Pigarov, A..Yu. *et al.*, J.Nucl.Mater. **313** (2003) 1076.