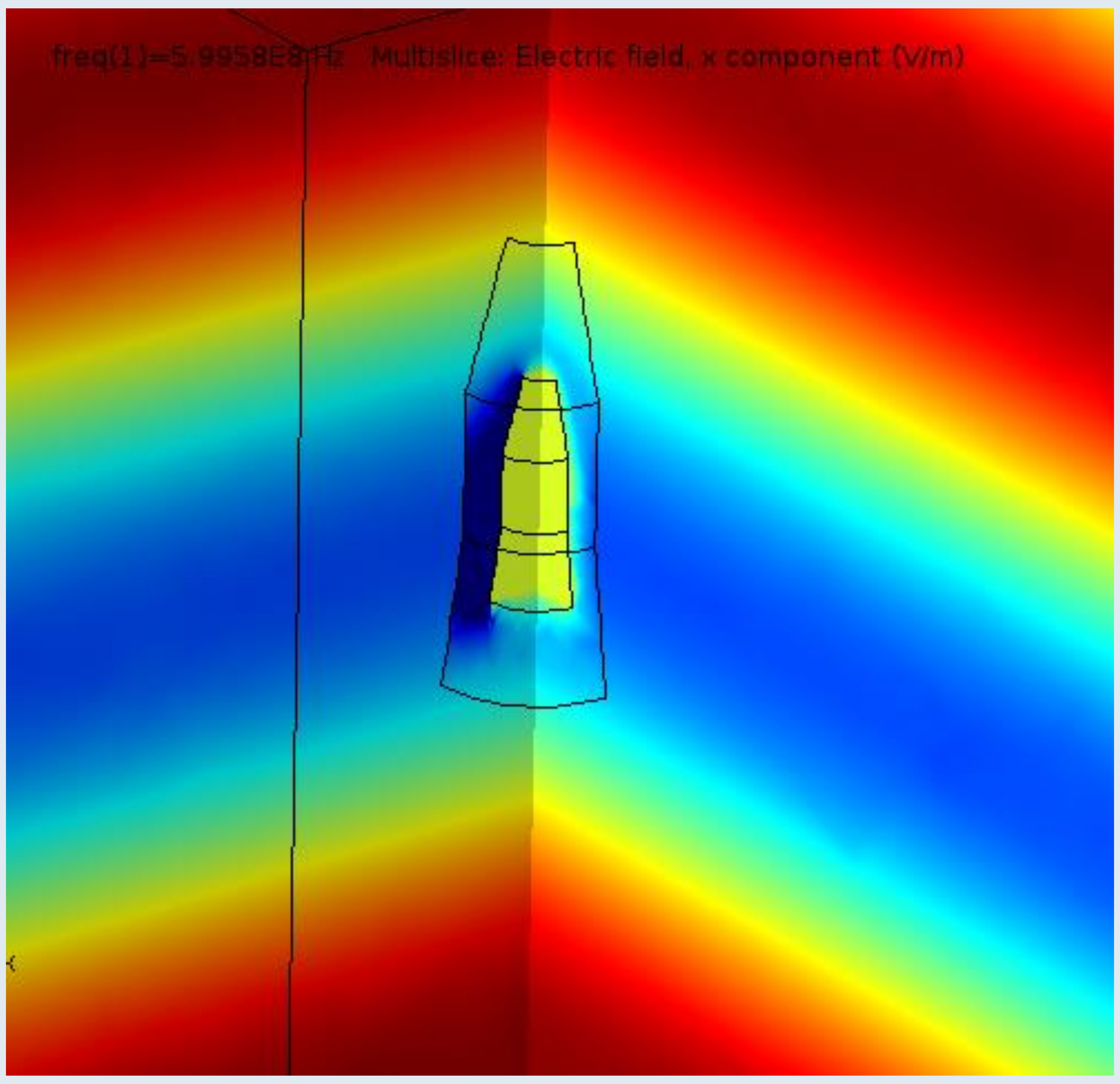

Numerical Electromagnetic Cloak for arbitrary 3D shapes using Laplace’s Equation

The numerical method of deriving cloaking parameters using the Laplace’s equation has been shown to work for 2D objects. This has been extended on complex 3D objects.

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Abstract

The Jacobian transformation tensor used in transformation optics has an equivalent in the domain of continuum mechanics called the deformation gradient tensor. This has been used as a tool to derive the permittivity and permeability tensors for cloaks and other TO based applications using numerical methods in the past for 2D shapes. In this paper the Laplace’s equation is solved by setting Dirichlet boundary conditions on the inner and outer boundaries of the cloak to get the inverse of the deformation gradient tensor. It is then used to calculate the final transformation tensor for an arbitrary 3D cloak.

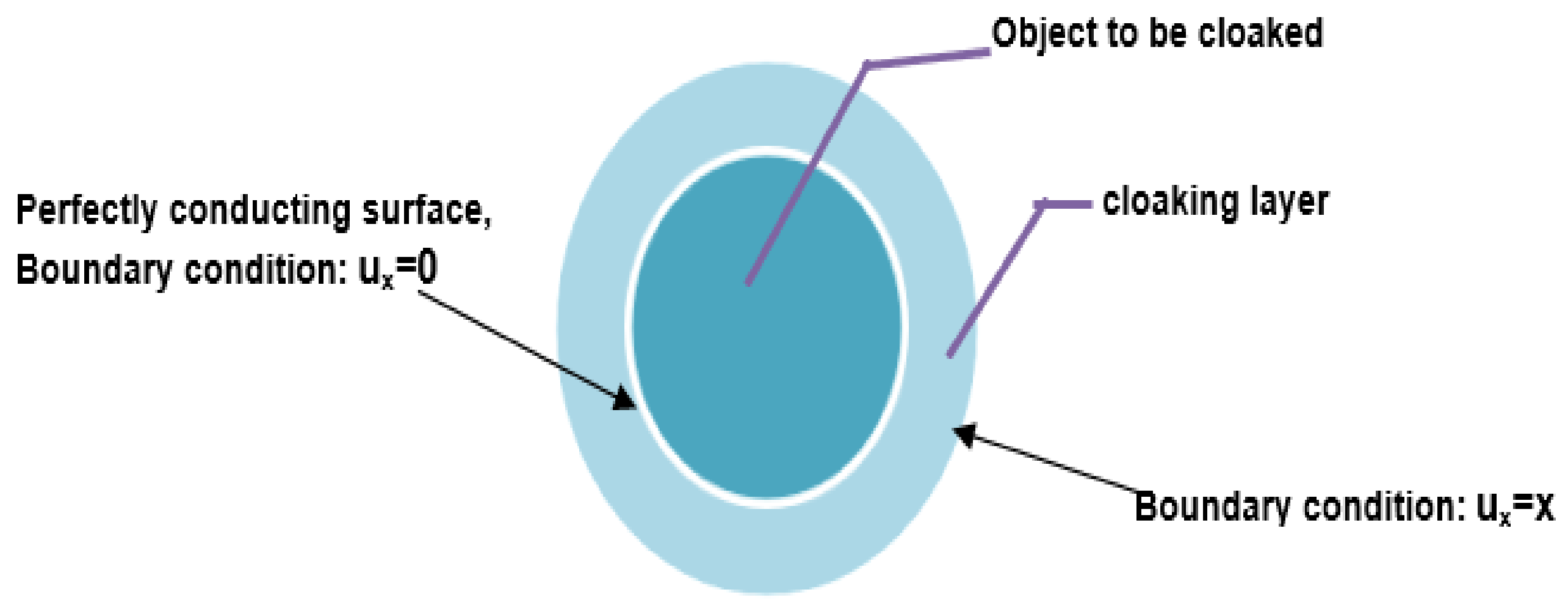


FIGURE 1. Schematic of the cloak with boundary conditions

Methodology

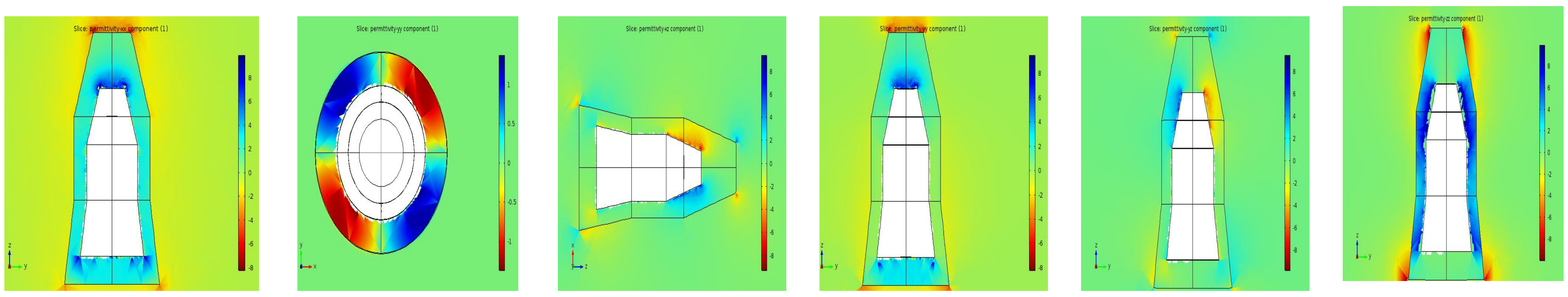
The form invariance of Maxwell’s equations allows for one to use transformation optics (TO) and find the permittivity and permeability tensors which can create a cloak of invisibility around an object. This can be produced by tailoring the material properties of the cloak according to the transformation equations given by:

$$\varepsilon' = \frac{J * \varepsilon * J^T}{\det(J)}$$

$$\mu' = \frac{J * \mu * J^T}{\det(J)}$$

Results

The results of using the technique to cloak a frustum-cylinder-frustum composite are shown in Figure 2 along with the permittivity distribution for the latter. The frequency of the waves used is 8GHz and the maximum dimension of the objects is 1m.



(a) (b) (c) (d) (e) (f)

FIGURE 2. Permittivity component (a) xx component (εxx) distribution on the yz plane (b) xy component (εxy) distribution on the xy plane (c) xz component (εxz) distribution on the xz plane (d) yy component (εyy) distribution on the yz plane (e) yz component (εyz) distribution on the yz plane (f) zz component (εzz) distribution on the yz plane

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