



Numerical Analysis Seminar

Multiscale Modelling for Time-harmonic Maxwell equations with impedance boundary conditions in heterogeneous media

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Abstract

Modeling time-harmonic Maxwell problems in heterogeneous media presents significant mathematical and computational challenges. Due to the inherent non-elliptic structure and non-coercive nature of Maxwell equations, conventional methods face severe numerical instabilities, particularly in high-contrast media and at high wave numbers. These challenges often lead to ill-conditioned discrete systems and prohibitively high computational costs, limiting their practical applicability. To overcome these challenges, we introduce an efficient multiscale framework for time-harmonic Maxwell equations with impedance boundary conditions in high-contrast media. The method constructs multiscale basis functions in two stages. First, an auxiliary space is built via local spectral problems incorporating a mass term and a Silver–Müller-type boundary penalty term. This ensures coercivity and automatically excludes the curl kernel from the dominant eigenspaces, eliminating the need for explicit divergence-free constraints. The auxiliary space is then used to construct the multiscale space, where the bilinear form differs from that of the first stage. By leveraging a resolution condition and various norm relationships, we rigorously establish the coercivity of the more complex bilinear form, which is essential for the whole analyses. Theoretical analysis shows that, with appropriate oversampling, the method achieves $O(H)$ convergence independent of the local contrast and the approximation error increases with the wave number k . Extensive numerical experiments are reported to validate the effectiveness of the proposed approach.

Date:	April 22, 2026 (Wednesday)
Time:	11:00 am – 12:00 pm
Venue:	Room 210, Run Run Shaw Building, HKU