Conference on Scattering and Inverse Scattering
in Multi-Dimensions

University of Kentucky

May 15–23, 2014

Participants and their Research Interests

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1 Ferenc Balogh

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I am interested in the asymptotic analysis of orthogonal polynomials associated with normal random matrix models in the complex plane.

Relevant recent works:

1. F. Balogh, J. Harnad, Superharmonic perturbations of a Gaussian measure, equilibrium measures and orthogonal polynomials, Complex Anal. Oper. Theory 3 (2009), no. 2, 333–360

2. F. Balogh, M. Bertola, K. T-R McLaughlin, S. Y. Lee, Strong asymptotics of the orthogonal polynomials with respect to a measure supported on the plane, to appear in Communications on Pure and Applied Mathematics arxiv:1209.6366

3. F. Balogh, D. Merzi, Equilibrium measures for a class of potentials with discrete rotational symmetries, submitted arxiv:1312.1483

4. F. Balogh, T. Grava, D. Merzi, Orthogonal polynomials for a class of planar measures with discrete rotational symmetries, in preparation

Problems I am interested in working on at the conference:

1. Reduction of two-dimensional orthogonality relations to non-hermitian, possibly multiple orthogonality relations on contours, for certain classes of normal matrix models.

2. Finding explicit solutions to the associated electrostatic variational problems in terms of conformal maps for various types of potentials.

3. Understanding the connection between the limiting distribution of the counting measure of the zeroes of the orthogonal polynomials and the electrostatic equilibrium measure that is associated with the random matrix model.

4. Calculating the asymptotic behavior of the norming constants of the orthogonal polynomials and of the partition function of the model.

5. Finding the local behavior of the correlation kernels in the bulk, in the edge and around critical points of the boundary of support of the equilibrium measure.

2 Deniz Bilman

University of Illinois at Chicago
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I am interested in long-time asymptotics for perturbations of completely integrable systems. With my advisor Irina Nenciu (UIC), we study perturbations of the doubly-infinite Toda lattice by applying the Toda scattering transform to perturbed lattices and analyzing the evolution of the scattering data under the perturbed dynamics. We also numerically study the scattering data associated to solitary wave solutions of the perturbed lattices. In an ongoing, recent project with Tom Trogdon (CIMS-NYU), we work on numerical inverse scattering transform for the Toda lattice and its perturbations. In addition to these, I am also interested in spectral theory for Jacobi matrices. Prior to my PhD studies I worked on standing wave and traveling wave solutions of the Zakharov-Schulman system in $2+1$-dimensions.

During the workshop, I would in general be interested in working on integrability, solitons, and direct/inverse scattering transform methods in multi-dimensions.

3 Robert Buckingham

University of Cincinnati
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My primary research interest is the asymptotic analysis of models from mathematical physics, in particular integrable ordinary and partial differential equations, orthogonal polynomials, and random matrix models.

Recent publications:

1. R. Buckingham and P. D. Miller, The sine-Gordon equation in the semiclassical limit: dynamics of fluxon condensates. *Mem. Amer. Math. Soc.* **225**, number 1059 (2013): 1–136.

2. M. Bertola, R. Buckingham, S. Lee, and V. Pierce, Spectra of random Hermitian matrices with a small-rank external source: supercritical and subcritical regimes. *J. Stat. Phys.* **153** (2013): 654–697.

3. R. Buckingham and P. D. Miller, The sine-Gordon equation in the semiclassical limit: critical behavior near a separatrix. *J. Anal. Math.* **118** (2012): 397–492.

4. M. Bertola, R. Buckingham, S. Lee, and V. Pierce, Spectra of random Hermitian matrices with a small-rank external source: The critical and near-critical regimes. *J. Stat. Phys.* **146** (2012): 475–518.

5. R. Buckingham, Semiclassical spectral confinement for the sine-Gordon equation. *Math. Comput. Simulation* **82** (2012): 1030–1037.

6. R. Buckingham and P. D. Miller, Large-degree asymptotics of rational Painlevé-II functions. I. arXiv:1310.2276 (2013).

For the workshop I am especially interested in the following problems, although I am also open to others:

1. Analysis of the semiclassical or small-dispersion limit of integrable 2-dimensional wave equations such as the defocusing Davey-Stewartson II equation.

2. Behavior of the normal matrix model and associated orthogonal polynomials via $\overline{\partial}$-methods for general potentials.

3. Cauchy problems for 1-dimensional wave equations with non-analytic initial data via $\overline{\partial}$-methods.

4. Numerical methods for $\overline{\partial}$-problems.

4 Melody Dodd

Colorado State University
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I am a PhD student in mathematics, currently working with Jennifer Mueller on the $\overline{\partial}$-method for the conductivity equation, applied to electrical impedance tomography.

We have recently submitted a publication: Dodd, M and Mueller, J. A Real-time D-bar Algorithm for 2-D Electrical Impedance Tomography Data. arXiv:1404.5978.

For the workshop, I am interested in studying exceptional points and exceptional sets, and developing theory and algorithms for incorporating these singularities into the inverse scattering transform.

5 Yi Ge

Department of Physics, University of Rome
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I am interested in inverse scattering for the dispersionless Davey-Stewartson system and the Dunajski system. I am working with Professor Paolo Maria Santini on these subjects. We are also interested in the inverse scattering method for solving integrable PDE's arising as the commutation condition of vector field Lax pairs.

6 Joe Gibney

University of Arizona
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I am a graduate student working with Ken McLaughlin. I am interested in inverse scattering for nonlinear PDEs in 2+1 dimensions, such as the Davey-Stewartson system, particularly in semi-classical and one-dimensional limits, and the numerical solution of Riemann-Hilbert and $\overline{\partial}$-problems.

7 Manuela Girotti

Concordia University
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I work in the area of random matrices, in particular I study gap probabilities (Tracy-Widom distributions) using Riemann-Hilbert techniques.

Publications:

1. M. Girotti, Riemann-Hilbert approach to gap probabilities for the Bessel process, submitted, 2013 arXiv:1306.5663.

2. M. Girotti, Riemann-Hilbert approach to gap probabilities for the Generalized Bessel process, submitted, 2013. arXiv:1309.7015.

3. M. Girotti, Asymptotics of the Tacnode process: a transition between the gap probabilities from the Tacnode to the Airy process, submitted, 2013. arXiv:1401.5446

Research Interests:

I would be interested in attending the Normal Random Matrices workshop, since close to my research area.

8 Jeremy Hoskins

University of Michigan
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Research Interests: diffuse optical tomography, scattering on graphs, mathematical physics, numerical methods

Recent publications: A.C. Gilbert, J.G. Hoskins, and J.C. Schotland, Diffuse scattering on graphs. arXiv:1401.4428

9 Robert Jenkins

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I am interested in scattering and inverse scattering for integrable systems, particularly those problems related to asymptotic limits of dispersive wave PDEs. Most of my research in this area has focused on the semi-classical limit of the cubic Nonlinear Schrödinger equation in both the focusing and defocusing cases for different classes of initial data. I have also been working on problems related to certain discrete orthogonal polynomials on the circle which in turn are related to the Ablowitz-Ladik system. Recently, I have also started working on using $\bar{\partial}$-methods to understand the stability of solutions of NLS under perturbations to the initial data.

Recent Publications:

1. Jenkins, R. Regularization of a sharp shock by the defocusing nonlinear Schrodingder equation. `arxiv:1402.4708`

2. Jenkins, R. and McLaughlin, K. T.-R., Semiclassical limit of focusing NLS for a family of square barrier initial data. *Comm. Pure Appl. Math.* **67** (2014), no. 2, 246–320.

3. Jenkins, R. and Baik, J., Limiting distribution of maximal crossing and nesting of Poissionized random matchings. *Ann. Probab.* **41** (2013), no. 6, 4359–4406

10 Anna Kazeykina

Université Paris-Sud
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Research interests

Nonlinear PDEs, asymptotic behavior of solutions, existence and stability of traveling waves; inverse problems and the inverse scattering method. I am also interested in complex analysis techniques which prove to be particularly useful in analysing 2+1 dimensional integrable equations via the scattering method.

Recent publications on the above subjects include:

1. Kazeykina A.V.: Absence of solitons with sufficient algebraic localization for the Novikov-Veselov equation at nonzero energy. Funct. Anal. Appl., 48(1), 24-35 (2014)
http://arxiv.org/abs/1201.2758

2. Kazeykina A.V. A large time asymptotics for the solution of the Cauchy problem for the Novikov-Veselov equation at negative energy with non-singular scattering data. Inverse Problems, 28(5), 055017 (2012)
http://arxiv.org/abs/1107.1150

3. Kazeykina A.V., Novikov R.G. Large time asymptotics for the Grinevich-Zakharov potentials. Bulletin des Sciences Mathematiques. 135, 374-382 (2011) http://arxiv.org/abs/1011.4038

4. Kazeykina A.V., Novikov R.G. A large time asymptotics for transparent potentials for the Novikov-Veselov equation at positive energy. J. Nonlinear Math. Phys. 18(3), 377-400 (2011)

Here are some topics that I would be glad to see included in the workshop part of the conference.

1. Complementarity of the inverse scattering approach and the classical PDE approach for studying integrable PDEs

2. Developing the inverse scattering method in the case of singular scattering data (solving the $\overline{\partial}$-(nonlocal) problem with singular coefficients)

3. Recent progress in the inverse scattering method for solving boundary value problems for nonlinear integrable PDEs

11 Christian Klein

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Research interests: dispersive PDEs, integrable systems, numerical methods.

Recent Publications:

1. C. Klein and K. Roidot, Numerical Study of the semiclassical limit of the Davey-Stewartson II equations, arXiv:1401.4745

2. B. Dubrovin, T. Grava, C. Klein and A. Moro, On critical behaviour in systems of Hamiltonian partial differential equations, arXiv:1311.7166

3. C. Klein, B. Muite and K. Roidot, Numerical Study of Blowup in the Davey-Stewartson System, *Discr. Cont. Dyn. Syst. B*, 18, No. 5, 13611387 (2013).

4. C. Kalla and C. Klein, On the numerical evaluation of algebro-geometric solutions to integrable equations, *Nonlinearity* **25**, 569-596 (2012).

5. C. Klein and K. Roidot, Fourth-order time-stepping for Kadomtsev-Petviashvili and Davey-Stewartson equations, *SIAM Journal on Scientific Computing* **33**, No. 6, DOI: 10.1137/100816663 (2011).

During the workshop, I plan to study inverse problems numerically and to study nonintegrable DS equations.

12 Bingying Lu

University of Michigan
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I am interested in dispersive PDEs, integrable systems, solitons.

I dont have a specific problem in mind. I will be interested in working on semiclassical analysis, inverse scattering, and beyond that open to anything.

13 Manabu Machida

University of Michigan
E-Mail: mmachida@umich.edu

I have recently focused on forward and inverse problems of the transport equation (the linear Boltzmann equation). Optical tomography is an application of such inverse problems. The diffusion equation is obtained as an asymptotic limit of the transport equation. My interest spans from stability analysis to numerical methods.

Recent publications include:

1. Machida, M. Singular eigenfunctions for the three-dimensional radiative transport equation. J. Opt. Soc. Am. A 31 (2014) 67–74

2. Machida, M., Yamamoto, M. Global Lipschitz stability in determining coefficients of the radiative transport equation. Inverse Problems 30 (2014) 035010

3. Ban, H. Y., Busch, D. R., Pathak, S., Moscatelli, F. A., Machida, M., Schotland, J. C., Markel, V. A., Yodh, A. G. Diffuse optical tomography in the presence of a chest wall. J. Biomed. Opt. 18 (2013) 026016.

4. Machida, M., Iitaka, T., Miyashita, S. The ESR intensity and the Dzyaloshinsky-Moriya interaction of the nanoscale molecular magnet V15. Phys. Rev. B 86 (2012) 224412

5. Machida, M., Miyashita, S. Survival probability and saturation energy in periodically driven quantum chaotic systems. Physics Letters A 376 (2012) 17771780

6. Machida, M., Panasyuk, G. Y., Schotland, J. C., Markel, V. A., The Green's function for the radiative transport equation in the slab geometry. J. Phys. A: Math. Theor. 43 (2010) 065402

7. Machida, M., Panasyuk, G. Yu., Schotland, J. C., Markel, V. A. Diffusion approximation revisited.

Here are some problems that I am interested in working on during the workshop portion of the meeting.

1. The transport equation in inverse scattering

2. The relation between inverse scattering in one and two dimensions

3. Almost any kind of progress in understanding the scattering transform

14 Dionyssis Mantzavinos

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My research focuses on initial and initial-boundary value problems for evolution equations that appear in water wave theory and other applications. In particular, I work on the Hadamard well-posedness and continuity properties of the initial value problem for certain Camassa-Holm type equations with cubic nonlinearities. Also, I study the well-posedness of initial-boundary value problems for nonlinear evolution equations with initial and boundary data in Sobolev spaces. In addition, I am interested in integrability and travelling wave solutions in multi-dimensions. Finally, for my PhD thesis I analyzed the Kadomtsev-Petviashvili I and II equations on the half-plane via a certain generalization of the Inverse Scattering Transform that uses Riemann-Hilbert and $\overline{\partial}$-techniques.

Recent publications include:

1. A.A. Himonas and D. Mantzavinos, *The Cauchy problem for the Fokas-Olver-Rosenau-Qiao equation. Nonlinear Analysis: Theory, Methods & Applications* **95** (2014), 499–529.

2. D. Mantzavinos and A.S. Fokas, *The unified method for the heat equation: I. Non-separable boundary conditions and non-local constraints in one dimension. Euro. J. Appl. Math.* **24** (2013), no. 6, 857–886.

3. D. Mantzavinos and A.S. Fokas, *The Kadomtsev-Petviashvili II equation on the half-plane. Physica D* **240** (2011), 477–511.

4. A.A. Himonas and D. Mantzavinos, *On the initial-boundary value problem for the linearised Boussinesq equation*, *Stud. Appl. Math.* (in press).

5. A.A. Himonas and D. Mantzavinos, *The initial value problem for a Novikov system.* (submitted)

Here are several problems that I am interested in working on during the workshop portion of the meeting.

1. Rigorous analysis of nonlinear dispersive PDE.

2. Inverse scattering for the Davey-Stewartson, the Kadomtsev-Petviashvili, and Novikov-Veselov equations.

3. Integrability and solitons in multi-dimensions.

4. $\overline{\partial}$-methods for PDE.

15 Peter Miller

University of Michigan
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I am interested in asymptotic problems in dispersive nonlinear waves (and related problems, some obviously related, some less obviously so). Of particular interest for me are completely integrable nonlinear wave equations, as they may yield to the synergistic use of inverse-scattering methods and

asymptotic analysis to give detailed answers where they are not available for more general problems. My favorite asymptotic limit is the semiclassical, or small-dispersion limit. I have experience with semiclassical limits for integrable nonlinear wave equations in one space and one time dimension, and while I have started thinking about problems in two space dimensions, my current perspective is that these problems are far more difficult than those in one dimension, and most of the work remains to be done. I hope that this conference and workshop can lead to new breakthroughs in this area.

Recent publications include:

1. P. D. Miller and Z. Xu, "On the zero-dispersion limit of the Benjamin-Ono Cauchy problem for positive initial data," *Comm. Pure Appl. Math.*, **64**, 205–270, 2011.

2. J. DiFranco, P. D. Miller, and B. Muite, "On the modified nonlinear Schrödinger equation in the semiclassical limit: supersonic, subsonic, and transsonic behavior," *Acta Math. Sci.*, **31**, 2343–2377, 2011.

3. P. D. Miller and Z. Xu, "The Benjamin-Ono hierarchy with asymptotically reflectionless initial data in the zero-dispersion limit," *Comm. Math. Sci.*, **10**, 117–130, 2012.

4. R. Buckingham and P. D. Miller, "The sine-Gordon equation in the semiclassical limit: critical behavior near a separatrix," *Journal d'Analyse Mathématique*, **118**, 397–492, 2012.

5. R. Buckingham and P. D. Miller, "The sine-Gordon equation in the semiclassical limit: dynamics of flux on condensates," *Memoirs of the AMS*, **225**, number 1059, 1–136, 2013.

6. J. DiFranco and P. D. Miller, "The semiclassical modified nonlinear Schrödinger equation II: asymptotic analysis of the Cauchy problem. The elliptic region for transsonic initial data," *Contemp. Math.*, **593**, 29–81, 2013.

Specific problems I would like to discuss in the workshop include:

1. The use of semiclassical methods to analyze the direct scattering transform for various integrable nonlinear wave equations in two space dimensions. More specifically: can WKB-type methods be applied to determine the reflection coefficient for the defocusing Davey-Stewartson II equation in the semiclassical limit?

2. Similar questions for the inverse-scattering transform: given a reflection coefficient in the form that one might obtain from direct scattering in the semiclassical limit, can one reconstruct the potential (also for positive time, and hence predict dynamics) in the same limit?

3. Linear elliptic problems in two space dimensions also arise in other settings in which a large parameter also appears (large-degree asymptotics of orthogonal polynomials with respect to an area measure in the plane is an example). Can WKB-type methods be applied to such problems successfully? Specific examples exist, but a general theory appears to be missing.

4. Suppose that a formal WKB scheme can be sensibly postulated to study, say, the complex geometrical optics solutions of elliptic PDE that arise in inverse-scattering analysis for various problems (Davey-Stewartson, Novikov-Veselov, etc). Can the error be rigorously controlled? This appears to involve the estimation of the inverse of a singularly perturbed elliptic operator acting on a subspace designed to allow a formal perturbation argument to go through. How can the conditions that define the subspace be exploited to bound the inverse?

16 Michael Music

University of Kentucky
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I am interested in completely integrable systems, particularly the Novikov-Veselov equation at zero energy. I am working on extending the inverse scattering method to more potentials. I would like to know how solitons fit into this framework and how to extend the method to such solutions. At the same time, I would like to branch out into other completely integrable systems.

Papers:

1. Music M, Perry P, Siltanen S. Exceptional circles of radial potentials. Inverse Problems 29 (2013), no. 4, 045004

2. Croke R, Mueller J, Music M, Perry P, Siltanen S, Stahel A. The Novikov-Veselov equation: theory and computation. To appear in Contemporary Mathematics.

3. Music M. The nonlinear Fourier transform for two-dimensional subcritical potentials http://arxiv.org/abs/1312.0567

Problems of interest:

1. Analysis of singular scattering transforms and methods for dealing with them for the Novikov-Veselov equation and other integrable systems

2. Understanding soliton solutions for the Novikov-Veselov equation in the context of the inverse scattering method

3. Any other problems that I could get into to help expand my research interests and knowledge of scattering methods

17 Peter Perry

Department of Mathematics, University of Kentucky
E-Mail: peteraperry@gmail.com

I am interested in inverse scattering for the Davey-Stewartson and Novikov-Veselov equations and related dispersive nonlinear equations in two space dimensions. I have a current student, Michael Music, with whom I am working on inverse scattering for the Novikov-Veselov equation at zero energy. I am also interesting in characterizing exceptional sets for the scattering transforms associated to these equations and developing methods for the rigorous analysis of soliton solutions and other solutions associated to singularities of the scattering transform.

Recent publications include:

1. Perry, P. Global well-posedness and large-time asymptotics for the defocussing Davey-Stewartson II equation. arXiv:1110.5589, to appear in *J. Spectral Theory*.

2. Perry, P. Miura maps and inverse scattering for the Novikov-Veselov equation. `arXiv:1201.2385`, to appear in *Analysis and Partial Differential Equations*.

3. Music, M., Perry, P., Siltanen, S. Exceptional circles of radial potentials. *Inverse Problems* **29** (2013), no. 4, 045004.

4. Croke, R., Mueller, J., Music, M., Perry, P., Siltanen, S., Stahel, A. The Novikov-Veselov equation: theory and computation. To appear in *Contemporary Mathematics*.

Here are several problems that I am interested in working on during the workshop portion of the meeting.

1. Small-dispersion limit of the DS II equation.

2. Scattering behavior for solutions of the defocussing DS II equation (asymptotics in L^2 rather than L^∞)

3. Rigorous analysis of multiple soliton solutions for the DS II equation using determinant methods (I will analyze the one-soliton solution using determinants in my second lecture)

4. Inverse scattering solution of the Novikov-Veselov equation when the initial data has "singular circles"

5. Rigorous analysis of the scattering transform for the Novikov-Veselov equation at nonzero energy, and in particular eliminating "small data" constraints

6. Almost any kind of progress in understanding the scattering transform for the KP equation, particularly for multiple line-soliton solutions

18 Roman Riser

Katholieke Universiteit Leuven, Belgium
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My research focus on Random Normal Matrices in the large n limit of the dimension of the matrices. I am especially interested in critical phenomenas.

In my PhD thesis I concentrated on Gaussian Normal Matrices where I used an identity similar to the Christoffel-Darboux formula to prove universality. Recently I found that the corrections of the density of eigenvalues of order $\mathcal{O}(n^{-1/2})$ are universal up to a dependency on the curvature at the boundary of support of eigenvalues.

Recent publications include:

1. R. Riser, Universality in Gaussian Random Normal Matrices, arXiv:1312.0068

Here are several questions and problems that I am interested in working on and discuss about in the workshop:

1. Higher order corrections in Random Normal Matrices
2. Physical interpretations of the corrections
3. "Christoffel-Darboux" formula for more general potential
4. Critical phenomena in Random Normal Matrices appearing when domains of eigenvalues merge
5. Riemann-Hilbert and $\overline{\partial}$-bar techniques for Random Normal Matrices

19 Abdualrazaq Sanbo

University of Dayton
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This topic is new for me, I need to attend and take advantage. I have some background in differential equations.

I made PowerPoint in Graduation Search "Boundedness of solutions in Volterra systems of difference equations."

Abstract. We use Lyapunov functionals combined with the z-transform and obtain boundedness results regarding the solutions of the nonlinear Volterra system of difference equations:

$$y(n+1) = f(y(n)) + \sum_{s=0}^{n} C(n,s)h(y(s)) + g(n)$$

20 Paolo Maria Santini

Department of Physics
University of Roma "La Sapienza"
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Current Research:

1. The IST theory for integrable dispersionless PDEs in arbitrary dimensions, and the analytic description of the associated multidimensional wave breaking.

2. Multiscale expansions for partial differential and difference equations, and integrability tests.

3. The transition to irregular motions explained as travel on complicated Riemann surfaces.

Recent publications include:

1. S. V. Manakov and P. M. Santini, "The dispersionless 2D Toda equation: dressing, Cauchy problem, longtime behavior, implicit solutions and wave breaking", *J. Phys. A: M ath. Theor.* **42** (2009) 095203 (16pp).
doi:10.1088/1751-8113/42/9/095203
arXiv:0810.4676

2. S. V. Manakov and P. M. Santini: "On the solutions of the second heavenly and Pavlov equations", *J. Phys. A: Math. Theor.* **42** (2009) 404013 (11pp).
doi: 10.1088/1751-8113/42/40/404013
ArXiv:0812.3323.

3. P. M. Santini, "Multiscale expansions of difference equations in the small lattice spacing regime, and a vicinity and integrability test. I", *J. Phys. A: Math. Theor.* **43** (2010) 045209 (27pp)
doi: 10.1088/1751-8113/43/4/045209
ArXiv:0908.1492

4. S. V. Manakov and P. M. Santini: "On the dispersionless Kadomtsev-Petviashvili equation in n+1 dimensions: exact solutions, the Cauchy problem for small initial data and wave breaking", *J. Phys. A: Math. Theor.* **44** (2011) 405203 (15pp).
doi:10.1088/1751-8113/44/40/405203
arXiv:1001.2134

5. S. V. Manakov and P. M. Santini: "Solvable vector nonlinear Riemann problems, exact implicit solutions of dispersionless PDEs and wave breaking", *J. Phys. A: Math. Theor.* **44** (2011) 345203 (19pp)
doi:10.1088/1751-8113/44/34/345203.
arXiv:1011.2619.

6. David Gomez-Ullate, Paolo Santini, Matteo Sommacal, Francesco Calogero: "Understanding complex dynamics by means of an associated Riemann surface", *Physica D: Nonlinear Phenomena* (2012)
doi: 10.1016/j.physd.2012.04.004.
arXiv:1104.2205

7. P. G. Grinevich and P. M. Santini: "Holomorphic eigenfunctions of the vector field associated with the dispersionless Kadomtsev - Petviashvili equation", arXiv:1111.4446. *J. Differential Equations*, **255**, 7, 1469-1491 (2013).
http://dx.doi.org/10.1016/j.jde.2013.05.010

8. S. V. Manakov and P. M. Santini: "Wave breaking in solutions of the dispersionless Kadomtsev-Petviashvili equation at finite time", *Theor. Math. Phys.* **172**(2) 1118-1126 (2012).

9. S. V. Manakov and P. M. Santini: "Integrable dispersionless PDEs arising as commutation condition of pairs of vector fields" Proceedings of the conference PMNP 2013. J. Phys.: Conf. Ser. **482** (2014) 012029.
doi:10.1088/1742-6596/482/1/012029
http://iopscience.iop.org/1742-6596/482/1/012029.
arXiv:1312.2740v1.

Suggested research topics to be pursued during the conference:

The connection between the study of integrable soliton PDEs in 2+1 dimensions in the small dispersion regime, and the recently developed IST theory in the case of zero dispersion.

21 Jean-Claude Saut

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I am interested in nonlinear dispersive equations and systems, in particular in relation with surface and internal water waves. A lot of progress has been made in the last 20 years on the local Cauchy problem but the qualitative behavior of solutions to those equations is far from being understoood. Results obtained by Inverse scattering techniques often provide challenging conjectures for the nonintegrable cases. This is why I am looking forward attending this conference which bring together scientists of the two communities.

Recent publications include:

1. (with C. Klein), Numerical study of blow-up and stability of solutions to generalized Kadomtsev-Petviashvili equations, *J. Nonlinear Science*, **22**, 5, (2012) 763-811.

2. (with Li Xu), The Cauchy problem on large time for surface waves Boussinesq systems, *J. Math.Pures Appl.* **97** (2012), 635-662.

3. (with R. Carles and R. Danchin), Madelung, Gross-Pitaevskii and Korteweg, *Nonlinearity* **25** (2012), 2843-2873.

4. (with Li Xu), Well-posedness on large time for a modified full dispersion system of surface waves, *J. Math. Phys.* **53**, 11 (2012), 115606.

5. (with C. Wang and R. Temam) An initial and boundary-value problem for the Zakharov-Kuznetsov equation, *J. Math. Phys.* **53**, 11 (2012), 115612.

6. (with D. Lannes and F. Linares), The Cauchy problem for the Euler-Poisson system and justification of the Zakharov-Kuznetsov equation, in *Studies in Phase Space Analysis with Aplications to PDEs*, Series *Progress in Nonlinear Differential Equations and Applications* vol. 84, M. Cicognani, F. Colombini, D. Del Santo Eds., Birkhaüser, (2013), 183-215.

7. (with P. Antonelli and C. Sparber), Well-Posedness and averaging of NLS with time-periodic dispersion management, *Adv. Diff. Equations*, **18** 1-2 (2013), 49-68.

8. (with D. Lannes), Remarks on the full dispersion Kadomtsev-Petviashvli equation, Kinetic and Related Models, American Institute of Mathematical Sciences **6**, Number 4 (2013), 989-1009.

9. (with F. Linares and D. Pilod), Dispersive perturbations of Burgers and hyperbolic equations I : local theory, *SIAM J. Math. Anal.* **46** (2) (2014), 1505-1537.

10. (with J. L. Bona, G. Ponce and C. Sparber), Dispersive blow-up for nonlinear Schrödinger equations revisited, `arXiv:1309.5023v1 [math.AP]` 19 Sep 2013, *J. Math. Pures Appl.* (2014).

11. (with D. Lannes), Remarks on the full dispersion Kadomtsev-Petviashvli equation, Kinetic and Related Models, *American Institute of Mathematical Sciences* **6**, Number 4 (2013), 989-1009.

12. (with C. Obrecht), Remarks on the full dispersion Davey-Stewartson systems, *Comm. Pure Appl. Analysis*, to appear.

13. (with C. Klein), A numerical approach to blow-up issues for dispersive perturbations of Burgers equation, submitted.

Here are several problems that I am interested in discussing during the conference or during the workshop portion of the meeting.

1. What is rigorously known for DS I by inverse scattering methods?

2. Can the small norm conditions needed to solve KP I or KP II by inverse scattering methods be removed. Same for the Benjamin-Ono equation?

3. What is the meaning of the "KP hierarchy" since the KP conserved quantities do not make sense after a certain rank?

4. Are properties of the focusing DS II (existence of a lump, finite time blow-up) still valid for the nonintegrable focusing DS II type systems (I think no)?

5. How can one explain that nonintegrable equations (say of "KdV type") display a dynamics looking similar to that of integrable equations (say KdV)?

22 Dave Smith

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I work in inverse scattering methods for linear and nonlinear problems with a boundary. I have an ongoing collaboration studying the semiclassical limit of sine-Gordon equation with critical or subcritical pure-impulse initial data. In another ongoing collaboration, I am investigating the long-time asymptotics for the lattice potential KdV equation. A further area of interest is obtaining a proper spectral understanding of the method of Fokas for linear problems. This work has been largely completed for problems on the half-line and finite interval via the notion of augmented eigenfunctions but is an attractive question for problems in two spatial dimensions.

Recent publications:

1. D. A. Smith, Well-posed two-point initial-boundary value problems with arbitrary boundary conditions, *Math. Proc. Cambridge Philos. Soc.* **152** 3 (2012), 473-496, arXiv:1104.5571v2 [math.AP]

2. A. S. Fokas, D. A. Smith, Evolution PDEs and augmented eigenfunctions, I. Finite interval, (2013), arXiv:1303.2205 [math.SP], (submitted)

Research questions:

1. One-dimensional limits (Ken McLaughlin's working group).

2. Semiclassical limits (Peter Miller's working group).

3. Extending the work on augmented eigenfunctions (see above reference) to two-dimensional linear problems. This could help elucidate the shortcomings of the Global Relation in multidimensions and offer clues to refining inverse scattering methods for problems in multidimensions with a boundary.

4. I am also keen to work with anyone who has an interest in studying 2-dimensional problems with a boundary.

23 Andreas Stahel

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Current research: Novikov-Veselov equations, mainly numerical algorithms

Relevant publications:

1. Matti Lassas, Jennifer L. Mueller, Samuli Siltanen, Andreas Stahel, The Novikov-Veselov Equation and the Inverse Scattering Method, Part I: Analysis, Physica D: Nonlinear Phenomena, Physica D: Nonlinear Phenomena, 2012

2. Matti Lassas, Jennifer L. Mueller, Samuli Siltanen, Andreas Stahel, The Novikov-Veselov Equation and the Inverse Scattering Method, Part II: Computation, Nonlinearity, Nonlinearity, 2012

3. Croke R, Mueller J L, Music M, Perry P, Siltanen S and Stahel A, The Novikov-Veselov Equation: Theory and Computation. To appear in Contemporary Mathematics.

4. R. Croke, J. L. Mueller and A. Stahel, 2013, Transverse instability of plane wave soliton solutions of the Novikov-Veselov equation, to appear in Contemporary Mathematics

Problems to work on at the conference:

Novikov Veselov equations, Steps toward either global existence or finite-time blow up, can we use any of the conservation laws?

24 Janne Tamminen

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I am interested in functional-analytic theory of $\overline{\partial}$–problems, numerical methods for $\overline{\partial}$-problems and NV equations, CGO solutions in general, all at zero and non-zero energies. I would like to understand these theoretical concepts in the framework of physics and apply our knowledge.

Recent publications include:

1. Samuli Siltanen and Janne P. Tamminen, Reconstructing conductivities with boundary corrected D-bar method. *Journal of Inverse and Ill-posed Problems*, 2014.

2. Janne P. Tamminen, Maarten V. de Hoop, Matti Lassas and Samuli Siltanen, D-bar method and exceptional points at positive energy: a computational study, Submitted.

3. P. Gaitan, H. Isozaki, O. Poisson, S. Siltanen and J. P. Tamminen, Probing for inclusions in heat conductive bodies. *Inverse Problems and Imaging* **6** (2012), pp. 423–446.

Here are several problems that I am interested in working on during the workshop portion of the meeting.

1. The $\overline{\partial}$-method at non-zero energies; creating a Sobolev-space based theory (as it is now found in other function spaces in inverse scattering).

2. More specifically: find Sobolev spaces for the CGO solutions and find the equivalent of the spectral limit $k \to 0$ of the zero-energy case for conducitivity-type potentials (at non-zero energies).

3. Work on the NV equation at non-zero energies.

4. Enhance the numerical computation of the Faddeev Green's function at non-zero energies.

25 Alexander Tovbis

University of Central Florida
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Research interests:

I am interested in the semiclassical limit of the scattering/ inverse scattering transform for the focusing NLS and in the similar problems in more complicated settings. In general, I am interested in various aspects of asymptotic analysis that include the nonlinear steepest descent method for Riemann-Hilbert Problems, exponential asymptotics, etc. , and their applications in integrable equations, orthogonal polynomials, medical imaging, etc.

Recent publications include:

1. Determinant form of the complex phase function of the steepest descent analysis of Riemann-Hilbert problems and its application to the focusing Nonlinear Schrödinger equation, with S. Venakides, *Int. Math. Res. Not.*, (2009) rnp011, 2056-2080.

2. Universality in the profile of the nonlinear Schrödinger equation at the first breaking curve, with M. Bertola, *Int. Math. Res. Not.*, (2010) rnp196, 49pp.

3. Nonlinear steepest descent asymptotics for semiclassical limit of integrable systems: Continuation in the parameter space, with S. Venakides, Comm. Math. Phys., **295** N1, (2010), 139-160.

4. Semiclassical limit of the scattering transform for the focusing Nonlinear Schrdinger equation, with S. Venakides, *Int. Math Res Notices*, (2011) doi: 10.1093/imrn/rnr092, 60p.

5. Semiclassical dynamics of quasi-one-dimensional, attractive Bose-Einstein condensates, with M. Hoefer, *Phys. Lett. A* **375** (2011), no.3, 726-732.

6. Finite Hilbert transform with incomplete data: null-space and singular values, with A. Katsevich,*Inverse Problems*, **28** (10) 105006 (2012).

7. Universality for the focusing nonlinear Schrödinger equation at the gradient catastrophe point: Rational breathers and poles of the tritronquée solution to Painleve I, with M. Bertola, *Comm. Pure and Appl. Math.*, **66**, no 5 (2013), 678-752.

8. Rogue waves: Analytical predictions, with R. Grimshaw, *Proc. Royal Society A*, **469**: 20130094 (2013).

9. Inversion formula for the cosh-transform in SPECT-tomography, with M. Bertola and A. Katsevich, *Proceedings of the AMS*, **141** (2013), 2703-2718.

10. Asymptotics of orthogonal polynomials with complex varying quartic weight: global structure, critical point behaviour and the first Painleve' equation, with M. Bertola, `arXiv:1108.0321`.

11. Singular value decomposition of a finite Hilbert transform defined on several intervals and the interior problem of tomography: the Riemann-Hilbert problem approach, with M. Bertola and A. Katsevich, *Comm. Pure and Appl. Math.*, accepted (`arXiv:1402.0216`).

12. On Sobolev instability of the interior problem of tomography, with M. Bertola and A. Katsevich, `arXiv:1403.1775`.

Problems of interest:

Semiclassical limit of DS2 solutions (including the semiclassical limits for the direct and inverse scattering transforms); asymptotics of orthogonal polynomials near critical points (double scaling limit).

26 Alfredo Wetzel

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I am interested in the direct and inverse parts of the inverse scattering for the Benjamin-Ono equation. In particular, I care about characterizations that arise in the zero dispersion limit. In collaboration with my advisor Peter D. Miller, we have been able to construct –with certain restrictions– a general theory for the solution of the Benjamin-Ono equation when the initial condition is a real rational function. Recent papers include:

1. A. N. Wetzel, B. K. Arbic, I. Cerovecki, M. C. Hendershott, R. H. Karsten, and P. D. Miller. On stratification, barotropic tides, and secular changes in surface tidal elevations: Two-layer analytical models. arXiv:1311.6349

2. A. N. Wetzel and P. D. Miller. Explicit Construction of the Direct Scattering Transform for the Benjamin-Ono Equation with Rational Initial Conditions (in preparation)

3. A. N. Wetzel, B. K. Arbic, and G. R. Flierl. Effects of Bottom Friction on Multi-Layer Quasigeostrophic Turbulence with a Surface Boundary (in preparation)

Here are several problems that I would be interested in working on during the workshop.

1. Connections between the KP equation and the Benjamin-Ono equation.

2. Possible generalizations of the inverse scattering transform for Benjamin-Ono when the initial data is no longer rational.

3. Riemann-Hilbert problems (scalar) with a non-local jump condition.

4. The inverse scattering transform of the Benjamin-Ono equation in the zero dispersion limit.

27 Allen Wu (Yilun Wu)

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We are currently looking at the zero dispersion limit of the Benjamin-Ono equation with negative initial condition. The central problem amounts to the asymptotic analysis of a non-local Riemann-Hilbert problem. The jump condition is given by an integral involving the limits of an analytic function on both sides of a line segment.

At the conference:

I would like to hear about the inverse scattering transforms of various integrable systems, and maybe an example of a successful analysis of a non-local Riemann-Hilbert problem.