Resolution of Skin Layer in EM Simulation

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1 Introduction

AC-currents penetrate good conductors in a layer only at their surface, the skin layer. It is important to resolve this skin layer in order to calculate ohmic power losses due to eddy currents, that may heat the conductor. For standard FEM a fine enough mesh is needed to resolve it. But in industry, it is often not possible to use a fine enough mesh. The following 2D elliptic boundary value problem on domain Ω is the subject of this presentation:

$$\begin{aligned} -\Delta u + \sigma(\vec{x})u &= 0 \qquad \text{in } \Omega \\ \frac{\partial u}{\partial \vec{n}} + zu &= g \qquad \text{on } \partial\Omega \end{aligned} \tag{1}$$

Where $\frac{1}{\sqrt{\sigma}}$ is the skin depth. The skin layer is an exponential decay from the surface of the conductor. If we use this knowledge, and take exponentially decaying basis functions, we can resolve the skin layer with coarser meshes, much coarser than the skin depth. The method presented here uses Trefftz-type basis functions in order to capture the exponential decay of the skin layer. Knowledge of the boundary edges in the mesh is used to choose a well fitting basis. The Discontinous Galerkin method is used to handle the discontinuities across element boundaries, similar to [1]. The resulting method works well for a wide range of skin depths.

References

[1] C. J. Gittelson, R. Hiptmair, and I. Perugia, ESAIM **M2AN 43**, 297 (2009).