Numerical Investigation on Propagation Characteristics of Millimeter-wave Vortex Field in Magnetized Plasma by using FDTD method

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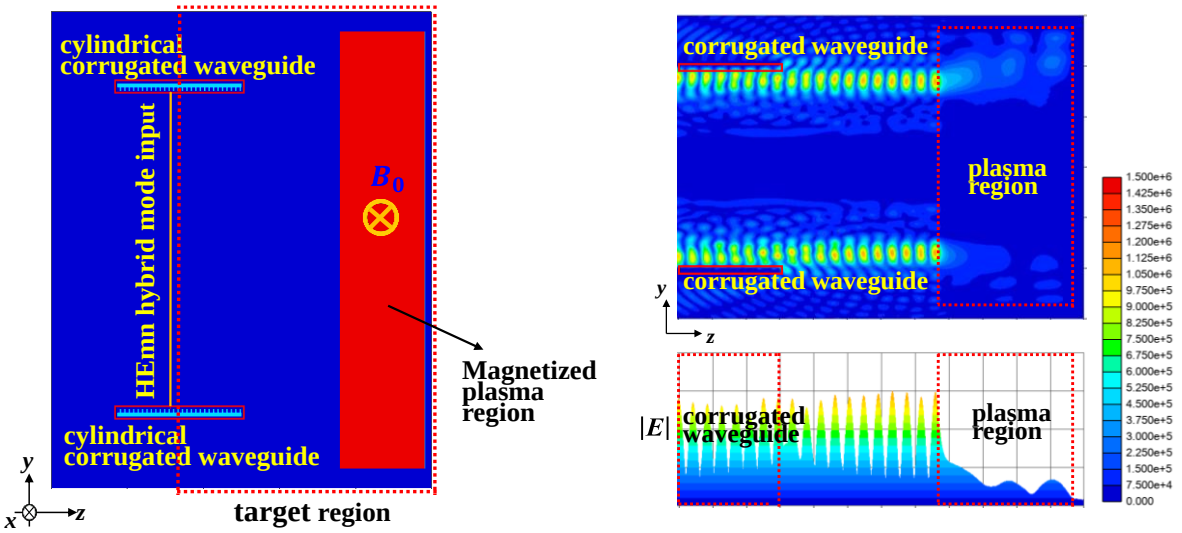
An optical vortex with orbital angular momentum (OAM) may lead in an efficient plasma heating since it was found that the optical vortex can propagate in plasma while the normal plane wave is cut-off condition.[1] However, in the plasma heating by the vortex fields, the millimeter wave vortex was assumed to be Laguerre-Gaussian (LG) mode vortex, which is not easy to be generated in millimeter wave frequency. On the other hand, it was pointed out that there exist stable hybrid modes vortex in the cylindrical corrugated waveguide, which carry well-defined orbital angular momentum.[2] In this paper, we discuss the propagation characteristics of a hybrid mode of cylindrical corrugated waveguide for millimeter-wave vortex with a helical wavefront in magnetized plasma that are evaluated by using three dimensional simulations with finite difference time domain (FDTD) method. It is confirmed that the hybrid mode of millimeter-wave vortex can propagate in the plasma region in which the normal plane wave is cut-off condition.

The numerical model is depicted in Fig.1(a). It is assumed that the hybrid mode millimeter vortex is excited inside the corrugated circular waveguide and illuminated to the plasma region located at downstream. A numerical example of the propagation of the millimeter wave vortex with topological charge l=20in the magnetized plasama is shown in Fig.1(b). It is also found by the FDTD simulation that plane wave can not propagate in the plasma region while the millimeter wave vortex can propagate under the same conditions.



(a) Numerical model (b) ***E*** field intensity distribution (l=20)

Figure 1. FDTD simulation of millimeter wave vortex propagation in magnetized plasma

[1] T. Tsujimura and S.Kubo, Phys. Plasmas, 28, 012502 (2021).
[2] H. Kawaguchi, S.Kubo, H. Nakamura, IEEE MWTL, Vol.33. No.2, pp.118-121, (2023).