Study of electromagnetic compatibility requirements in space 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 the above problem in EMC requirements of spacecraft, we developed a FDTD simulation code which can treat wave propagations in magnetized plasma. Though we need to perform full particle simulations in order to recognize accurate characteristics of waves propagating in space plasma, FDTD simulations can be performed with much less computer resources than those necessary for full particle simulations, in memories as well as cpu times. In providing EMC requirements of spacecrafts, we have to perform many simulations with various conditions, such as the shape of a conductive hood, therefore, FDTD simulation is a very convenient tool. 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. In FDTD simulations, it is essential that how to realize an effective absorbing boundary. We developed PML (Perfectory Matched Layer) absorbing boundary condition with anisotropy and dispersibility, and succeeded to realize very effective absorbing boundary.

In this study, we studied the propagation characteristics of electromagnetic noises emitted from the star scanner onboard NOZOMI spacecraft. We performed a series of three-dimensional FDTD simulations with different shape of a conductive hood, and confirmed its shielding effects of the conductive hood on the propagation characteristics of electromagnetic noises. According to the simulation results, shielding effects of the conductive hood onboard NOZOMI spacecraft are confirmed on electromagnetic noises propagating in space plasma. Shielding effects of the conductive hood are shown all the electric components. Since the ambient magnetic field is along the z-axis in these simulations, the magnitudes of Ez fields are much larger than other two components of electric fields. Among all the electric components, therefore, its shielding effects are especially shown in Ez component. The magnitudes of Ez fields at the wire antenna with the conductive hood are smaller in about 20dB than those without the conductive hood. In addition, we performed another series of FDTD simulations about shielding effects of a conductive hood against various types of noises, e.g. high frequency noises or impulsive noises, on NOZOMI spacecraft, and evaluated its shielding effects quantitatively.