Cross-Reference Simulation by Code-To-Code Adapter (CoToCoA) Library for the Study of Planetary Magnetospheres

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1 INTRODUCTION

A multi-scale code is powerful in understanding the planetary magnetosphere, which consists from naturally multi-scale processes, and must be the next generation tool for the planetary science in the exascale computing era. However, its huge load in developing/modification of the original code prevents us to carry out simulations by a multi-scale code ubiquitously. In order to improve the difficulties in merging the different codes used in planetary science, we have been developing the Code-To-Code Adopter (CoCoToA) library. The design concept of the CoToCoA library is to realize the communication among the codes with keeping necessary modification of the original code minimum. In this paper, we show an example of a multi-scale code for the study of planetary magnetospheres and its advantage from the technique used in the conventional simulation studies.

2 CROSS-REFERENCE SIMULATION

We have been carried out a "cross-reference simulation" for the study of planetary magnetospheres. The cross-reference simulation is a simulation model combining multiple simulation codes, while the codes employed in the model are developed individually by a different set of basic equations. Here we show an example of the cross-reference simulation, combing a fluid code (Meso) [1] and an electron hybrid code (Micro) [2]. In the conventional cross-reference simulation, we carried out the data exchange between the codes by file output; we call 'weak' cross-reference simulation for the data exchange through the file IO. However, the amount of the output data becomes huge and the file IO restricts the computational efficiency significantly; we use a few millions of time steps in both Micro and Meso codes and therefore the file size to be used becomes the order of TByte. In order to overcome the limitation by the file IO, the data exchange among simulation codes should be conducted by direct memory access, which we call 'strong' cross-reference simulation. The strong cross-reference simulation enables us to carry out a multi-scale simulation efficiently and should be the next generation simulation code in the exascale computing era. One significant problem of the strong cross-reference simulation is difficulties in merging the simulation codes. The motivation of the development of the CoToCoA library is to overcome the difficulties in implementing simulation codes in the strong cross-reference simulation code.

The CoToCoA library is developed as a framework to connect a requester program to multiple worker programs via a coupler program [3]. In the present study, the Meso code plays a role of a requester program and the Micro code becomes a worker program. The design concept of the CoToCoA library is to realize the communication among the codes in the cross-reference simulation with keeping necessary modification of the original code minimum, which enables us to carry out 'strong' cross-reference simulations.

3 DISCUSSION AND SUMMARY

We have been developing a cross-reference simulation code by a newly developed CoToCoA library for the study of wave-particle interactions in planetary magnetospheres. The cross-reference simulation is a simulation model combining multiple simulation codes, while the codes employed in the model are developed individually by a different set of basic equations. We further developed the cross-reference simulation by employing the newly developed CoToCoA library. The design concept of the CoToCoA library is to realize the communication among the codes in the cross-reference simulation with keeping necessary modification of the original code minimum, which enables us to carry out 'strong' cross-reference simulations; the data exchange among simulation codes is conducted by direct memory access, instead of file output as has been used in conventional 'weak' cross-reference simulations. We carry out a benchmark using a cross-reference simulation code, which consists from electron fluid code [1] and electron hybrid code [2], so as to evaluate the computational efficiency. Since the elapse time used for the code-to-code communication was less than 0.05% of those used for the computation, the result of the present study clarifies that we can realize the 'strong' cross-reference simulation without incurring appreciable overheads as we used in the conventional 'weak' cross-reference simulations.

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