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Abstracts of the Posters

Ngoc Do, *Some graph models in nano-science and solid state*

Abstract: Graph model is proven in many cases to be much simpler to study than other approaches and yet preserves all essential ingredients of the dispersion relation. We study some spectral problems for periodic operators originating from mathematical physics. Using quantum graph model, we analyze the dispersion relation, and thus spectra, of periodic Schrödinger operators on a particular graphyne structure and its nanotubes. We found highly directional Dirac cones, which makes graphynes fascinating. We also study a conjecture, which has been widely assumed in solid state physics, for a class of periodic differential operators on graphs. Namely, we prove that extrema of dispersion relations of generic periodic differential operators on a class of discrete graphs are non-degenerate. (Here by non-degeneracy we mean extrema having non-degenerate Hessian.)

Silvia Gazzola, *Arnoldi-Tikhonov methods for sparse reconstruction*

Abstract: Hybrid Krylov subspace methods for inverse problems apply a standard regularization method, such as Tikhonov, to projected least squares problems at each iteration. In this poster we focus on methods based on the Arnoldi algorithm and we describe some new preconditioning approaches that can be used to enforce sparsity constraints into the approximate solution. This is a joint work with James Nagy (Emory University, USA) and Paolo Novati (University of Padova, Italy).

Rim Gouia-Zarrad, *Reconstructing a function from its conical Radon transform*

Abstract: In recent years, Radon type transforms that integrate functions along families of curves or surfaces, have been intensively studied due to their applications to inverse scattering, synthetic aperture radar, imaging science, nuclear industry, etc. In this presentation, we consider the transform that integrates a function f over a family of cones invariant to translation. A new exact inversion formula is presented in the case of fixed opening angle and vertical central axis. In addition, the results of numerical simulations are presented to demonstrate the efficiency of the suggested algorithm in 2D.

Benjamin Holman, *Thermo-acoustic imaging in a reverberating cavity*

Abstract: Thermo-acoustic tomography (TAT) is a hybrid form of medical imaging in which biological tissues are radiated with microwaves to illicit a thermal expansion which produces acoustic pressure waves. These waves are measured outside of the tissue. Traditional reconstruction algorithms for TAT assume that acoustic pressure waves eventually leave a region of interest. We consider a non-standard data acquisition scheme with acoustically reflecting walls that cause pressure waves to reverberate within the region of interest. This type of boundary condition requires a new reconstruction procedure. We propose a method that produces an approximate reconstruction from a finite measurement time and improves as the measurement time increases. This is joint work with Leonid Kunyansky.

Minh Kha, *Green's function asymptotics near a spectral edge for a generic periodic Schrödinger operator*

Abstract: Precise asymptotics known for the resolvents of the Laplacian have found their analogs for periodic elliptic operators of the second order below the bottom of the spectrum. Due to the band-gap structure of the spectra of such operators, the question arises whether similar results can be obtained near the edges of spectral gaps. For "generic" periodic Schrödinger operators, this is possible near a spectral edge when the dimension d¿1. This is joint work with Peter Kuchment and Andy Raich.

Peter Kuchment and Sergey Lvin, *Medical imaging, identities for* $\sin(x)$*, and non-commutative binomials*

Abstract: Our research on the so called Single Photon Emission Computed Tomography has lead to a series of seemingly unknown (at least to the authors) nonlinear differential identities for $\sin(x)$, which were followed by similar identities for some other elementary functions, as well as for binomial type identities for some pairs of non-commuting operators. Some of the results are presented in [2] (see also relevant tomography discussion in [1].

References

[1] P. Kuchment, *The Radon Transform and Medical Imaging*, SIAM 2014.
[2] P. Kuchment and S. Lvin, Identities for $\sin(x)$ that came from medical imaging, Amer. Math. Monthly **120** (2013), no. 7, 609 - 621.

Hui Liu and Alexandra Smirnova, *On generalized cross validation for regularization parameter selection in disease modeling*

Abstract: We study advantages and limitations of the Generalized Cross Validation (GCV) approach for selecting a regularization parameter in case of a partially stochastic linear operator equation. The research has been motivated by an inverse problem in epidemiology, where the goal was to reconstruct a time dependent treatment recovery rate for Plasmodium falciparum malaria. Initial numerical simulations gave rise to a theoretical analysis of the expected value of the GCV function and the efficiency of the GCV method for different noise levels. It was shown that, as opposed to L-curve, the GCV does not necessarily generate a systematic error in the value of the regularization parameter for Tikhonovs stabilizing algorithm.

Alexander Mamonov, Vladimir Druskin and Mikhail Zaslavsky, *Full waveform inversion in the model order reduction framework*

Abstract: Seismic inversion is traditionally performed in a non-linear least squares setting referred to as the full waveform inversion (FWI). It has numerous known issues such as an abundance of local minima, slow convergence, multiple reflections, high sensitivity to the quality of the initial model, etc. We propose to alleviate some of these issues by replacing the objective functional with a non-linearly preconditioned one. The non-linear preconditioner transforms the seismic data to the parameters of the reduced order model that are the coefficients of a finite difference scheme. This resolves much of the nonlinearity of the inverse problem.

Stepan Manko, *Inverse scattering problem for energy-dependent Schrödinger equations*

Abstract: We develop the direct and inverse scattering theory for one-dimensional energy-dependent Schrödinger equations

$$-y'' + (q(x) + 2kp(x))y = k^2 y$$

on the half-line with highly singular potentials q, namely, we consider potentials q of the form $q = u' + u^2$ for some $u \in L^2(\mathbb{R}^+)$. Such potentials are called Miura potentials. Under some additional assumptions this Riccati

representation of q is unique, and we study scattering problem for the above equation along with some boundary condition at the origin. We show that the mapping that to every problem determined by (u, p) puts into correspondence its scattering function S is continuous with continuous inverse. We also obtain an explicit reconstruction formula for (u, p) in terms of S. To do so, we exploit the connection between the ZS-AKNS system and scattering with Miura potentials. The talk is based on a joint project with R. Hryniv (Lviv, Ukraine).

Darren Ong, *Decaying oscillatory perturbations of periodic Schrödinger, Jacobi and CMV operators*

Abstract: We consider decaying oscillatory perturbations of periodic Schrödinger operators on the half line. More precisely, the perturbations we study satisfy a generalized bounded variation condition at infinity and an Lp decay condition. We show that the absolutely continuous spectrum is preserved, and give bounds on the Hausdorff dimension of the singular part of the resulting perturbed measure. Under additional assumptions, we instead show that the singular part embedded in the essential spectrum is contained in an explicit countable set. Finally, we demonstrate that this explicit countable set is optimal. That is, for every point in this set there is an open and dense class of periodic Schrödinger operators for which an appropriate perturbation will result in the spectrum having an embedded eigenvalue at that point. We also discuss analogues for the Jacobi and CMV settings.

Allie Ray, *Two- and three-step nilpotent Lie algebras associated with Schreier graphs*

Abstract: We associate a two-step nilpotent Lie algebra to any Schreier graph. We then use properties of the Schreier graph to determine necessary and sufficient conditions for this Lie algebra to extend to a three-step nilpotent Lie algebra. As an application, if we start with pairs of isospectral, non-isomorphic Schreier graphs coming from Gassmann-Sunada triples, we prove that the pair of associated two-step nilpotent Lie algebras are always isometric. We use a well-known pair of isospectral Schreier graphs to show that the associated three-step nilpotent extensions need not be isometric.

Fatma Terzioglu, *Compton camera imaging and cone transforms*

Abstract: Compton camera imaging arises in medical imaging, astronomy, and lately in homeland security applications. This triggers an active current interest in this topic. It naturally leads to a variety of Radon type transforms where integration is done over conical surfaces. The poster will present a brief history and a few new results on this.