§15. Development and Improvement of SONIC Code for Divertor Study

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The integrated divertor code, SONIC[1] consists of the 2D plasma fluid code (SOLDOR), the neutral Monte-Carlo code (NEUT2D) and the impurity Monte-Carlo code (IMPMC). Monte-Carlo (MC) approach for impurity transport is suitable for modelling of interactions between impurities and walls, and for including kinetic effects and complicated diffusion processes of hydrocarbons. In the IMPMC code, we have developed a new diffusion model for scattering process and optimized with the Message Passing Interface (MPI). Thereby the self-consistent coupling of the IMPMC code to the divertor code SOLDOR/NEUT2D has been accomplished.

The purpose of this research is to extend the IMPMC code toward 3 dimensional modelling for divertor experiment of LHD. It takes a long period to develop a full-scale 3 dimensional impurity Monte-Carlo code. Then 2 dimensional model concept has been proposed by Takayama in order to contains equivalently 3D transport properties in peripheral region of LHD. It is called "LHD Equivalent Axis-symmetric Plasma modelling", "LEAP" for short. The modelling to change the connection length both spatially and temporally in the ergodic region is presented in order to incorporate 3D transport effects of impurities into the IMPMC code. In the LEAP modelling, we determine approximately a 2D equilibrium with characteristic of the width of the stochastic region and the connection length from the X-point to the strike point by using the current filament approximate method. And then, the steady plasma parameter are calculated with UEDGE or SOLDOR/NEUT2D. Under the background plasma parameters obtained, the impurity transport is studied with the extended IMPMC which include the effect of stochastic region. The impurity contamination process from the stochastic region into the core is investigated with this LEAP analysis.

The planned code for 3D impurity transport has a lot of similarities to Monte-Carlo schemes in the EMC3[2] code introduced at NIFS, because the EMC3 solves the fluid equations by Monte-Carlo techniques. Therefore we frame a plan to develop 3D impurity code on the basis of the EMC3 code. We examined mesh system of EMC3 and investigated a routine to find a cell number from the position of a test particle.

As for the SONIC code, we intend to couple to a tokamak transport code to simulate the transport in the main plasma, e.g. TASK and TOPICS, as shown in Fig. 1. In the SONIC code, as well as other integrated divertor codes, e.g. B2/EIRENE, UEDGE, EDGE2D, except COCONUT and COREDIV, the particle and heat fluxes at the core edge (normally r/a=0.95) are fixed at the given values as input parameters. However, these fluxes should be essentially determined by the plasma transport at the core edge. They are also affected by MHD activities, i.e. ELMs. On the other hand, the SOL/divertor plasma has a strong effect on the core edge plasma through the particle source, the charge exchange loss and the impurity radiation. In order to study the divertor characteristics including such interactions between the core plasma and the SOL/divertor plasma, SONIC should be consistently coupled to a tokamak transport code.

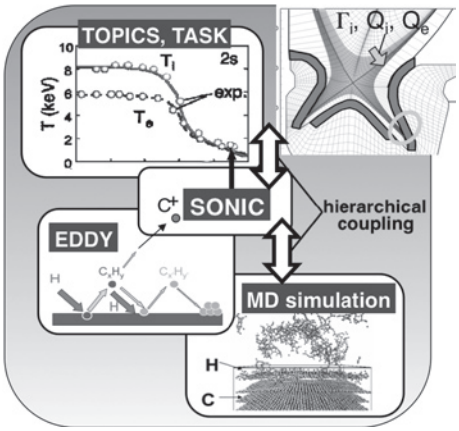

Fig. 1 Future plan of integrated divertor code SONIC

On such code integration, it is serious problems that each code has been developed independently by different researcher and that integration must be performed with code improvement. It is necessary that the codes are integrated while keeping originality of each code. We have developed a new MPMD (Multiple Program Multiple Data) computing system, as shown in Fig. 2. In this system, the grand master PE (processing element) issues commands to control each load module via MPI (Massage Passing Interface). The mutual interface between codes is limited to exchange data through MPI_Send/MPI_recv routines. We can develop each code independently without affecting code integration. The SONIC code package is coupled to a core code (TASK or TOPICS) using this system.

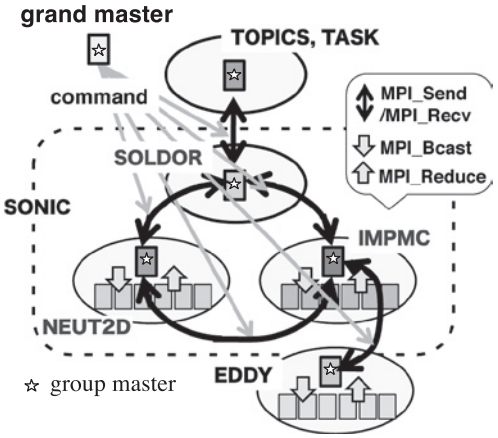

Fig. 2 New MPMD parallel computing system

1) Shimizu, K., et al., Nucl. Fusion **49** (2009) 065028
2) Kobayashi, M., et al., Contrib. Plasma Phys. **48** (2008) 255.