Recent Progress in the Mixed Spectral Element Method for Computational Electromagnetics

Jie Liu[1], Xuanying Hou[1], Ke Chen [1], Yuanguo Zhou[1], Na Liu[1], and Qing Huo Liu[2]*
[1] *Institute of Electromagnetics and Acoustics, and Department of Electronic Science, University of Xiamen, Xiamen, Fujian, P. R. China, 361005*
[2] *Department of Electrical and Computer Engineering, Duke University, Durham, NC, USA, 27708*
qhliu@duke.edu

In recent years, the spectral element method (SEM) has been extensively applied to computational electromagnetics for large scale problems. As a special high-order finite element method, however, the SEM also includes DC spurious modes as in the traditional finite element method. Since 2015, the mixed spectral element method has been developed to remove such spurious modes by incorporating Gauss's law into the traditional SEM (N. Liu, L. Tobon, Y. Tang, Q. H. Liu, "Mixed Spectral Element Method for 2D Maxwell Eigenvalue Problem," *Communications in Computational Physics*, vol. 17, no. 2, pp. 458-486, 2015; N. Liu, L. Tobon, Y. Zhao, Y. Tang, Q. H. Liu, "Mixed Spectral Element Method for 3-D Maxwell Eigenvalue Problem," *IEEE Trans. Microwave Theory Tech.*, vol. 64, no. 2, pp. 317-325, 2015).

In this paper, we will overview some recent developments in applying the mixed SEM for other electromagnetic applications:

(a) First, we have extended this mixed SEM to solving waveguide problems with Bloch (Floquet) periodic boundary conditions to remove the spurious modes. We have further used this method as an important ingredient in the spectral numerical mode matching (SNMM) method for large scale, layered nanophotonic problems. We show that this SNMM is orders of magnitude faster and with higher accuracy than the traditional finite element method for large structures

(b) We have extended the mixed SEM to remove the well-known low-frequency breakdown problem in computational electromagnetics. We have applied this method to simulate realistic subsurface sensing and imaging problems.

In the presentation, we will fist review the mixed spectral element method. We will then present the spectral element method and several numerical examples to show the advantages of this method over the traditional finite element method in various applications.