Mathematical methods in electromagnetics workshop

9-10 October 2025

Workshop program - Thursday

- 10:00 Coffee and opening
- 10:20-10:50 Eric Stachura

  Title: *Wave propagation in fractal porous media*

  Abstract: *Recent work related to wave propagation in porous media with fractal microstructure. I will discuss a fractal version of the Drude-Born-Fedorov system.*

- 10:50-11:20 Qian Liu

  Title: *Very weak evolution multiscale convergence in homogenization of parabolic PDEs.*

  Abstract: *PDEs with rapidly oscillating spatial and temporal scales are challenging to solve numerically. To address this, we apply evolution multiscale and very weak evolution multiscale convergence to homogenize a parabolic PDE with one spatial and one temporal scale. Using compactness results, we derive the homogenized problem that describes the macroscopic behavior on the entire space-time domain, and determine the corresponding local problems that capture the microscopic oscillations on the reference space-time cell. Both homogenized and local problems are more tractable, enabling efficient analysis of multiscale systems.*

- 11:20-11:50 Niklas Wellander

  Title: *Electromagnetic wave propagation in the atmosphere*

  Abstract: *The atmosphere is a heterogeneous medium with electromagnetic properties that change with respect to time. This may have a significant effect on communication and radar systems. Modeling the propagation is nontrivial since the length of the propagation path usually is on a scale many times the wavelength. In addition, boundary conditions imposed by a rough or smooth land/sea surface, the conductivity of land/sea, as well as scattering from e.g. precipitation, vegetation or insects may strongly impact the transmitted wave. I will show some simplified models that are used, and how numerical weather predictions (NWPs) can be used to forecast the electromagnetic properties of the atmosphere. Finally, I will discuss the uncertainties in the results given by the models.*

- 11:50-13:00 Lunch at Brazilia restaurant

  Address: Brinellvägen 64B, KTH campus

Workshop program - Thursday

- 13:00-13:30 Balwan Rana

  Title: *Longitudinal solution ansatz for electromagnetic wave propagation through an inhomogeneous metamaterial*

  Abstract: *We derive the longitudinal field solution for the TEM mode in a waveguide filled with an impedance matched metamaterial, where the permittivity and permeability vary according to hyperbolic tangent functions. An analytical ansatz for the longitudinal field solution is introduced, and compared to the derived longitudinal field solution. Finally, we confirm that the proposed ansatz fulfills the governing wave equation.*

- 13:30-14:00 Mariana Dalarsson

  Title: *Space-harmonic analysis of temporal metamaterials*

  Abstract: *We use the space-harmonic method to study a temporal metamaterial. By gradually switching the material parameters in time between two values, the medium can be described using the hyperbolic tangent function. Exact analytical solutions for the fields are obtained and analyzed, demonstrating the duality between the space-harmonic analysis of temporally graded metamaterials and the time-harmonic analysis of spatially graded metamaterials.*

- 14:00-14:30 Erik Orvehed Hiltunen

  Title: *Wave scattering and generalised energy conservation of time-modulated scatterers*

  Abstract: *We consider a composite medium containing scatterers with time-modulated properties. The temporal modulation induces a coupling between wave harmonics, creating a family of scattered waves whose frequencies differ by the modulation frequency. Such frequency conversion is made possible by breaking the conservation of energy. We introduce a generalized energy conservation relation for such systems. We derive an optical theorem, and compute the active power describing scattering power input or output. We test our results by developing an integral-operator approach for efficient numerical calculation of the scattering properties of time-dependent materials.*

- 14:30-15:00 Yannick De Bruijn

  Title: *Complex band structures in the spectral theory of Toeplitz operators applied to metamaterials*

  Abstract: *We use complex band structures to study localisation in finite periodic media, implementing them for tridiagonal and multiband Toeplitz matrices.*

Workshop program - Thursday

- 15:00-15:30 Coffee break with pastries
- 15:30-16:00 Annemarie Luger

  Title: *On Herglotz-Nevanlinna functions and beyond*

  Abstract: *In this talk, we recall some facts about Herglotz-Nevanlinna functions and their generalizations, as an overview on what kind of questions we have been working with. Moreover, we share some recent observations on rational Herglotz-Nevanlinna functions in several variables.*

- 16:00-16:30 Mitja Nedic

  Title: *Characterization of Nevanlinna measures via the Fourier transform*

  Abstract: *I will present a way of characterizing Nevanlinna measures corresponding to Herglotz functions of several variables using the Fourier transform, based on joint work with Eero Saksman.*

- 16:30-17:00 Lars Jonsson

  Title: *Structured matrices, exact coverage, and properties of array antennas*

  Abstract: *In this talk, we investigate how structured matrices - such as Toeplitz, Loewner and Cauchy matrices - can be used to determine properties of large array antennas. These structured matrices admit, fast stable $O(n^2)$ and even superfast algorithms for solving linear systems, utilizing their low displacement rank. We present how some of these algorithms can be generalized to hierarchical block Toeplitz matrices. This has interesting applications in an optimization problem that utilize solutions to the exact coverage problem. If time premits, we will also discuss results that use the Loewner matrix in interpolation for antennas.*

- 17:00-17:30 Wrap up and walk to dinner
- 17:30 Dinner at Kouzina (greek restaurant)

  Address: *Valhallavägen 131, 115 31 Stockholm, approx. 1.5 km walking distance from the venue.*

Workshop program - Friday

- 10:00 Coffee and opening
- 10:20-10:50 Mika Söderström

  Title: *Effective permittivity of functionally graded gold nanoparticles*

  Abstract: *We use homogenization techniques to model the effective permittivity of graded ellipsoidal particles. Using the electrostatic approximation, we analyze a single graded ellipsoid and a suspension of randomly oriented ellipsoids. Analytical results for graded and isotropic particles, individually or in a suspension, demonstrate variations in effective permittivity depending on the particle grading profile, aspect ratio, and volume fraction to the surrounding medium. These findings enable more accurate prediction of the particles' properties and electromagnetic behavior in biomedical applications.*

- 10:50-11:20 Daniel Sjöberg

  Title: *Scattering and characteristic modes of nonreciprocal scatterers.*

  Abstract: *Characteristic modes (CM) can be used to capture the dominating scattering from material structures. Although mostly associated with perfect electric conductor structures, recent developments have shown that they can also be defined as eigenvectors for the scattering or transition matrix. This formulation makes it possible to compute CM also for nonreciprocal structures. We demonstrate the implications of this theory for nonreciprocal scatterers, and discuss to what extent nonreciprocity can be quantified.*

- 11:20-11:50 Henrik Wallén

  Title: *Characteristic modes of combined PEMC and PEC objects*

  Abstract: *The perfect electromagnetic conductor (PEMC) is a lossless, isotropic and nonreciprocal boundary condition, based on linear combination of the perfect electric conductor (PEC) and perfect magnetic conductor (PMC), and it can serve as an interesting test case for studying non-reciprocity. Recently, new surface-integral-operator-based characteristic mode (CM) formulations for pure PEMC objects were presented. The work is here continued with formulations for objects consisting of a PEMC part and a PEC part that are slightly separated.*

- 11:50-13:00 Lunch

Workshop program - Friday

- 13:00-14:30 Networking session with focus on collaboration
- 14:30-15:00 Coffee break with pastries
- 15:00 Closing