§25. Edge Plasma Simulations for Stellarator by Use of SET

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We have introduced and developed a stellarator-equivalent tokamak (SET) method in order to simulate the stellarator edge region. The method has following properties:

- Double null (bottom and top X-points) configuration,
- Same large aspect ratio,
- Same plasma cross-section elongation,
- Similar position of X-points, strike points at divertor plates, and plasma axis,
- Same radial gradient of magnetic flux in the core region adjacent to separatrix, and
- Similar compression factor for the edge magnetic flux tube, that is, the relation between the characteristic width of magnetic tube at the SOL mid-plane and its width in the divertor near strike points.

This approach is applied to edge plasma modeling for Large Helical Device (LHD). We simulate the LHD-stellarator-equivalent tokamak with 2D edge plasma transport code UEDGE1).

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".

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 conditions are similar to that in tokamaks1). The combined 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 data2).

Figures are the simulation results of the case with the following conditions: B_t=3[T], R_0=3.75[m], n_{ec}=4.0x10^{19}[m^3], P_e= $\gamma_{ei}W_0$, P_i= (1-γ_{ei})W_0, γ_{ei}=0.4, W_0=W_{NBI}-W_{rad}, W_{NBI}=3.5[MW], W_{rad}=0.5[MW]. In the obtained steady-state solutions, the plasma flux through core interface is equal to the neutral flux plus the NBI fuelling rate F_{NBI}. Anomalous diffusivity for this case is $D_{\perp}$=0.20[m^2/s], $\chi_{\perp}$=0.40[m^2/s].

Remarkable observations are

- Bump of ion density in the private flux region just inside the separatrix, as shown in Fig. 1, and
- Ion flow reversal or vortex structure shown in Fig. 2.

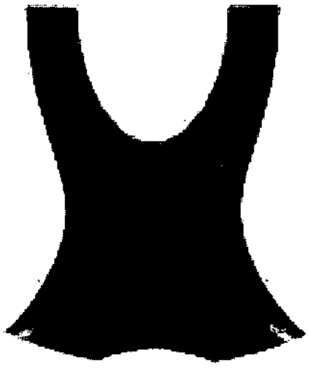

Fig. 1. Ion density n_i profile

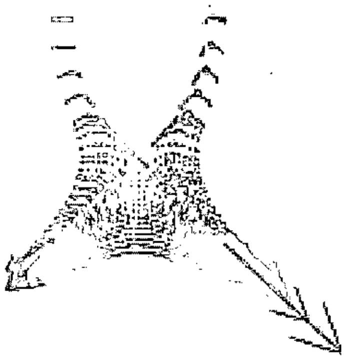

Fig. 2. Ion flow velocity profile

References

1) Rognlien, T.D. *et al.*, J.Nucl.Mater. **196** (1992) 345.
2) Pigarov, A..Yu. *et al.*, J.Nucl.Mater. **313** (2003) 1076.