MOPNET Meeting 6

University of Bath
Monday April 2nd to Tuesday April 3rd 2012

Abstracts

Patrick Joly (ENSTA ParisTech)

Mathematical modelling of non homogeneous coaxial cables for time domain simulation

In this work, we focus on the time-domain simulation of the propagation of electromagnetic waves in non-homogeneous lossy coaxial cables. This question has been motivated by a collaboration with CEA-LIST about the numerical modeling of non-destructive testing by ultra-sounds. The main characteristic of such cables is that their transverse directions are very small with respect to their length as well as the wavelength. As a consequence, one would like to use a simplified 1D model as an effective (or homogenised) model for electromagnetic propagation. In this work, we construct and justify rigorously such a model by way of an asymptotic analysis of time harmonic 3D Maxwell' s equations in such a structure. The effective model appears as a generalized wave equation with additional time convolution terms that take into account electric and magnetic losses. By this way, we justify and extend some models proposed in the electrical engineering literature , in particular the well-known telegraphist's equation. The properties of our limit model in time domain will be analyzed and a stable discretization process will be proposed. Some numerical academic numerical simulations will be presented.

Rafael Benguria (Universidad Católica de Chile)

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Charles Johnson (The College of William and Mary)

Eigenvalues, Multiplicities and Graphs

The graph of an n-by-n real symmetric or complex Hermitian matrix is an undirected graph on n vertices, in which there is an edge between i and j if and only if the i, j entry is nonzero. Given a graph G, we denote by $H(G)$ the set of all n-by-n Hermitian matrices whose graph is G. The diagonal entries (which must be real) do not matter. $L(G)$ denotes the lists of multiplicities for the eigenvalues that occur among matrices in $H(G)$; these can be "ordered" by the numerical values of the eigenvalues of the underlying eigenvalues or "unordered" (simply given in numerical order of the multiplicities themselves. We survey what is known about these possible multiplicities as a function of the graph, especially in the case of trees, including maximum multiplicity, minimum number of distinct eigenvalues, all multiplicity lists for some classes, minimum number of multiplicities $= 1$, etc.

Valeria Simoncini (Università di Bologna)

The rational Krylov subspace for parameter dependent systems

The Rational Krylov Subspace has recently received considerable attention as a powerful tool for matrix function evaluations and other problems involving large matrices. In this talk we review some properties of these spaces, and their great potential within projection-type methods for effectively solving several important large-scale algebraic problems: we focus on general parameter-dependent matrix equations, and on the approximation of the transfer function by projection. Numerical experiments stemming from real applications show the effectiveness of the approach.

David Krejčiřik (Nuclear Physics Institute ASCR, Czech Republic)

Waveguides with non-Hermitian boundary conditions

We develop a spectral analysis for the Laplacian in tubular neighbourhoods of hyperplanes with non-Hermitian complex-symmetric Robin-type boundary conditions. Under the condition that the heterogeneity of the boundary conditions is local in a sense, we prove that the essential spectrum is real and stable, find sufficient conditions which guarantee the existence of real weakly coupled eigenvalues and construct the leading terms of their asymptotic expansions. The peculiar spectral properties observed in numerical experiments are explained in the regime of the singular limit when the width of the neighbourhood diminishes. We focus on open problems related to non-perturbative proofs of the existence and absence of discrete spectrum.

Christiane Tretter (Universität Bern)

Quadratic numerical range (QNR) of analytic block operator matrix functions

In this talk the quadratic numerical range of analytic block operator matrix functions is presented. The main results include the spectral inclusion property and resolvent estimates; they generalize corresponding results for the numerical range of operator functions.

Karl Meerbergen (KU Leuven)

The solution of two-parameter eigenvalue problems arising from the determination of Hopf bifurcations of dynamical systems

The detection of a Hopf bifurcation in a large scale dynamical system that depends on a physical parameter often consists of computing the right-most eigenvalues for a sequence of large sparse eigenvalue problems. We discuss a method that computes a value of the parameter that corresponds to a Hopf point without actually computing right-most eigenvalues. This method utilises a certain sum of Kronecker products and involves the solution of matrices of squared dimension. The proposed method is based on finding purely imaginary eigenvalues of a two-parameter eigenvalue problem. The problem is formulated as an inexact inverse iteration method that requires the solution of a sequence of Lyapunov equations with low rank right hand sides. It is this last fact that makes the method feasible for large systems. We show numerical examples from Navies-Stokes equations and show a connection with the implicitly restarted Krylov method and the rational Krylov method.

Emre Mengi (Koç University)

Optimization of Eigenvalues of Hermitian Matrix Functions and Applications

The main theme of this talk is a Hermitian matrix function depending on its parameters analytically. We describe a numerical algorithm for the global optimization of a specified eigenvalue of such a Hermitian matrix function over the space of parameters. The algorithm is driven by piece-wise quadratic under-estimators for the eigenvalue function, and locating their global minimizers. In the multi-dimensional case the global minimization of the piece-wise quadratic models can be posed as quadratic programs. The algorithm generates sequences converging to global optimizers at a linear rate in practice. The second part of the talk is devoted to specific distance problems over the space of matrices leading to these eigenvalue optimization problems. We discuss problems such as the distance to the nearest defective matrix, and the distances to matrix pencils and matrix polynomials with specified eigenvalues, which are motivated by sensitivity analysis in numerical linear algebra as well as applications in control theory and signal processing.

This is a joint work with Mustafa Kilic, E. Alper Yildirim, Michael Karow, Daniel Kressner, Ivica Nakic, Ninoslav Truhar.

Dmitri Vassiliev (UCL)

Spectral theory of first order systems: an interface between analysis and geometry

We consider an elliptic self-adjoint first order pseudodifferential operator acting on columns of complex-valued half-densities over a connected compact manifold without boundary. The eigenvalues of the principal symbol are assumed to be simple but no assumptions are made on their sign, so the operator is not necessarily semi-bounded. We study the following objects:

a) the propagator (time-dependent operator which solves the Cauchy problem for the dynamic equation),

b) the spectral function (sum of squares of Euclidean norms of eigenfunctions evaluated at a given point of the manifold, with summation carried out over all eigenvalues between zero and a positive lambda) and

c) the counting function (number of eigenvalues between zero and a positive lambda).

We derive explicit two-term asymptotic formulae for all three. For the propagator "asymptotic" is understood as asymptotic in terms of smoothness, whereas for the spectral and counting functions "asymptotic" is understood as asymptotic with respect to the parameter lambda tending to plus infinity. In performing this analysis we establish that all previous publications on the subject are either incorrect or incomplete, the underlying issue being that there is simply too much differential geometry involved in the application of microlocal techniques to systems.

We then focus our attention on the special case of the massless Dirac operator in dimension 3 and provide simple spectral theoretic characterisations of this operator and corresponding action (variational functional).

Charles Johnson (The College of William and Mary)

New Generalizations of the Field of Values to Pairs of Matrices

The classical field of values $x^*Ax : x^*x = 1$ is well studied (see Horn and Johnson, Topics in Matrix Analysis) and has many nice properties and applications. We survey recent work that generalizes the classical field to pairs of matrices in several ways by replacing x^*Ax with $(x^*Ax)^k(x^*Bx)^j$ for integers j and k. Possible shapes and generalizations of convexity are the focus. The new generalizations are motivated by the case $j = 1$, $k = -1$, which arose in numerical work with Lev Krukier.