Global MHD simulation by the gyrokinetic PIC code

Hiroshi Naitou, Masatoshi. Yagi[1)], Shinji Tokuda[2)]
Yamaguchi University, 2-16-1 Tokiwadai, Ube 755-8611, Japan
[1)] RIAM, Kyushu University, 6-1 Kasuga-kouen, Kasuga 816-8580, Japan
[2)] IFERC, 2-166 Omotedate, Obuchi, Rokkasho 039-3212, Japan

It is a challenging project to perform magnetohydrodynamic (MHD) simulation by the electromagnetic gyrokinetic PIC (particle-in-cell) code. Such a code is free from "closure" problem, although it needs huge computer resources. The gyrokinetic PIC code for MHD simulation, Gpic-MHD, for cylindrical geometry was developed based on the standard gyrokinetic theory with delta-f method.[1)] To simulate larger and higher beta tokamak plasma, a new algorithm was proposed in which the vortex equation and the generalized Ohm's law along the magnetic field are used to temporally integrate field quantities of the electrostatic potential and the longitudinal vector potential.[2)] The basic algorithm is equivalent to solve reduced-MHD-type equations with kinetic corrections. The dominant kinetic term is the perturbed electron pressure estimated by particle information. The feasibility of new Gpic-MHD for m=1 and n=1 collisionless internal kink mode simulation was verified for realistic large scale and high beta tokamak parameters. The 3-dimensional (3d) Gpic-MHD is used as a benchmark code to study parallelization performance on SR16000 ("Plasma Simulator" at NIFS).[3,4)] The hybrid parallel programming model of thread parallel and process parallel is used. The total simulation domain is decomposed in 2d (axial and radial) directions. Replicas of field quantities are used to utilize logical cores larger than the number of decomposed subdomains. The performance for the mesh of $1025\times128\times128$ (radial$\times$poloidal$\times$toroidal) showed good scaling up to 8192 logical cores. The formulation for the toroidal geometry will be presented in the conference.

1) H. Naitou, H. Hashimoto, Y. Yamada, S. Tokuda, M. Yagi, J. Plasma Fusion Res. SERIES 8, 1158 (2009)
2) H. Naitou, Y. Yamada, K. Kajiwara, W.W. Lee, S. Tokuda, M. Yagi, submitted to Plasma Science and Technology
3) H. Naitou, H. Hashimoto, Y. Yamada, S. Tokuda, M. Yagi, accepted in Progress in Nuclear Science and Technology.
4) H. Naitou, Y. Yamada, S. Tokuda, Y. Ishii, M. Yagi, Plasma and Fusion Res. 6, 2401084 (2011).