Study of electromagnetic compatibility requirements of spacecrafts in magnetized plasma with FDTD method

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Spacecrafts have many sensors and instruments onboard themselves to observe various scientific data in space plasma. It is very important for electromagnetic compatibility (EMC) requirements of spacecrafts to identify the propagation characteristics of electromagnetic noises emitted from instruments onboard themselves. Ordinarily, we provide EMC requirements of spacecrafts by performing EMC experiment in large vacuum chamber. However, spacecrafts that observe electromagnetic waves in space plasma usually have very long wire antennas, and such long antennas cannot extend in vacuum chamber. We cannot perform complete EMC provision of spacecraft in observing electromagnetic waves in space plasma.

To solve this problem of EMC requirements of spacecraft, we developed a FDTD simulation code which can treat wave propagations in magnetized plasma, and performed FDTD simulations of electromagnetic noises which propagate in space plasma. Though we need to perform full particle simulations in order to recognize complete characteristic of waves propagating in space plasma, FDTD simulations can be peformed with much less computer resources than those necessary for full particle simulations, in memories as well as cpu time. In provinding EMC requirements of spacecrafts, we have to perform many simulations with various conditions, therefore, FDTD simulation is a very effective method. Since space plasma is magnetized, it is necessary to incorporate the dielectric tensor with anisotropy and dispersibility in FDTD simulation code, in order to calculate the electromagnetic field in space plasma. We use PLRC method to formulization FDTD scheme to reduce numerical errors. In FDTD simulations, it is essential that how to realize an effective absorbing boundary. We developed PML absorbing boundary condition with anisotropy and dispersibility, and succeeded to realize very effective absorbind boundary.

In this study, we studied the propagation characterictics of electromagnetic noises emitted from the star scanner onboard NOZOMI spacecraft. At first, we performed three-dimensional FDTD simulations of electromagnetic noises around NOZOMI spacecraft in free space, in order to compare with the EMC experiment data performed on ground before launch. In this EMC experiment in free space, the conductive hood onboard NOZOMI spacecraft have shielding effects in preventing electromagnetic noises emitted from the star scanner. We confirmed that this conductive hood have sufficient shielding effects at wire antennas of NOZOMI spacecraft which observe electric fields, at least in free space with performing FDTD simulations. Next, we performed three-dimensional FDTD simulations of electromagnetic noises around NOZOMI spacecraft in magnetized plasma, and confirmed shielding effects of the conductive hood onboard NOZOMI spacecraft against electromagnetic noises emitted from the star scanner in space plasma. Since FDTD simulations can be performed with less computer resources, we can perform many simulation experiments with various conditions, for example, with varying the shape of conductive hood. This method with FDTD simulations is very effective tool for providing EMC requirements of spacecrafts in space plasma.