Near-fields and its Applications in Space Plasmas

*Tadas Nakamura[1]

1. Fukui Prefectural University

Solutions to Maxwell's equations consists of two parts: propagating components (electromagnetic waves) and the so-called near-field. Unfortunately, there seems to be considerable confusion on the latter, and the words "near-field" have different meanings depending on authors. For example, Coulomb interaction is often explained as the result of the interchange of virtual photons, however, the Coulomb field is not a photon but a near-field in the sense of this talk. Also, little attention is paid to the difference between propagating plasma waves and plasma near-fields in space physics.

The near-field in the present talk is understood as the off-shell solution to the inhomogeneous linear equations; the term "off-shell" means solutions that do not satisfy the dispersion relation. When the field source is static (Coulomb field or magnetic dipole, for example), it is easy to decompose the field into waves and off-shell near-fields. Here in this talk, the way to do this decomposition for time-dependent field source is explained. When we solve Maxwell's equations, usually we make use of Fourier-Laplace transform to obtain the dispersion relation. The time dependence of the fields is obtained by the inverse Laplace transform using the residue theorem; the wave components are obtained from the residue at the pole of the dispersion relation. One can obtain the near-field component by subtracting this residue contribution from the solution of the inhomogeneous equations.

The author reported the derivation of this result at the fall meeting of SGEPSS last year, and will report its application to space physics this time. The talk at the fall meeting was mainly about the electromagnetic fields in a vacuum; fields in plasmas will be discussed this time. The athematical structure of the fields in plasmas are essentially the same as that in a vaccum, however, currents and charges in plasmas cause a wide variety of phenomena in space. Phenomena such as current generation around small bodies in space plasma flows, the return currents genereted by energetic auroral electrons, and several others will be examined as examples.

Keywords: plasma waves, Laplace transform, near field

