Association for Women in Mathematics, Fairfax, VA

Final Technical Report

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Title: *Conference on Non-linear Phenomena in Mathematical Physics: Dedicated to Cathleen Synge Morawetz on her 85th Birthday*.

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Final Report, as of October 15, 2012

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The Association for Women in Mathematics and the Fields Institute co-sponsored the conference *Non-linear Phenomena in Mathematical Physics: Dedicated to Cathleen Synge Morawetz on her 85th birthday* which was held at the Fields Institute in Toronto, Canada on September 18-20, 2008.

This scientific meeting focused on the legacy of Cathleen S. Morawetz and the impact that her scientific work on transonic flow and the non-linear wave equation has had in recent progress on different aspects of analysis for non-linear wave, kinetic and quantum transport problems associated to mathematical physics. These are areas where the elements of continuum, statistical and stochastic mechanics, and their interplay, have counterparts in the theory of existence, uniqueness and stability of the associated systems of equations and geometric constraints.
It was a central event for the applied and computational analysis community focusing on Partial Differential Equations.

The goal of the proposal was to honor Cathleen Morawetz, a highly successful woman in mathematics, while encouraging beginning researchers. The conference was successful in show casing the work of successful women, enhancing the visibility of women in the profession and providing role models for those just beginning their careers. The two-day conference included seven 45-minute lectures and one day of six 45-minute lectures, and a poster session for junior participants. The conference program included 19 distinguished speakers, 10 poster presentations, about 70 junior and senior participants and, of course, the participation of Cathleen Synge Morawetz.

The conference celebrated Morawetz's paramount contributions to the theory of non-linear equations in gas dynamics and their impact in the current trends of nonlinear phenomena in mathematical physics, but also served as an awareness session of current women's contribution to mathematics. Of those twenty speakers, seven were women whose research has been inspired from or carried the legacy of Morawetz work. The list of speakers and their topics may be found below (Suncica Canic, University of Houston, was unable to attend). The list of poster presenters and their topics are found below. Of the list of ten poster presenters five were women.

The conference was sponsored and partially funded by the Fields Institute and The Association for Women in Mathematics (AWM), through the Department of Energy (DOE) grant. Barbara Keyfitz, the Director of the Fields Institute, coordinated the sponsorship between the AWM and the Institute. The DOE funds and the Fields Institute sponsorship provided participant travel support for the invited speakers and the poster presenters. The DOE funds provided travel support for women participants only. A conference banquet which provided further networking opportunities for participants was self-funded through a meal registration fee.

Organizing/Scientic Committee consisted of:

Jim Colliander, University of Toronto
Susan Friedlander, University of Southern California
Irene M. Gamba, University of Texas at Austin (Committee Chair)
Fern Hunt, National Institute on Standards and Technology
Barbara L. Keyfitz, Fields Institute, Canada
Walter Strauss, Brown University

Invited Speakers (See Addendum A for abstracts)

Claude Bardos, University of Paris VI, France
Remarks on Navier Stokes and Euler Equation

Lia Bronsard, McMaster University
On the Mixed State in Anisotropic Superconductors

Gui-Qiang Chen, Northwestern University
Shock Reflection-Diffraction Phenomena, Transonic Flow, and Free Boundary Problems

Costas Dafermos, Brown University
Hyperbolic Conservation Laws with Weak Dissipation

Susan Friedlander, University of Southern California
Energy Conservation and Onsager's Conjecture for the Euler Equations

Irene M. Gamba, The University of Texas at Austin
Sharp Estimates for the Boltzmann Equation

Manoussos Grillakis, The University of Maryland
Correlation Estimates and Applications to Schroedinger Equations

Yan Guo, Brown University

Boltzmann Equation in Bounded Domains

Tom Hou, CalTech
On the Stabilizing Effect of Convection in 3D Incompressible Flows

Izabella Laba, The University of British Columbia
Arithmetic Progressions in Sets of Fractional Dimension

Peter Lax, Courant Institute of Mathematical Sciences, New York University
Spectral Representation and Translation Representation

Louis Nirenberg, Courant Institute of Mathematical Sciences, New York University
Some Remarks on Nonlinear Second Order Elliptic Equations

Kevin Payne, Universita di Milano
Weak Well-posedness of the Dirichlet Problem for Equations of Mixed Elliptic-hyperbolic Type

Sylvia Serfaty, Courant Institute of Mathematical Sciences and Université Pierre et Marie Curie
From the Ginzburg-Landau Energy to Vortex Lattice Problems

Jalal Shatah, Courant Institute of Mathematical Sciences, New York University
The Method of Space-time Resonances

Gigliola Staffilani, Masschuesetts Institute for Technology
Kato's Smoothing Efect for Solutions to the Â Capillary Water-Wave Problem.

Walter Strauss, Brown University
Two Problems: Nonlinear Wave Scattering and Plasma Stability

S.R.S. Varadhan, Courant Institute of Mathematical Sciences, New York University
Large Deviations for Random Walks in a Random Environment

Horng-Tzer Yau, Harvard University
Lower Bounds on the Blow-up Rate of the Axisymmetric Navier-Stokes Equations

<u>Poster Presentations</u> (See Addendum B for abstracts)

Ricardo J. Alonso, Rice University
Inelastic Boltzmann Equation: Existence and uniqueness theorem for granular and dilute materials.

Lorena Bociu, University of Nebraska-Lincoln
Existence, Uniqueness and Blow-Up of Solutions to Wave Equations with Supercritical Boundary/Interior Sources and Damping.

Bin Cheng, University of Michigan
Multiscale dynamics of 2D rotational compressible Euler equations: an analytical approach.

Jennie D'Ambroise, University of Massachusetts, Amherst
A linear Schrodinger Formulations of (d+1)-Dimensional Bianchi I Scalar Field Cosmology

Anna Ghazaryan, University North Carolina – Chapel Hill & University of Kansas-Lawrence
Existence and stability of waves in combustion of high density liquid fuels

Cristi Darley Guevara, Arizona State University
Scattering for the Focusing 2D Quintic Nonlinear Schodinger Equation

Christian Klingenberg, Wurzburg University, Germany
Computing turbulence flows using subgrid scale modeling

Petronela Radu, University of Nebraska-Lincoln
Wave equations with variable coefficients and space dependent damping

Erwin Suazo, Arizona State University
Evolution operator for a one-dimensional Schrodinger equation with a time dependent Hamiltonian.

Elizabeth Thoren, University of Texas at Austin
Linear instability criteria for Euler's equation: two classes of perturbations.

Vlad Vicol, University of Southern California
The Radius of Analyticity of Solutions to the Three-Dimensional Euler Equations

ADDDENDUM A
Speaker Abstracts

Claude Bardos, (Paris VI)
Remarks on Navier Stokes and Euler Equation
In this talk I want to emphasize the following points.
1 The importance of the ``basic" properties of Euler equation (like the conservation of energy).
2 The instabilities of the solution.
3 The existence of solutions with decaying energy in connection with the fact that the zero viscosity limit of the $2d$ Navier-Stokes with no slip boundary condition is still an open problem.
4 The interpretation of the Kolmogorov inertial range in term of Wigner measure.

Lia Bronsard, (McMaster)
On the mixed state in anisotropic superconductors
In this talk, I will present an overview of the effect of anisotropy in the mathematical study of superconductors. Anisotropy is very important in the understanding of high temperature superconductors, and it presents very nice unexpected mathematical results. I will present our study on periodic minimizers of the Anisotropic Ginzburg-Landau and Lawrence-Doniach models for anisotropic superconductors, in various limiting regimes. We are particularly interested in determining the direction of the internal magnetic field (and vortex lattice) as a function of the applied external magnetic strength and its orientation with respect to the axes of anisotropy. We identify the corresponding lower critical fields, and compare the Lawrence-Doniach and anisotropic Ginzburg-Landau minimizers in the periodic setting. This talk represents joint work with S. Alama and E. Sandier.

Suncica Canic, (Houston)
Nonlinear moving-boundary problem for blood flow: analysis and computationmoving-boundary problem for blood flow: analysis and computation
The focus of the lecture will be on a benchmark fluid-structure interaction problem between pulsatile blood flow and viscoelastic arterial walls. The model equations couple the Navier-Stokes equations for an incompressible, viscous fluid with the linearly elastic/viscoelastic membrane equations.

The analysis and numerical computation of a solution to the problem is complicated due to the multi-physics and multi-scale nature of the underlying problem, and due to the exceedingly complicated nonlinear coupling between the fluid and the structure equations. Existence of strong solutions for large data is still an open problem and computational algorithms for the calculation of a solution are far from optimal.

In this talk, an analysis of the existence of a solution to the reduced, effective problem will be presented. The existence proof motivated the design of a novel computational scheme for the full problem. The new scheme, based on an implicit kinematic coupling and on a clever operator splitting approach, provides a superbly stable and efficient computational scheme to study this fluid-structure interaction problem in blood flow.

The speaker will give a brief overview of the current status in the field of fluid-structure interaction in blood flow, and outline the efforts by the group in Houston toward using nonlinear analysis and scientific computation to move evidence-based medicine closer to the future of quantitative medicine.

This work was done in collaboration with Roland Glowinski, Giovanna Guidoboni, and Taebeom Kim.

Gui-Qiang Chen, (Northwestern)
Shock Reflection-Diffraction Phenomena, Transonic Flow, and Free Boundary Problems
In this talk we will discuss a research project on shock reflection-diffraction phenomena and related topics, inspired and motivated highly by Cathleen Morawetz's fundamental works on transonic flow and related areas. We will start with various shock reflection-diffraction phenomena and their fundamental scientific issues. Then we will describe how the shock reflection-diffraction problems can be formulated into free boundary problems for nonlinear partial differential equations of mixed-composite hyperbolic-elliptic type. The problems involve two types of transonic flow: One is a continuous transition through a pseudo-sonic circle, and the other is a jump transition through the transonic shock as a free boundary. Finally we will discuss some recent developments in attacking the shock reflection-diffraction problems, including some recent results on the existence, stability, and regularity of global solutions of shock reflection-diffraction by wedges. This talk is based mainly on the joint work with Mikhail Feldman.

Costas Dafermos, (Brown)
Hyperbolic Conservation Laws with Weak Dissipation

Susan Friedlander, (Southern California)
Energy Conservation and Onsager's Conjecture for the Euler Equations
Onsager conjectured that weak solutions of the Euler equations for 3 D incompressible fluids conserve energy only if they have a certain minimal smoothness. As a consequence, in 3 D turbulent flows, energy dissipation might exist even in the limit of vanishing viscosity. We discuss some recent results where we prove that energy is conserved in a Besov space with regularity "almost" that conjectured by Onsager.
This is joint work with Alexey Cheskidov, Peter Constantin and Roman Shvydkoy.

Irene M. Gamba (Texas at Austin)
Sharp estimates for the Boltzmann Equation
We prove L1 and L8 Gaussian weighted estimates to the collisional integral and its derivatives associated to the Boltzmann equation. Such control allow us to prove the propagation and creation of L1 and L8 Gaussian weighted bounds to solutions of the homogeneous Boltzmann equation, and to any of its derivatives in n-dimensions, for realistic intra-molecular potentials leading to collisional kernels of variable hard potentials type with for unbounded, integrable

angular cross sections (Grad's forms).One of the interesting developments is the sharp Povzner estimates and summability of moments to variable hard potentials and unbounded, integrable cross section which carries on to all derivatives. We will also discuss some extension Young's type estimates both in the case of elastic and inelastic collisions, by means of symmetrization and Fourier representation of the collisional operator.This work is in collaboration with Vlad Panferov and Cedric Villani, and more recently with Ricardo Alonso and Emanuel Carneiro.

Manoussos Grillakis, (Maryland)
Correlation Estimates and Applications to Schroedinger Equations
In the present talk I will outline various methods that can be employed in order to obtain correlation type estimates for Schroedinger equations. The idea originated in the work of Lin and Strauss inspired by earlier work of C. Morawetz and W. Strauss. Recent advances due to Colliander, Keel, Stafillani, Takaoka and Tao make it a general and powerfull tool. I will outline a general method of obtaining such estimates. In two space dimensions one can obtain an apriori estimate which is the nonlinear analog of a bilinear estimate obtained by Bourgain. In higher space dimensions one can obtain global in time estimates for the density after the collapse of some internal variables. I will explain how these estimates can be used in order to prove scattering for nonlinear Schr¨odinger equations and how to obtain apriori estimates for the Bose-Einstein condensation problem. For the Bose-Einstein problem one can use the original idea of Lin, Strauss and Morawetz in order to collapse some internal variables. It turns out that this is a natural operation if we consider what happens as the number of particles tends to infinity. This work is in collaboration with a) J.Colliander, N. Tzirakis and b) D. Margetis.

Yan Guo (Brown)
Boltzmann equation in bounded domains.
In bounded domains, we establish well-posedness and exponential decay for solutions to the Boltzmann equation near Maxwellians, in the presence of in-flow, bounce back, specular, or diffuse refections boundary conditions. If the domain is strictly convex, then these solutions will remain continuous away from the grazing set at the boundary.

Tom Hou, (CalTech)
On the stabilizing effect of convection in 3D incompressible flows.
We investigate the stabilizing effect of convection in 3D incompressible Euler and Navier-Stokes equations. The convection term is the main source of nonlinearity for these equations. It is often considered destabilizing although it conserves energy due to the incompressibility condition. Here we reveal a surprising nonlinear stabilizing effect that the convection term plays in regularizing the solution. We demonstrate this by constructing a new 3D model which is derived from axisymmetric Navier-Stokes equations with swirl using a set of new variables. The only difference between our 3D model and the reformulated Navier-Stokes equations is that we neglect the convection term in the model. If we add the convection term back to the model, we will recover the full Navier-Stokes equations. This model preserves almost all the properties of the full 3D Euler or Navier-Stokes equations. In particular, the strong solution of the model satisfies an energy identity similar to that of the full 3D Navier-Stokes equations. We prove a non-blowup criterion of Beale-Kato-Majda type as well as a non-blowup criterion of Prodi-Serrin type for the model. Moreover, we we prove that for any suitable weak solution of the 3D

model in an open set in space-time, the one-dimensional Hausdorff measure of the associated singular set is zero. This partial regularity result is an analogue of the Caffarelli-Kohn-Nirenberg theory for the 3D Navier-Stokes equations.
Despite the striking similarity at the theoretical level between our model and the Navier-Stokes equations, the former has a completely different behavior from the full Navier-Stokes equations. We will present convincing numerical evidence which seems to support that the 3D model develop a potential finite time singularity. We will also analyze the mechanism that leads to these singular events in the new 3D model and how the convection term in the full Euler and Navier-Stokes equations destroys such a mechanism, thus preventing the singularity from forming in a finite time.

Izabella Laba, (British Columbia)
Arithmetic progressions in sets of fractional dimension
Let $E\subset {\bf R}$ be a closed set of Hausdorff dimension α. We prove that if α is sufficiently close to 1, and if E supports a probability measure obeying appropriate dimensionality and Fourier decay conditions, then E contains non-trivial 3-term arithmetic progressions. (Joint work with Malabika Pramanik.)

Peter Lax, (Courant)
Spectral Representation and Translation Representation.
For selfadjoint operators whose spectrum is the whole real line with constant multiplicity,spectral representation and translation representation are Fourier transforms of each other.For the automorphic wave equation the translation representation is given by integrals along one parameter families of horocycles. Consider automorphic functions with respect to discrete subgroups of isomorphisms of two-dimensional hyperbolic space.It is known that for generic subgroups the spectrum of the wave equation has only a finite point spectrum.This raises an intriguing question about the geometry of the horocycles.

Louis Nirenberg, (Courant)
Some remarks on nonlinear second order elliptic equations.
Some properties of such equations are presented,with some applications.

Kevin Payne, (Milano)
Weak well-posedness of the Dirichlet problem for equations of mixed elliptic-hyperbolic type
We present joint work with Daniela Lupo and Cathleen Morawetz on the question of existence and uniqueness of solutions to the Dirichlet problem for mixed type equations. While it is well known that the presence of hyperbolicity renders such a problem overdetermined for solutions with classical regularity, we show well-posedness for solutions belonging to suitably weighted Sobolev spaces. This follows from global energy estimates which are obtained by exploiting integral variants of Friedrichs' multiplier method. Attention is paid to the problem of obtaining results with minimal restrictions on the boundary geometry and the form of the type change function in preparation for the construction of stream functions in the hodograph plane for transonic flows about profiles.

Jalal Shatah, (Courant)
The Method of Space-time Resonances

Sylvia Serfaty, (Courant & Universite Pierre et Marie Curie)
From the Ginzburg-Landau energy to vortex lattice problems
In a joint work with Etienne Sandier, we study the behavior of vortices for minimizers of the 2D Ginzburg-Landau energy of superconductivity with an applied magnetic field, in a certain asymptotic regime where the vortices become point-like. In the regime of applied fields we are interested in, it is observed that vortices are densely packed and form triangular lattices names Abrikosov lattices.
We derive rigorously from the Ginzburg-Landau energy, via methods of Gamma convergence, first a leading order ``mean field model" describing the optimal density of vortices; second a next order limiting energy which governs the position of the vortices after blow-up at their inter-distance scale. This limiting energy is a logarithmic interaction between points in R^2. By using tools from number theory (modular form), it turns out that, among lattice configurations, this energy is uniquely minimized by the triangular (or hexagonal) lattice.

Gigliola Staffilani, (MIT)
Kato's smoothing effect for solutions to the Â capillary water-wave problem.
In a collaboration with Hans Cristianson and Vera Hur we proved that the solutions to the Cauchy problem for exact free-surface water waves in presence of surface tension, as t>0, gain 1/4 derivative smoothness compared to the initial profile, this is what we call the 1/4 Kato's smoothing effect. The major difficulty in proving this result is severe nonlinearity on free surface. To deal with a nonlinearity, first, we reformulate the problem as a nonlinear dispersive equation for a modified velocity on the free surface, whose linear part may be recognized as a hybrid of the wave equation and the Schroedinger or the Korteweg-de Vries equation. Our novel formulation exhibits strong dispersive property due to surface tension, and indeed, smoothing effects. Dispersion allows us to treat nonlinear terms with first or second spatial derivatives by means of techniques of oscillatory integrals. But this would not be enough.
Secondly, we view the most severe nonlinear term as a "linear component" of the equation, but with a variable coefficient which happens to depend on the solution itself. That is, we reduce the size of the nonlinear terms at the cost of making the linear part more complicated. A sophisticated microlocal analysis approach is to establish smoothing effects for this 'water-wave operator' with variable coefficient. We provide more refined analysis than classical energy estimates, which is the only estimate known so far in the analysis of the Cauchy problem for water waves. Our result requires less number of derivatives in the choice of Sobolev spaces, which is a major improvement of this project and proves some new Kato type smoothing effect for the solutions.

Walter Strauss (Brown University)
Two Problems: Nonlinear Wave Scattering and Plasma Stability
I will speak on two different problems, both of which are closely related to Cathleen's past work. Both are concerned with understanding the asymptotic behavior of waves in the absence of

dissipation. First I will consider the global scattering problem of nonlinear scalar waves in the defocusing case. After a survey of the older work on NLKG and NLS, I will present the very recent results of Benoit Pausader on fourth-order equations.
Next I will consider the Vlasov-Maxwell system that models collisionless plasmas. There are many equilibria and one wants to know which ones are stable and which ones unstable. I will describe the recent work of Zhiwu Lin and myself on this problem.

S.R.S Varadhan (Courant)
Large deviations for Random walks in a Random Environment
We will explore some open problems regarding large deviation behavior of random walks in a random environment. They have to do with the existence of positive harmonic functions. The random environment can be viewed as a limiting case of periodic environments and the question is how much of the theory in the periodic case extends to the stationary random case.

Horng-Tzer Yau, (Harvard)
Lower bounds on the blow-up rate of the axisymmetric Navier-Stokes equations
Consider axisymmetric strong solutions of the incompressible Navier-Stokes equations in $\R^3$ with non-trivial swirl. Let z denote the axis of symmetry and r measure the distance to the z-axis. Suppose the solution satisfies, for some $0 \le \e \le 1$, $|v (x,t)| \le C_* r^{-1+\varepsilon } |t|^{-\varepsilon /2}$ for $-T_0\le t < 0$ and $0<C_*<\infty$ allowed to be large. We prove that v is regular at time zero.

ADDENDUM B
Poster Presentation Abstracts

Ricardo Alonso (The University of Texas at Austin)
Inelastic Boltzmann Equation: Existence and uniqueness theorem for granular and dilute materials.
The Cauchy problem for the inelastic Boltzmann equation is studied for small data. Existence and uniqueness of mild and weak solutions is obtained for sufficiently small data that lies in the space of functions bounded by Maxwellians. The technique used to derive the result is the well known iteration process of Kaniel & Shinbrot.

Lorena Bociu *(*University of Nebraska-Lincoln)
Existence, Uniqueness and Blow-Up of Solutions to Wave Equations with Supercritical Boundary/Interior Sources and Damping
with coauthors: Irena Lasiecka
We consider finite energy solutions of a wave equation with supercritical nonlinear sources and nonlinear damping. A distinct feature of the model under consideration is the presence of the double interaction of source and damping, both in the interior of the domain and on the boundary. Moreover, we consider nonlinear sources on the boundary driven by Neumann boundary conditions. Since Lopatinski condition fails to hold (unless the dim(W) = 1), the analysis of the nonlinearities supported on the boundary, within the framework of weak

solutions, is a rather subtle issue and involves strong interaction between the source and the damping. We provide positive answers to the questions of local existence and uniqueness of weak solutions and moreover we give complete and sharp description of parameters corresponding to global existence and blow-up of solutions in finite time.

Bin Cheng (University of Michigan)
Multiscale dynamics of 2D rotational compressible Euler equations: an analytical approach.
Coauthors: Eitan Tadmor (University of Maryland)
We study the 2D rotational compressible Euler equations with two independent parameters: the Rossby number t for rotational forcing and the Froude/Mach number s for pressure forcing. The competition of these two forces leads to a newly found parameter d = ts-2 that serves as a characteristic scale separating two major dynamics regimes: d << 1 for the strong rotation regime ([1]) and d >> 1 ([2]) for the mid/weak rotation regime. Our results reveal, in an analytic level, the stabilizing effect of rotation and the dispersive effect of pressure when these singular forces interact with the inherent nonlinearity of Euler dynamics. The understanding of such interaction is essential to the analysis/simulation of rotating dynamics, primarily to geophysical flows. Our results are consistent with geophysical observations of e.g. Near Inertial Oscillation and nonlinear Rossby adjustment.

The analytical novelty relies on several approximation and associated error estimates. Differing from existing literature, our approach imposes algebraic constraint not on individual parameters t and s, but on their relative strength d. In the d << 1 regime, we utilize the method of iterative approximation, starting with the pressureless rotational Euler equations ([3]). The resulting approximation yields a periodic-in-time, fast rotating flow that reflects the domination of rotation in a nonlinear fashion. On the other hand, for d >> 1, we combine an invariant-based nonlinear wave analysis with Strichartz type estimates to reveal an approximate incompressible flow. This approach, free of Fourier analysis, has the potential to be extended to e.g. domains with nontrivial geometry.

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[3] H. Liu and E. Tadmor Rotation prevents finite-time breakdown. Phys. D 188 (2004), no. 3-4, 262-276.

Jennie D'Ambroise (University of Massachusetts Amherst)
A Linear Schrodinger Formulation of (d+1)-Dimensional Bianchi I Scalar Field Cosmology
by various authors such as J. Lidsey, T. Christodoulakis, T. Grammenos, C. Helias, P. Kevrekidis, G. Papadopoulos and F. Williams are known to have formulated equivalent versions of the 3+1-dimensional Einstein's field equations in terms of a so-called generalized Ermakov-Milne-Pinney (EMP) differential equation. This reformulation provides an alternate method for acquiring exact solutions to the field equations, and has been accomplished within the frameworks of FRLW and some Bianchi universe models. Further inspired by an EMP-

Schrödinger correspondence as noted by J. Lidsey, the author has recently published a linear Schrödinger version of the Bianchi I scalar field cosmology. This model has now been extended to an arbitrary number of dimensions, and will be presented here.

Anna Ghazaryan (UNC-Chapel Hill & University of Kansas-Lawrence)
Existence and stability of waves in combustion of high density liquid fuels
I will discuss the stability of traveling waves for a model that describes combustion of high density liquid fuels. The stability analysis is performed for a parameter regime when the spectral information is not definitive. It is shown that the wave is orbitally stable with respect to a carefully chosen exponentially weighted norm.

Cristi Darley Guevara (Arizona State University)
Scattering For the Focusing 2D Quintic Nonlinear Schrödinger Equation
Coauthors: Fernando Carreon (Arizona State University), Svetlana Roudenko(Arizona State University)

Recent developments for the energy critical nonlinear Schrödinger equation (NLS) in 3d, and nonlinear wave equation (NLW) by Carlos Kenig and Frank Merle have attracted attention from Harmonic Analysis and PDE audience. Their approach is based on concentration-compactness method which dates back to works of P.-L. Lions and the localized virial argument. It gives a sharp threshold for the scattering and finite time blow up of solutions at least in the case of radial data, and in many problems can be extended to nonradial data as well. These methods have been recently applied to the focusing cubic NLS in 3d by Holmer-Roudenko and Duyckaerts-Holmer-Roudenko as well as to the mass critical (both focusing and defocusing) NLS in 2 and higher dimensions by Killip-Tao-Visan, Killip-Visan-Zhang. Using the above techniques, we characterize the behavior of H1 solutions to the focusing quintic NLS in R2, namely,
i ?t u+\triangle u+|u|4u=0, (x, t) ? R2×R.

We obtain scattering for globally existing solutions (under an a priori mass-energy threshold) and mention how this extends to a general mass supercritical and energy subcritical NLS with H1 data.

Christian Klingenberg (Wurzburg University, Germany)
Computing turbulence flows using subgrid scale modeling
Coauthors: Wolfram Schmidt, Jens, Niemeyer
We have a new numerical method to compute turbulence flows arising in astrophysical applications. The idea is to combine subgrid scale modeling with adaptive mesh refinement. This has been implemented into the cosmological code called ENZO.

Petronela Radu (University of Nebraska-Lincoln)
Wave equations with variable coefficients and space dependent damping
by Coauthors: Grozdena Todorova (University of Tennessee, Knoxville) Boris Yordanov (University of Tennessee, Knoxville)
Damped wave equations with variable coefficients can be seen as models of either hyperbolic diffusion or wave propagation under the action of friction forces in a heterogeneous medium. We

establish decay rates for the energy and the L2 norm of the solution by employing a strengthened multiplier method. The central piece in the proof is an approximating profile constructed from a special subsolution of a related elliptic problem. Decay rates for higher energies are obtained by following an approach due to Nakao.

Erwin Suazo (Arizona State University)
Evolution operator for a one-dimensional Schrodinger equation with a time dependent Hamiltonian.
Coauthors: Sergei Suslov, Raquel Lopez, Ricardo Cordero-Soto.
We propose an explicit construction of the fundamental solutions to the one-dimensional Schrodinger equation with a particular linear time-dependent Hamiltonian such that the sum of the order of derivative and the degree of polynomial in the respective coefficient equals two. For some special choice of coefficients of the Hamiltonian this system can be integrated and therefore the fundamental solution has an explicit form. Applications to physics are outlined.

Elizabeth Thoren (University of Texas at Austin)
Linear instability criteria for Euler's equation: two classes of perturbations
One criteria for linear instability of a steady flow of an ideal incompressible fluid involves computing the essential spectral radius of the associated evolution operator for the linear perturbation about the steady equilibrium. This quantity is known to be equal to a Lyapunov type exponent associated with the equilibrium flow. In this work, the essential spectral radius of the linear evolution operator is investigated in the invariant subspace corresponding to the perturbations preserving the topology of the vortex lines and the associated factor space.

Vlad Vicol (University of Southern California)
The Radius of Analyticity of Solutions to the Three-Dimensional Euler Equations
Coauthors: Igor Kukavica (University of Southern California)
We address the problem of analyticity and Gevrey-regularity of smooth solutions u of the incompressible Euler equations. If the initial datum is real-analytic, the solution remains real-analytic as long as ?0t ??u(·, s)?L8 ds < 8 (cf. Bardos and Benachour). In the periodic case, using a Fourier method, we obtain a lower bound on the uniform radius of space analyticity which depends algebraically on exp?0t ??u(·, s)?L8ds. In particular, we positively answer a question posed by Levermore and Oliver.