§8. Simulation Methodology in Advanced Computing

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Recently, devices such as GPU and physical random number generator are proposed to set to supercomputers to perform large scale fusion plasma simulations efficiently. We have made verifications of efficiency of such devices. We have also made development of methodology for advanced computing such as micro-macro interlocked simulation method and adaptive mesh reduction (AMR) method.

We have up-dated a three dimensional open boundary electromagnetic particle simulation code for magnetic reconnection study (PASMO) to employ Exact Charge Conserving method in order to perform efficient computing at the massively scalar parallel high-performance computer. As a result we have achieved good strong scaling[1].

We have decided to develop each component code by module system in the Micro-Macro Interlocked Simulation (MMIS) code where micro PIC model and macro fluid model are dynamically connected through an interface, succeeding in constructing modules of the code[2].

Application of physical random number generator to Monte Carlo plasma simulation codes has been evaluated. Since most of the plasma simulation codes calculate several physical processes, the calculation time of random number generation is much smaller than total calculation time. It is confirmed that there is no difference in total calculation time of the drift kinetic Monte Carlo simulation (KEATS) code between the use of physical random number generator and software random number generator.

Modeling and simulation of complexity of relativistic plasmas are studied in application to different schemes for generation of intense ultra-fast, attosecond (AS) range photon and electron bunches in relativistic laser-plasmas. A new scheme for AS pulse generation by FS laser pulse reflection off relativistic plasma mirror was proposed, and justified by analytics and 2D PIC simulations. Further, features of stimulated Raman back-scattering are critically explored, in particular, related to a proposal (IZEST) for FS pulse generation at exa-watt, and beyond, laser intensity regime, for nuclear and high-energy physics studies. Relativistic plasma phenomena have been performed, finding that the laser pulse reflected by relativistic electron plasma mirror creates atto-second photon pulse[3].

For long time operation of the nuclear fusion reactor, reduction of divertor heat load is a crucial issue. The detached plasma, which is caused by gas puffing, has been proposed and it is the most promising way to solve this issue. Most of the theoretical and numerical works deal only with steady state. However, dynamical behavior of the detached plasma might affect the core plasma characteristics. Combination of plasma kinetic physics and atomic processes such as line radiation, ionization, charge-exchange collision and recombination might play important role in the detachment plasma behavior as well.

In order to investigate dynamical kinetic behavior of the detached plasma, which is caused by gas puffing to achieve the reduction of divertor heat load, we started to construct a high-performance PIC simulation with Monte Carlo collisions, where spatial and velocity space distributions of charged particles, self-consistent electric field created by charged particles, and atomic processes such as ionization and charge exchange are included.

In Fig. 1, schematic of simulation model is presented. While plasma emitter is placed in the right hand boundary, plasma absorbing plate corresponding to divertor is placed in the left hand boundary. Neutral gas is assumed to be supplied in the left hand side of the system and atomic processes take place there. Charge exchange and ionization occur there and a gradual decrease in ion temperature is observed as shown in Fig. 2 [4].

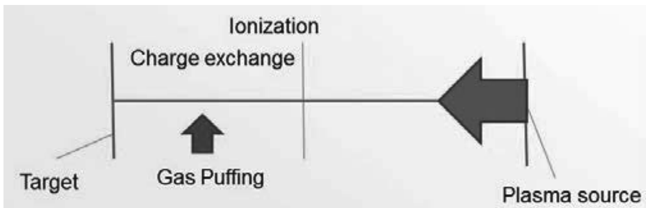

Fig. 1. Simulation model for detached plasma simulation.

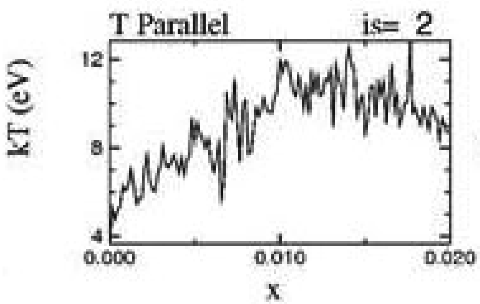

Fig. 2. Spatial profile of ion temperature. Ion temperature decreases towards the target.

1) Ohtani, H. et al.:APS-DPP 2014.
2) Usami S. et al.: J. Phys.:Conf. Ser. **561** (2014) 012021
3) Skoric, M. M. et al.; ICPP 2014 invited talk.
4) Ishiguro, S., et al.: APPTC 2014 invited talk.