

**PROGRAM IN APPLIED MATHEMATICS**

**UNIVERSITY OF COLORADO  
AT BOULDER**

**BOULDER, COLORADO 80309-0526**

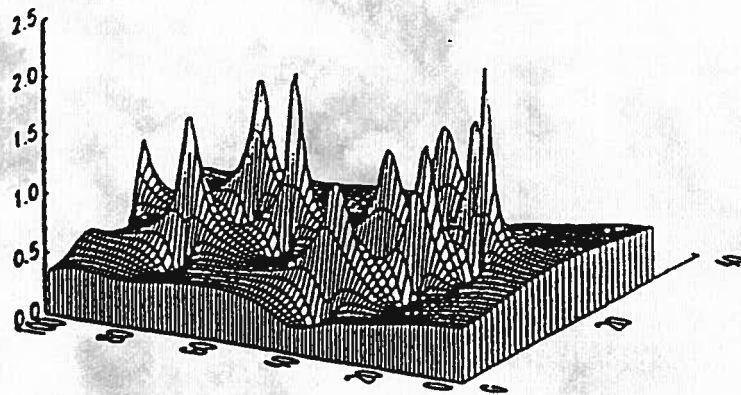
**ANNUAL REPORT**

**1993-94**

**Mark J. Ablowitz, Director**

**Robert Easton, Associate Director**

**July 1, 1994**





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## 1. OBJECTIVES

The objectives of the Program in Applied Mathematics at the University of Colorado at Boulder are summarized below:

- a) To provide undergraduate and graduate students with excellent courses and educational experiences in applied and computational mathematics. Students are engaged in tasks necessary for gaining background in order to meet demands of careers in business, industry, R & D laboratories and academic professions.
- b) To offer and develop a broad curriculum that serves the students of all departments and programs of the University.
- c) To monitor and maintain excellence in the B.S., M.S. and Ph.D. degrees in Applied Mathematics.
- d) To create and nourish an environment in which excitement, creativity and enjoyment of professional activities are of central importance to and valued by the Program.

## 2. ORGANIZATION AND COMMENTS

### A. Overview

In 1993-94, the Program in Applied Mathematics had a core of twelve faculty members plus two full-time instructors responsible for the teaching and advising of all undergraduate and graduate students taking applied mathematics courses. The program has a large teaching commitment since most undergraduate engineering majors are required to take four courses in applied mathematics. The Program taught a total of 2809 undergraduate and graduate students in 20 undergraduate courses (divided into 34 sections) and 12 graduate courses. In addition, the Program has 29 affiliated faculty members, each of whom can direct a graduate student towards a Ph.D. in Applied Mathematics. Providing high quality instruction is essential in order that our students learn the fundamental mathematical tools, methods and strategies that are frequently required in application.

The graduate student population continues to grow. The Program currently has 33 graduate students and we anticipate more than 40 students for 1994-95. In 1993-94 we had 20 teaching assistantships and currently nine graduate students are supported by research grants. The number of graduate students supported by research grants has increased substantially; this is due in part to the success of our faculty in obtaining research support and to the affiliated faculty program. It should be noted that, counter to national trends, we have been very successful in recruiting U.S. citizens to study in our graduate program. In 1994-95 over 80% of incoming students with support will be U.S. citizens from U.S. undergraduate universities. Currently we have three foreign graduate students and three more will be starting in the fall. Although we certainly encourage international applications, our success in being able to attract high quality American graduate students is remarkable.

This year the first two National Science Foundation graduate traineeships were awarded to Erik Bollt and Joseph Iwanski. This \$555,000 NSF grant provides full support for six predoctoral students over a five year period. The Program is very grateful for the efforts of Jim Meiss in having the foresight and investing so much effort in procuring this prestigious award, which was one of only three such awards by NSF in the mathematical sciences. In addition, there are seven students who are supported by DOD AASERT Awards: Robert Cramer and James Keiser (ONR; Prof. Beylkin), Ron Flickinger, Daryl McCallister and Tony Werckman (ONR, Profs. Segur and Curry), Scott Mock (AFOSR, Prof. Ablowitz) and David Trubatch (ONR, Prof. Ablowitz)

The research activities of the core faculty in the Program are varied. They include nonlinear dynamics, chaos theory, solitons and integrable nonlinear evolution equations, nonlinear optics, inverse problems, analysis of nonlinear equations arising in physical phenomena, computational mathematics including wavelet analysis, multigrid, iterative methods and computational fluid dynamics, matrix algebra, applied probability and statistics. Our affiliated faculty are rostered in a wide range of departments including Aerospace Engineering; Astrophysical, Planetary, and Atmospheric Sciences; Chemistry and Biochemistry; Civil Engineering; Computer Science; Electrical and Computer Engineering; Geological Sciences; Mathematics; Mechanical Engineering; and the Graduate School of Business.

#### **B. Core Faculty and Long Term Visitors**

Mark J. Ablowitz, Director, Professor; PhD, Massachusetts Institute of Technology. Partial Differential Equations, Solitons, Nonlinear Waves.

Jerrold Bebernes, Professor; PhD, University of Nebraska. Differential Equations, Reaction Diffusion Systems, Combustion Theory, Analysis.

Gregory Beylkin, Professor; PhD, New York University. Computational Methods, Wavelets, Geophysical Inverse Scattering.

Mary Brewster, Assistant Professor; PhD, California Institute of Technology. Singular Perturbation Methods, Computational Mathematics, Combustion Theory.

Sarbarish Chakravarty, Lecturer, Research Associate; PhD, University of Pittsburgh. General Relativity, Nonlinear Integrable Systems.

James H. Curry, Professor; PhD, University of California at Berkeley. Dynamical Systems, Numerical Methods, Nonlinear Equations. (Also Interim Director MASP, Minority A&S Program.)

Silvana DeLillo, Visiting Professor (from Universita di Perugia; INFN, Italy); PhD, University of Salerno, Italy. Nonlinear Field Theory (semiclassical quantization of soliton solutions) and Statistical Mechanics of Nonlinear Systems; Nonlinear Evolution Equations: Integrability and Forced Problems; Stochastic Forcing.

Robert Easton, Associate Director, Professor; PhD, University of Wisconsin. Dynamical Systems, Hamiltonian Mechanics.

Yoshi Kimura, Instructor; PhD, University of Tokyo. Theoretical and Computational Fluid Dynamics, Statistical Theory of Turbulence.



Kadir Kirkkopru, Research Associate; PhD, University of Colorado. Perturbation Methods, Computational Fluid Dynamics.

Congming Li, Assistant Professor; PhD, New York University. Nonlinear Differential Equations.

John Maybee, Professor Emeritus; PhD, University of Minnesota. Applied Combinatorics and Matrix Analysis.

Robert McLachlan, Instructor (until 11/1/93); PhD, California Institute of Technology. Computational Mathematics, Computational Fluid Dynamics.

Tom Manteuffel, Professor; PhD, University of Illinois, Urbana. Numerical Linear Algebra, Iterative Mathematics, Numerical Solution of PDE's.

Steve McCormick, Professor; PhD, University of Southern California. Computational Math, Numerical Partial Differential Equations, Multigrid Methods, Parallel Computation, Computational Fluids, Tomography, Electromagnetics

James D. Meiss, Professor; PhD, University of California at Berkeley. Dynamical Systems, Hamiltonian Mechanics, Plasma Physics.

Monika Nitsche, Instructor; PhD, University of Michigan. Computational Fluid Dynamics, Numerical Analysis.

J. Adam Norris, Part-time Instructor; PhD, University of Colorado, Boulder. Phase Change Kinetics, Perturbation Methods, Numerical Methods.

Constance Schober, Instructor, Research Associate; PhD, University of Arizona. Integrable Systems, Computational Methods.

Harvey Segur, Professor; PhD, University of California at Berkeley. Nonlinear Waves, Fluid Dynamics, Asymptotic Methods.

John Williamson, Professor; PhD, University of Minnesota. Statistical Methods in Genetics, Applied Probability, Mathematical Statistics.

### **C. Short Term Visitors:**

Chris I. Amos, University of Texas M.D. Anderson Cancer Center, Houston (January 1994)

Alberto Bressan, SISSA, Trieste, Italy (June 1994)

Wenxiong Chen, South West Missouri State University (June 1994)

Peter Clarkson, University of Exeter, UK (ended his eight month visit in August 1993)

Barend Herbst, University of the Orange Free State (January 1994)

Willy Hereman, Colorado School of Mines (Sabbatical May 1993-April 1994)

Andrei Illarionov, P.N. Lebedev Physics Institute, Moscow (Summer 1993)

Isaak M. Khalatnikov, L.D. Landau Institute of Theoretical Physics, Moscow (Summer 1993)

Martin D. Kruskal, Princeton and Rutgers Universities (July 1993)

Andrew Lacey, Heriott-Watt University, Edinburgh, Scotland (Sept 1993; May 1994)

Yi Li, Univ. of Rochester (July 1993)

Vladimir Makhankov, Joint Institute for Nuclear Research, Dubna, Russia; and Center for Nonlinear Studies, Los Alamos National Laboratory (August 1993)

Elizabeth Mansfield, University of Exeter, UK (ended her eight month visit in August 1993)

Andre Monin, Institute of Oceanology, Moscow (Summer 1993)

Lev Pitaevskii, P.L. Kapitza Institute for Physical Problems, Moscow (Summer 1993)

Bruno Torresani, CPT, CNRS-Lumny, Marseilles (July 1993)

Javier Villarroel, University of Salamanca, Spain (August-September 1993)

#### **D. Affiliated Faculty--Graduate Program in Applied Mathematics**

William Blumen (Astrophysical, Planetary, and Atmospheric Sciences and Physics),  
Geophysical Fluid Dynamics in Atmospheric Science

Elizabeth Bradley (Computer Science), Scientific Computation, Artificial Intelligence,  
Nonlinear Dynamics.

Richard Byrd (Computer Science), Numerical Computation, Optimization Algorithms

John Cary, (Astrophysical, Planetary, and Atmospheric Sciences and Physics), Nonlinear  
Dynamics, Plasma Physics, Accelerator and Space Physics

Senarath deAlwis (Physics), Theoretical Physics, String Theory, Quantum Gravity

Thomas DeGrand (Physics), Numerical Methods for Quantum Field Theory

Fred Glover (Graduate School of Business), Large-scale Systems, Applied Artificial  
Intelligence, Optimization Models

Martin Goldman (Astrophysical, Planetary, and Atmospheric Sciences and Physics), Plasma  
Physics, Nonlinear Waves, Turbulence

Vijay Gupta (Geological Sciences), Hydrology, Stochastic Processes, Fluid Dynamics

Tissa Illangasekare (Civil Engineering), Mathematical Modeling of Flow and Transport in  
Porous and Fractured Media, Computational Methods, Numerical Modeling

Elizabeth Jessup (Computer Science), Numerical Computation, Parallel Computation

David Kasso (Mechanical Engineering), Fluid Dynamics, Combustion Theory, Thermal  
Science

James Kelly (College of Business), Heuristic Search, Optimization, Artificial Intelligence

Manual Laguna (College of Business), Exact and Heuristic Methods for Combinatorial  
Optimization Problems, Network Flow Programming, Applied Artificial Intelligence

Michael Lightner (Electrical Engineering), VLSI, Discrete Mathematics, Graph Theory

Oliver McBryan (Computer Science), Parallel Computation, Graphics and Visualization,  
Computational Fluid Dynamics

John Rundle (Geological Sciences; Cooperative Institute for Research in Environmental  
Sciences), Statistical Mechanics Applied to Earth Sciences, Complex Systems,  
Simulations of Nonlinear Systems, Earthquakes, Transport Processes in the Geological  
Sciences

Robert Sani (Chemical Engineering), Computational Fluid Dynamics, Free and Moving  
Boundary Problems, Stability of Systems

Duane Sather (Mathematics), Partial Differential Equations, Fluid Mechanics

Robert Schnabel (Computer Science), Numerical Methods for Optimization, Nonlinear  
Equations, Parallel Scientific Computation

Richard Seebass (Aerospace Engineering), Aerodynamics, Gas Dynamics, Supersonic and  
Hypersonic Flows

**J. Michael Shull** (Astrophysical, Planetary, and Atmospheric Sciences), Theoretical Astrophysics

**Rex Skodje** (Chemistry and Biochemistry, Joint Institute for Laboratory Astrophysics), Nonlinear Dynamics, Quantum Chaos, Molecular Dynamics

**Gary Stormo** (Biology), Molecular Structures and Patterns, Computer Sequence Analysis, Splicing Algorithms

**Renjeng Su** (Electrical Engineering), Nonlinear Dynamics Modeling, Control, Robotics

**Juri Toomre** (Astrophysical, Planetary, and Atmospheric Sciences, Joint Institute for Laboratory Astrophysics), Astrophysics, Mathematical Modelling, Numerical Simulation

**Patrick Weidman** (Mechanical Engineering), Hydrodynamic stability, solitary waves and their interaction, counterrotating vortex rings, Stokes flow on dendrite models, similarity flows in natural convection, fluid sloshing in freely suspended containers

**Jeffrey B. Weiss** (Astrophysical, Planetary, and Atmospheric Sciences; Program in Atmospheric and Oceanic Sciences), Geophysical Fluid Mechanics, Turbulence, and Climate Predictability.

**Ellen Zweibel** (Astrophysical, Planetary, and Atmospheric Sciences), Plasma Physics, Astrophysics

#### **E. Staff**

Stu Naegele - Administrative Assistant

Janet Glasser - Student Coordinator

Margy Lanham - Word Processing Operator

#### **F. General Comments**

• The enrollment in the courses offered by the Program continues at extremely high levels. This is particularly noteworthy given the faculty's small size. The statistics over the past few years are as follows:

##### **Total enrollment**

<b><u>Year</u></b>	<b><u>Total number of students</u></b>
1990-91	2562
1991-92	2781
1992-93	2797
1993-94	2809

##### **Graduate students**

<b><u>Year</u></b>	<b><u>Total number of students</u></b>
1990-91	17
1991-92	27
1992-93	28
1993-94	33



• Faculty in the Program were recently honored with distinguished teaching awards. We are extremely pleased to note that Professor Harvey Segur has been awarded the Boulder Faculty Assembly (BFA) Teaching Award for 1993-94. All of us in the Program know of Professor Segur's high quality lecturing and deep concern for teaching. It is wonderful to have this recognized by the BFA. Congratulations Professor Segur! This is the second time a faculty member in the Program has been a recipient of the BFA teaching honor. In 1991-92 Professor Curry was the recipient of this honor; Professor Curry has also been recognized as a President's Teaching Scholar for 1993-95.

• This report provides data which shows that the faculty in the Program are extremely active in their research and scholarly work (a list of publications, invited lectures and Program Preprints are included at the end of this report). However, another very important aspect of the faculty's role in the national and international scholarly effort in applied mathematics is service as editors and advisory boards of archival journals. In fact, the faculty in the Program currently serve in sixteen such capacities on twelve journals. The journals include:

- Applied and Computational Harmonic Analysis* (Beylkin)
- Chaos* (Ablowitz)
- Inverse Problems* (Ablowitz, Beylkin)
- Journal of Engineering Mathematics* (Ablowitz)
- Journal of Numerical Linear Algebra and Applications* (Manteuffel)
- Physica D* (Meiss)
- Rocky Mountain Journal of Mathematics* (Bebernes)
- SIAM Journal on Applied Mathematics* (Ablowitz)
- SIAM Journal on Matrix Analysis* (Manteuffel, Maybee)
- SIAM Journal on Numerical Analysis* (Beylkin, Manteuffel)
- SIAM Journal on Scientific Computing* (Manteuffel, McCormick)
- Studies in Applied Mathematics* (Ablowitz)

• Faculty in the Program have been awarded over \$1 million dollars in external funding. This includes significant grant support for graduate students: a) the NSF traineeship grant which will support six students; b) the DOD AASERT program which now supports seven students; and c) one student who has been awarded her own fellowship support (next year there will be three students who have such external fellowships). We are also pleased to note that Professor Meiss was awarded a faculty fellowship for 1993-94 and Professor Ablowitz was awarded one for 1994-95. During 1994-95 Professor Robert Easton will serve as director of the Program.

• During the summers of 1993 and 1994 the Program hosted seven long term visitors from the former Soviet Union (FSU) and four short term visitors. The scope of the program is broad, involving theoretical and mathematical problems in physics and astrophysical sciences and related fields. This program is sponsored by the Sloan Foundation; the Program in Applied Mathematics; Dept. of Astrophysical, Planetary, and Atmospheric Sciences; Dept. of

Physics; Dean of Arts and Sciences, Dean of CU Graduate School; Vice President for Academic Affairs and Research; Vice Chancellor for Academic Affairs; and the National Center for Atmospheric Research. In 1994 our long term visitors are Victor A. Galaktionov, Isaac M. Khalatnikov, Vladimir N. Prigodin and Boris Stern. Short term visitors to the FSU summer program will also include Peter Clarkson, Martin Kruskal, Vladimir Makhankov, and Michael Spector.

- We expect to continue our tradition of having a short mini conference: "Rocky Mountain Experience" which will coincide with the end of the 1994 visiting FSU summer program on August 3 and 4. In 1993, Rocky Mountain Experience III had 15 presentations on August 17 and 18.

- We note that this year a group of sixteen graduate students, visitors and faculty from the Program travelled to the Los Alamos National Laboratory to take part in a two day workshop (alternating annually between Los Alamos and Boulder) entitled "Colorado Days". The purpose of this meeting is to give our graduate students, instructors and visitors an opportunity to meet other young scientists in related fields and, when feasible, to give lectures to gain valuable experience in speaking before scientific audiences. The consensus opinion is that this meeting is a very worthwhile experience for our young scientists. Thanks go to our local organizer, Monika Nitsche.

- The Program hosted an industrial mathematics workshop during the third week in May. The conference was organized by Mary Brewster with the purpose of bringing together industrial and academic mathematicians to solve real problems which confront industry. On the first day of the workshop five problems were presented by representatives of Storage Tek, Colorado Department of Transportation, Western Geophysical, Auto-trol, and NASA-White Sands. All of the problems were extensively discussed by approximately 30 faculty including representatives from most Colorado campuses and visitors from as far away as the United Kingdom together with graduate students. All industrial representatives expressed their satisfaction and even surprise at the progress made towards solving the problems in this one-week period. Next year the workshop will be held at Colorado State University in Fort Collins.

- We were pleased to have Dr. Yoshi Kimura as our new instructor for 1993-94. Dr. Kimura is an expert in computational fluid dynamics and mathematical theories of turbulence. Our students were enthusiastic and, in fact, laudatory about Dr. Kimura's teaching ability. Dr. Monika Nitsche finished her two years as an instructor. Next year Monika will be going to the Institute for Mathematics and its Applications at the University of Minnesota. It has been a pleasure having Monika as a colleague. In addition we are happy to note that Dr. Nitsche was recently awarded an NSF grant. This is significant given the difficulty of obtaining NSF support, particularly for young scientists. Next year we will have as our new instructors Dr.

Anne Dougherty from the University of Wisconsin and Dr. Mark Coffey who is currently a research scientist at NIST in Boulder. Anne's research specialty is applied probability and Mark's is physical applications of mathematics, especially the modelling of high temperature superconductors.

- The program's long term visitors for 1993-94 included Dr. Silvana DeLillo from Perugia, Italy. Dr. DeLillo is an expert in the study of exactly solvable nonlinear systems. Dr. DeLillo taught our senior level class in Methods in Applied Mathematics which was enthusiastically received by our students. This was the first time the Program has taught "Methods I" in the spring semester, but due to demand it is likely we will teach this course both fall and spring semesters in the future.

- The Program continued its tradition of supporting outstanding colloquia and seminar series. Distinguished speakers this year included Robert Burrige (Schlumberger-Doll Research), John F. Clarke (Cranfield Institute of Technology, UK), Stanley Osher (UCLA), Achi Brandt and Lee Segal (Weizmann Institute of Science, Israel), Moshe Israeli (Technion-Israel Institute of Technology), Pierre Lochak (Ecole Normale Supérieure, Paris), Norm Riley (University of East Anglia, UK) and O.S. Ryzhov (Russian Academy of Sciences and RPI). Thank you to our colloquium chair, Gregory Beylkin.

- Professors Steve McCormick and Tom Manteuffel, world renowned experts in computational mathematics, joined the Program this year. We are absolutely delighted to have them! Tom Manteuffel was awarded the Stanislaw Ulam fellowship at the Center for Nonlinear Studies at Los Alamos National Laboratory for 1993-94. Consequently, Tom was on leave for this academic year.

- We are saying goodbye to one of our faculty members, Mary Brewster, who has been an Assistant Professor in the Program since 1990-91. Mary is taking a position at the Battelle Pacific Northwest Laboratories in Richland, Washington. She has contributed significantly here and we are sad to see her leave. Mary helped begin our undergraduate SIAM chapter, advised our winning team in the math modelling competition in 1991-92 and so ably organized the industrial math workshop held this year in Boulder. We wish Mary the best of luck in her new position.

- A warm and sincere appreciation to our fine staff: Stu Naegele (Administrative Assistant), Janet Glasser (Student Coordinator), Margy Lanham (word processing operator), Helena Hill (part time secretary--Helena is a new addition to our staff; we welcome you aboard Helena!) and Linh Huynh (work study student) for the outstanding job they have done this year. Our staff members work very hard and certainly go the "extra mile" for the Program; without them we would be lost. The faculty of the Program THANK YOU VERY MUCH!

• We would like to congratulate our students who graduated this past year with a degree in Applied Mathematics. They are:

**Ph.D. degree:**

Arthur Mizzi	May 94
Linda Sundbye	May 94
Scott Herod	Aug 94

**Master's degree:**

John Fowler	May 94
James Keiser	May 94
Angela Liao	May 94
Jennifer McDiarmid	May 94
Kerrie Paige	May 94

**Bachelor's degree:**

Melissa Walden	Aug 93	Michelle Clifford	May 94
Erin Masson	Dec 93	Hilarie Dana	May 94
Seth Okeson	Dec 93	Phillip Driggers	May 94
Steve Soulé	Dec 93	Iliya Goikhman	May 94
Derek Bale	May 94	Kirk Groves	May 94
Robert Bryant	May 94	Laura Mather	May 94

**G. Applied Mathematics Colloquia and Seminars**

Our Applied Mathematics Colloquium series continued this year. The colloquia were held Friday afternoons during the academic year at 3:00 p.m., with coffee and tea preceding at 2:45 p.m. in the PAM conference room, ECOT 2-01. Additionally, the Program maintained the Applied Mathematics Seminar, a weekly seminar series on Thursday afternoons at 4:00 p.m. Each Thursday we used the Physics seminar room G-030 and had coffee and tea on the 11th floor of Duane Physics. We are grateful to the Physics Department for allowing us to use their facilities. A list of visiting speakers and the titles of their talks follows:

**Applied Math Colloquium Schedule: 1993-1994**

**L. Segal**, Weizmann Institute of Science, Israel and CNLS, Los Alamos National Laboratory, September 3, 1993

“Vaccination against auto-immune disease: a case study of modeling by ‘reverse engineering’”

**A.A. Lacey**, Heriot-Watt University, Edinburgh, September 10, 1993

“Blow-up with oscillatory boundary conditions”

**T. Russell**, University of Colorado, Denver, September 17, 1993

“Eulerian-Lagrangian Localized Adjoint Methods”

**N. Riley**, University of East Anglia, UK, September 24, 1993

“Acoustic Streaming”

**R. McLachlan**, Program in Applied Mathematics, University of Colorado, October 1, 1993

“Symplectic Integrators--Here to Stay”

**G.H. McClelland**, Psychology, University of Colorado, October 8, 1993

“Statistical Difficulties of Detecting Interactions and Moderator Effects in the Social Sciences”

- P. Phillipson, Dept. of Physics, University of Colorado, October 15, 1993  
 "Map Dynamics of Replication"
- A. Brandt, Weizmann Institute of Science, Israel, October 22, 1993  
 "Multilevel Computations in Physics, Chemistry and Engineering"
- R. Parashkevov, Center for Computational Mathematics, University of Colorado, Denver, October 29, 1993  
 "Efficient Solvers for Linear Systems Arising from Mixed Finite Element Discretizations of Elliptic PDE's"
- C.E. Patton, Dept. of Physics, Colorado State University, November 5, 1993  
 "High Frequency Magnetic Excitations: Resonance, Spin-wave Instability, and Solitons"
- P.D. Weidman, Dept. of Mechanical Engineering, University of Colorado, November 12, 1993  
 "High Amplitude Solitary Wave Reflection from a Vertical Wall: The Loss of Phase Shift"
- W.L. Kath, Engineering Sciences and Applied Mathematics, Northwestern University, November 19, 1993  
 "Phase-sensitive Amplification of Pulses in Nonlinear Optical Fibers"
- S. Herod, Program in Applied Mathematics, University of Colorado, December 3, 1994  
 "Computer Assisted Computation of Lie Point Symmetries"
- R.H. Byrd, Dept. of Computer Science, University of Colorado, January 28, 1994  
 "A Neglected Method for Unconstrained Optimization: The Symmetric Rank-One Update"
- B. Herbst, Applied Mathematics, University of the Orange Free State, Bloemfontein, RSA, February 4, 1994  
 "How to Solve or Not Solve the Sine-Gordon Equation Numerically"
- S.K. Turitsyn, Institute of Automation and Electrometry, Novosibirsk, Russia, February 11, 1994  
 "Exact Results in the Theory of Wave Collapse"
- R. Burridge, Schlumberger-Doll Research, Ridgefield, CT, February 18, 1994  
 "Wave Propagation Through Finely Layered or Rapidly Varying Media"
- M. Israeli, Computer Science, Technion-Israel Institute of Technology, February 25, 1994  
 "Mixed Analytical/Numerical Algorithms for Scientists and Engineers (Applied to Semi-Conductor Device Simulation)"
- J.F. Clarke, Cranfield Institute of Technology, UK, March 4, 1994  
 "Combustion, Mathematics and Mutual Aid"
- L. Rudin, Director of R&D, Cognitech, Inc., Santa Monica, CA, March 11, 1994  
 "PDE's, Crime and Videotapes (Applications of Nonlinear Numerical Analysis to Investigative and Trial Image/Video Processing)"
- R.J. LeVeque, University of Washington, March 18, 1994  
 "Cartesian Grid Methods for PDEs on Regions with Irregular Boundaries or Interfaces"
- M. Rabinovich, Institute for Nonlinear Science, U.C. San Diego and Institute of Applied Physics, Russia, April 1, 1994  
 "Spatio-temporal Wave Patterns: The Model and Analysis"
- O.S. Ryzhov, Rensselaer Polytechnic and Russian Academy of Sciences, April 8, 1994  
 "Boundary Layer Stability and Paths to Transition: Theoretical Concepts and Experimental Evidence"



S. Osher, UCLA, April 22, 1994  
"The Scope of the Level Set Method for Computing Interface Motion"

P. Lochak, Ecole Normale Supérieure, Paris, April 29, 1994  
"Hamiltonian Perturbation Theory: A New Approach"

### **Seminars In Applied Mathematics, 1993-1994**

M. Nitsche, Program in Applied Mathematics, University of Colorado, September 16, 1993  
"Singularity Formation in Vortex Sheets"

R. McLachlan, Program in Applied Mathematics, University of Colorado, September 23, 1993  
"Symplectic Integration of Hamiltonian ODE's and PDE's"

R. McLachlan, Program in Applied Mathematics, University of Colorado, September 30, 1993  
"Symplectic Integration of Hamiltonian ODE's and PDE's" (continued)

R. McLachlan, Program in Applied Mathematics, University of Colorado, October 7, 1993  
"Symplectic Integration of Hamiltonian ODE's and PDE's" (continued)

M. Chen, Dept. of Physics, Colorado State University, October 14, 1993  
"Microwave Envelope Solitons in Magnetic Films"

K. Kirkkopru, Program in Applied Mathematics, University of Colorado, October 21, 1993  
"Secondary Separation from a Slender Delta Wing"

D. McCallister, Program in Applied Mathematics, University of Colorado, October 28, 1993  
"Experimental Verification of the KP Equation as a Model for Shallow Water Waves"

Y. Kimura, Program in Applied Mathematics, University of Colorado, November 4, 1993  
"2D Vortex Collapse and Complex Time Singularity"

Y. Kimura, Program in Applied Mathematics, University of Colorado, November 11, 1993  
"Search for Complex Time Singularity in Navier-Stokes Turbulence"

L. Bradley, Computer Science, University of Colorado, November 18, 1993  
"Controlling Chaos"

S. de Alwis, Physics Department, University of Colorado, December 2, 1993  
"Quantum Black Holes and the Problem of Time"

R. Joseph, Electrical Engineering and Computer Science, Northwestern University, January 27, 1994  
"Maxwell's Equations Modeling of Nonlinear Optics"

S. De Lillo, Physics Dept., Universita di Perugia; INFN, Italy; Program in Applied Mathematics, University of Colorado, February 3, 1994  
"The Burgers Equation Under Multiplicative Noise"

S.K. Turitsyn, Institute of Automation and Electrometry, Novosibirsk, Russia February 10, 1994  
"Nonlinear Pulse Propagation in Optical Fibers Near the Zero Dispersion Point"

A. Abdullayev, National University, Sacramento, CA, February 17, 1994  
"Asymptotic Integration of Nonlinear Differential Equations and the Painlevé Transcendents"

A.P. Mizzi, Program in Applied Mathematics, University of Colorado; Climate and Global Dynamics Division, NCAR, February 24, 1994  
"Three-dimensional spectral models of the atmosphere on equatorial  $\beta$ - and  $f$ -planes  
Part I: Analysis, numerical problems and model derivation."

J.F. Clarke, Cranfield Institute of Technology, UK, March 3, 1994  
"Combustion and Compressible Flow--High-Speed Combustion Waves"

J.F. Clarke, Cranfield Institute of Technology, UK, March 10, 1994  
"Combustion and Compressible Flow--Longitudinal Waves in Reactive Gases"

J.F. Clarke, Cranfield Institute of Technology, UK, March 17, 1994  
"Combustion and Compressible Flow--Evolution of Detonation"

O.S. Ryzhov, Rensselaer Polytechnic and Russian Academy of Sciences, April 7, 1994  
"The Development of Nonlinear Solitary-Like Waves in Boundary Layers and Their Randomization"

C. Goedde, Dept. of Applied Mathematics, Northwestern University, April 14, 1994  
"Perturbed Solitons, Homoclinic Orbits and Energy Transport in a Nonlinear Oscillator Chain"

K. Wagner, S. Blair, B. Mcleod, Optoelectronic Computing Systems Center, Dept. Electrical and Computer Engineering, Univ. of Colorado, April 21  
"Optical Logic, Spatial Soliton Dragging, and Robust Light Bullets"

P. Duchateau, Dept. of Mathematics, Colorado State University, April 28, 1994  
"Inverse Problems for Partial Differential Equations: Solvability of a Class of Parabolic Inverse Problems"

**Joint Seminars--Program in Applied Mathematics and  
the Center for Computational Mathematics at the University of  
Colorado in Denver, 1993-94**

P. LeTallec, INRIA Rocquencourt; Université de Paris Dauphine, August 12, 1993  
"Domain Decomposition Methods for 3D Problems in Nonlinear Mechanics"

B-N Jiang, Institute for Computational Mechanics in Propulsion, NASA Lewis Research Center, Cleveland, September 14, 1993  
"Least-Squares Finite Method in Computational Fluid Dynamics"

R. Bates, NASA/Goddard Laboratory for Atmospheres, Greenbelt, MD, October 18, 1993  
"Atmospheric Modeling Using Semi-Lagrangian Numerical Techniques"

A. Rodriguez-Bernal, Applied Mathematics, Universidad Complutense de Madrid, December 13, 1993  
"Attractors and Inertial Manifolds for the Dynamics of a Closed Thermosyphon"

**Rocky Mountain Experience III, 1993**

Rocky Mountain Experience III, a mini-workshop, was held August 17-19, 1993 and featured talks by M.J. Ablowitz, S. Arendt, S. Chakravarty, M. Chen, P.A. Clarkson, S.P. de Alwis, D. Kassoy, R. Kerr, I.M. Khalatnikov, V. Makhankov, L.P. Pitaevskii, and J. Villarroel.

**In addition we had several special seminars during the year:**

J. Villarroel, University of Salamanca, Spain, gave two informal lectures on the Nonlinear Differential-Delay Toda Equation, September 7 & 8, 1993.

C. Liu, University of Colorado, Denver, Sept. 14, 1993,  
"Multilevel Methods for Combustion"

M.J. Ward, (joint with L. Reyna of IBM), Dept. of Mathematics, University of British Columbia, December 8, 1993  
"Dynamic Metastability, Exponentially Small Eigenvalues and Singular Perturbations"

A.P. Mizzi, Program in Applied Mathematics, Climate and Global Dynamics Division, NCAR, March 10, 1994

“Three-dimensional Spectral Models of the Atmosphere on Equatorial  $\beta$ - and  $f$ -planes  
Part II: Spectral Adiabatic Adjustment and Model Experiments”

A.M. Dougherty, University of Wisconsin, Madison, March 18, 1994

“A Heavy Traffic Limit Theorem for a Controlled Multi-Access Channel”

A. Long, Program in Applied Math, University of Arizona, April 1, 1994

“Geostatistical Interpolation--Overview and Recent Developments”

M.B. Isichenko, Fusion Research Center, The University of Texas, April 28, 1994

“Weiner Integrals, Turbulence, and Computation”

C.C. Chow, Dept. of Astrophysical, Planetary and Atmospheric Sciences, University of Colorado, May 3, 1994

“Integrability in Nonlinear Accelerator Lattices”

M.W. Coffey, Electromagnetic Technology Division, National Institute of Standards and Technology, Boulder, CO, May 6, 1994

“Type-II Superconductivity: An Introduction to Vortices”

E.A. Kuznetsov, L.D. Landau Institute for Theoretical Physics, Moscow, May 17, 1994

“Sharper Criteria for the Wave Collapse”

### **3. COMMITTEES**

#### **A. Undergraduate Committee--Robert Easton, Chair**

The Program in Applied Mathematics has 47 undergraduate majors. Sixteen of our majors were on the Dean's list last semester with grade point averages of 3.5 or better (yes, over 1/3 of our majors are Dean's List students!). There were twelve graduates this year. One of our graduating seniors, Laura Mather, was selected to receive a National Physical Science Consortium fellowship.

The recently instituted advising procedure is working well. Students in each entering class are assigned a faculty advisor who works with them until they graduate.

A new Minor in Applied Mathematics has been approved and is available to students in the College of Arts and Sciences as well as students in the College of Engineering. The minor will allow undergraduate students on the Boulder Campus to receive systematic training in applied mathematics and will appear as a minor on their transcripts. Presently there are eight students in this program.

Two new courses have been added to our offerings: “An Introduction to Nonlinear Systems: Chaos” (APPM 3010) and “An Introduction to Symbolic and Numerical Computation” (APPM 3050).

This year our undergraduate student chapter of SIAM (the Society for Industrial and Applied Mathematics) has really taken off. Over sixty people, students and faculty both, were involved in SIAM this year! Events included meetings, mentor lunches, and “Professor's Nights Out.” Four student officers will be going to the national meeting this July. We are

truly grateful to Mary Brewster who had the foresight and invested so much time in organizing and developing this important aspect of our undergraduate program.

#### **B. Graduate Committee--Harvey Segur, Chair**

The Program Graduate Committee consists of Harvey Segur (chair), Steve McCormick and Congming Li. The main business of the committee is administering the preliminary exams, advising the current graduate students, and processing graduate applications. Currently the Program has 33 graduate students, of whom thirteen began last fall. Two students received their PhDs this spring and five received their MS degrees.

There were 63 applicants for the fall semester of 1994, of whom we chose nine for new TA positions. In addition, four of the incoming students will have fully-funded fellowships during their graduate study (one National Physical Science Consortium Fellowship, one NSF Graduate Fellowship, and two NSF Graduate Traineeships). When added to the two NSF Graduate Traineeships currently held by our graduate students, these new fellowships demonstrate an increasingly high quality of graduate students in the Program.

In addition to the preliminary exams in Applied Analysis, Computational Analysis and Partial Differential Equations, we are now offering an exam in Probability and Statistics. These exams are administered before classes begin in the Fall and Spring.

During the spring semester, several graduate students organized a series of seminars designed to allow Applied Mathematics and affiliated faculty to introduce their research interests to the Applied Math graduate students. Four sessions were held, with three to five speakers on each occasion. Participating speakers came from Astrophysics, Biology, Business, Chemistry, Civil Engineering, and Computer Science. The format was deliberately designed to allow students a glimpse of the diverse interests available to them within Applied Mathematics. The response from those who attended was very positive.

#### **C. Instructor Search Committees**

During this academic year we received over 200 applications in response to our advertisement for instructor positions. We have hired Dr. Anne Dougherty from the University of Wisconsin to be the Program's new long term instructor. Anne's field of expertise is applied probability. We have also hired Dr. Mark Coffey, an expert in mathematical modelling from the National Bureau of Standards as a one year instructor. We welcome both Anne and Mark.

#### **D. Faculty Service to the University, Program and Societies, Calendar 1993**

Mark Ablowitz: Program Director; member of Council of Chairs in the College of Arts and Sciences

Jerrold Bebernes: member of Program Graduate Committee; member of Advisory Committee to University Mathematics Program

Gregory Beylkin: member of Program Graduate Committee; member of the Program Faculty Recruiting Committee

Mary Brewster: member of Program Undergraduate Committee; member of Engineering Safety Committee; member of Honors Committee; faculty member of Center for Combustion Research; Faculty Advisor for undergraduate SIAM University Chapter

James Curry: Program Associate Director (through 7/93); Chair of Program Teaching Committee; member of Program Undergraduate Committee; Acting Director, Minority Arts and Sciences Program; member of Chancellor's Search Committee

Robert Easton: Program Associate Director (from 7/93); Chair, Program Undergraduate Committee; member of Program Instructor Search Committee; Chair, Educational Policy and Planning Committee (Engineering); member of Administrative Council (Engineering)

Congming Li: member of Program Undergraduate Committee

Steve McCormick: member of Program Graduate Committee; member of Program Faculty Search Committee; member of Program Computer Committee

James Meiss: Chair, Program Graduate Committee; member of University Scholarship Committee; Chair, Goldwater Scholarship Committee

Harvey Segur: Chair of Program Graduate Committee; member of Program Faculty Search Committee; member of Faculty Advisory Committee for Minority Engineering Program; member of Boulder Faculty Assembly; member of Applied Mathematics Committee for University of Colorado

John Williamson: member of Program Undergraduate Committee; member of Program Teaching Committee; member of College of Engineering Scholarship Committee; member of Engineering Academic Affairs Committee

#### **4. TEACHING ACTIVITIES**

##### **A. Courses Taught by Program Faculty During Academic Year 1993-94**

###### **(i) UNDERGRADUATE COURSES**

APPM 1340 *Easton*, Intensive Calculus.

APPM 1350 *Curry, Brewster, Chakravarty, Sundbye, Nitsche*, Calculus 1 for Engineers.

APPM 1360 *Ablowitz, Curry, Herod, Chakravarty*, Calculus 2 for Engineers.

APPM 2350 *Segur, McCormick, Schober, Chakravarty, Nitsche*, Calculus 3 for Engineers.

APPM 2360 *Kimura, Nitsche, Bebernes, Norris*, Linear Algebra and Differential Equations.

APPM 3050 *Curry, Herod*, Introduction to Symbolic and Numerical Computation.

APPM 3310 *Li*, Matrix Methods and Applications.

APPM 3570 *Williamson*, Applied Probability.

APPM 4350 *Brewster, DeLillo*, Boundary Value Problems, Methods in Applied Mathematics.

APPM 4360 *Schober*, Complex Variables, Methods in Applied Mathematics.

APPM 4520 *Williamson*, Introduction to Mathematical Statistics.

APPM 4560 *Williamson*, Introduction to Probability Models.



APPM 4570 *Williamson*, Statistical Methods.

APPM 4650 *McCormick*, Intermediate Numerical Analysis 1.

APPM 4660 *Beylkin*, Intermediate Numerical Analysis 2.

(ii) GRADUATE COURSES

APPM 5350 *Brewster, DeLillo*, Boundary Value Problems, Methods in Applied Mathematics

APPM 5360 *Schober*, Complex Variables, Methods in Applied Mathematics.

APPM 5440 *Li*, Applied Analysis 1.

APPM 5450 *Li*, Applied Analysis 2.

APPM 5470 (MATH 5470) *Bebernes*, Partial Differential Equations, Methods in Applied Mathematics.

APPM 5480 *Brewster*, Perturbation and Asymptotic Analysis, Methods in Applied Mathematics

APPM 5520 *Williamson*, Introduction to Mathematical Statistics.

APPM 5560 *Williamson*, Introduction to Probability Models.

APPM 5570 *Williamson*, Statistical Methods.

APPM 5600 (MATH 5600) *Beylkin*, Numerical Analysis 1.

APPM 5610 (MATH 5610) *Beylkin*, Numerical Analysis 2.

APPM 7100 *Easton*, Mathematical Methods in Dynamical Systems.

APPM 7300 *Segur*, Mathematical Methods in Nonlinear Waves and Integrable Equations.

APPM 7400 *Nitsche*, Topics in Applied Mathematics--Computational Fluid Dynamics.

APPM 7400 *Segur*, Topics in Applied Mathematics--Nonlinear Waves.

APPM 8000 Seminar in Applied Mathematics

**B. Summer Courses, 1994**

APPM 1350 *M. Albert*, Calculus 1 for Engineers.

APPM 1360 *R. Cramer*, Calculus 2 for Engineers.

APPM 2350 *Chakravarty*, Calculus 3 for Engineers.

APPM 2360 *Kimura*, Introduction to Linear Algebra and Differential Equations.

APPM 4650 *Norris*, Intermediate Numerical Analysis 1.

APPM 8000 Seminar in Applied Mathematics.

**5. RESEARCH ACTIVITIES FOR CALENDAR YEAR 1993**

**A. Research Publications for Calendar Year 1993**

**Mark Ablowitz:**

"Numerical Chaos, Symplectic Integrators and Exponentially Small Splitting Distances", B.M. Herbst and M.J. Ablowitz, *J. Comp. Phys.*, **105** (1993) 122-132.

"On the Inverse Scattering Transform of the 2+1 Toda Equation", J. Villarroel and M.J. Ablowitz, *Physica D*, **65** (1993) 48-70.

"Numerical Chaos, Roundoff Errors and Homoclinic Manifolds", M.J. Ablowitz, C. Schober and B.M. Herbst, *Phys. Rev. Lett. A*, **71** (1993) 2683-2686.

"Solitons and Computation", M.J. Ablowitz and B.M. Herbst, in *Important Developments in Soliton Theory*, Eds. A. Fokas, V. Zakharov, Series in Nonlinear Dynamics, Springer-Verlag, Berlin (1993).

"On the Method of Solution of the Differential-Delay Toda Equation", J. Villarroel and M.J. Ablowitz, *Phys. Lett. A*, **180** (1993) 413-418.

#### **Gregory Beylkin:**

"Wavelet-Like Bases for the Fast Solution of Second-Kind Integral Equations", B. Alpert, G. Beylkin, R.R. Coifman and V. Rokhlin, *SIAM Journal on Scientific and Statistical Computing*, **14** (1) (1993), 159-184.

"On the Fast Algorithm for Multiplication of Functions in the Wavelet Bases", G. Beylkin, in *Progress in Wavelet Analysis and Applications*, Proceedings of the International Conference on Wavelets and Applications, eds. Y. Meyer and S. Roques, Editions Frontieres, 1993.

"On Wavelet-Based Algorithms for Solving Differential Equations", G. Beylkin in *Wavelets: Mathematics and Applications*, ed. J.J. Benedetto and M.W. Frazier, CRC Press, 1993.

#### **Mary Brewster**

"Thin Plates and Compressive Membrane Solutions II: A Nonexistence Result", M.E. Brewster, *SIAM J. Math. Anal.* **24** (1993) 634-647.

"Dean Vortices with Wall Flux in a Curved Channel Membrane System: 1. A New Approach to Membrane Module Design", M.E. Brewster, K.Y. Chung and G. Belfort, *J. Memb. Sci.* **81** (1993) 127-137.

"Curved Channel Membrane Filtration", G. Belfort, M.E. Brewster, and K.Y. Chung, US Patent #5204002, granted April 20, 1993.

#### **Sarbarish Chakravarty:**

"SDYM Hierarchies and Classical Soliton Systems", S. Chakravarty, *Proceedings of NATO Advanced Research Workshop*, Exeter, ed. P.A. Clarkson (Kluwer, 1993).

"A Self-Dual Yang-Mills Hierarchy and Its Reductions to Integrable Systems in 1+1 and 2+1 Dimensions", Mark J. Ablowitz, S. Chakravarty, and Leon A. Takhtajan, *Commun. Math. Phys.*, **158** (1993).

#### **Peter Clarkson:**

"Numerical Studies of the Fourth Painlevé Equation", A.P. Bassom, P.A. Clarkson and A.C. Hicks, *IMA Journal of Applied Mathematics*, **50** (1993) 167-193.

"Applications of Analytic and Geometric Methods to Nonlinear Differential Equations", Edited by P.A. Clarkson, proceedings, Exeter, England, 1993 *NATO Advanced Study Institute Series C: Mathematical and Physical Sciences*, Kluwer, Dordrecht (1993). (See also articles by P.A. Clarkson and associates therein).

"Symmetry Reductions of a Cylindrical Nonlinear Schrödinger equation", P.A. Clarkson and S. Hood, *Journal of Physics A: Mathematical and General*, **26** (1993) 133-150.

#### **Robert Easton:**

"Exit Times and Transport for Symplectic Twist Maps", (with J. Meiss and S. Carver), *Chaos*, **3** (2), (1993) 153-165.

"Transport of Phase Space Volume Near Isolated Invariant Sets", *Journal of Dynamics and Differential Equations*, 5, 3 (1993) 529-536.

**Yoshi Kimura:**

"Search for complex time singularities in Navier-Stokes turbulence", Y. Kimura and R.B. Pelz, in *Unstable and Turbulent Motion in Fluid* (ed. S. Kida), World Scientific, Singapore, (1993) 91-101.

"Statistics of an advected passive scalar", Y. Kimura & R.H. Kraichnan, *Phys. Fluids A* 5 (1993) 2264-2277.

"Probability distribution of passive scalar with nonlinear mean gradient", Y. Kimura, in *Theory of Solar and Planetary Dynamos* (eds. M.R.E. Proctor, P.C. Matthews and A.M. Rucklidge), Cambridge University Press, Cambridge, (1993) 189-193.

**Congming Li:**

"Nonautonomous Nonlinear Scalar Field Equations in R-2", *J. Differential Equations*, 103 (1993) 421-430.

"A Priori Estimates for Solutions to Semilinear Elliptic Equations in R-2", *Arch. Rational Mech. Anal.*, 122 (1993) 145-157.

"Qualitative Properties of solutions to some Nonlinear Elliptic Equations in R-2", *Duke J. Math.*, 71 (2), (1993) 427-439.

"Prescribing Gaussian Curvature on Singular Surfaces", *J. Geom. Anal.*, 3 (4), (1993) 315-334.

**Tom Manteuffel:**

"Optimal Equivalent Preconditionings", (with J.S. Otto), *SIAM J. of Numer. Anal.*, 30, 3 (1993) 790-812.

**Steve McCormick:**

"Multilevel Adaptive Methods for Laminar Diffusion Flames", (with C. Liu and Z. Liu) *SIAM J. Sci. Comp.*, 8 (1993).

**Robert McLachlan:**

"Explicit Lie-Poisson integration and the Euler equations", *Phys. Rev. Lett.*, 71 (1993) 3043-3046.

"Explicit symplectic splitting methods applied to PDE's", *Proc. AMS-SIAM Conf. Exploiting Symmetry in Applied Mathematics, Lects. Appl. Math.*, 29, AMS 1993, 325-337.

"Integrable four-dimensional symplectic maps of standard type", *Phys. Lett. A* 173 (3), (1993) 211-214

"Asymptotic methods for the prediction of transonic wind-tunnel wall interference", (with N. D. Malmuth, H. Jafroudi, C. C. Wu, and J. D. Cole) *AIAA J.*, 31 (5), (1993) 911-918.

"A note on the charged isosceles three-body problem", (with P. Atela), *Proc. Int. Conf. Diff. Eqs. EQUADIFF 91*, (C. Perello, C. Simo, and J. Sola-Morales, eds., World Scientific, Singapore, 1993) pp. 292-297.

**James Meiss:**

"Exit Times and Transport for Symplectic Twist Maps", R.E. Easton, J.D. Meiss, and S. Carver, *Chaos* 3 (1993) 153-165.

"Break-up of Invariant Tori for the Four Dimensional Semi-Standard Map", E. Boltt and J.D. Meiss, *Physica D* 66 (1993) 282-297.

"Periodic Orbits and Resonances for the Many Dimensional Sawtooth Mapping", *Chaos in Australia, Conference Proceedings*, World Scientific Press, (1993) 95-113.

**Monika Nitsche:**

"Numerical Simulation of Axisymmetric Vortex Sheet Roll-Up", in *Vortex Flows and Related Numerical Methods*, (J.T. Beale et al. eds), Kluwer Academic Publishers, (1993), pp 293-301.

**Constance Schober:**

"Numerical Chaos, Roundoff Errors and Homoclinic Manifolds", M.J. Ablowitz, C. Schober and B.M. Herbst, *Phys. Rev. Lett. A*, 71 (1993) 2683-2686.

**Harvey Segur:**

"Analysis of a Hamiltonian Amplitude Equation", (with C.C. Chow and S.J. Fromm), *J. Phys. Soc. Japan* 62 (1993) 1927-1931.

**John Williamson:**

"Robustness of the Maximum Likelihood (LOD) Method for Detecting Linkage", C.I. Amos and J.W. Williamson, *American Journal of Human Genetics* 52 (1993) 213-214.

"Path Analysis and Sib-Pair Linkage", G. Carey and J.W. Williamson, *Genetic Epidemiology* 10 (1993) 103-112.

## **B. Invited Lectures and Meetings Attended for Calendar Year 1993**

**Mark Ablowitz:**

Challenge of Teaching Science and Mathematics, Graduate Teacher Program, University of Colorado at Boulder, "Coherence and Chaos", January 11, 1993.

Colorado School of Mines, Golden, Colorado, Sigma Xi lecture, "Solitons and Coherent Structures", March 30, 1993.

International Conference on Inverse Scattering, Bad Honnef, Germany, "Inverse Scattering and Nonlinear Wave Equations, 1+1, 2+1 and Higher Dimensions", May 17-20, 1993.

NATO Lectures, Bilkent University, Department of Mathematics and Faculty of Science, Ankara, Turkey, "Coherence and Chaos---Illustrative Case Studies"; "Reductions of Self Dual Yang Mills and New Special Functions in Integrable Systems", May 20-25, 1993.

Conference: Nonlinear Evolution Equation, Solitons and the Inverse Scattering Transform, Oberwolfach, Germany, "Numerical Chaos Roundoff Errors and Homoclinic Manifolds", July 11-17, 1993.

FSU-USA Conference on Chaos, NAS Center, Woods Hole, Mass., "Roundoff Errors and Homoclinic Manifolds", July 19-23, 1993.

Nonlinear Optics Workshop and Colloquium, Department of Mathematics, University of Arizona, "Roundoff Errors and Homoclinic Manifolds", Sept. 9-11, 1993.

Workshop on Nonlinear Astronomy--Higher Dimensional Dynamical Systems, University of Florida, Gainesville, "Chaos, Roundoff Errors and Homoclinic Manifolds", Oct. 1993.

**Jerrold Bebernes:**

International Meeting on Differential Equations and Their Applications, Univ. Firenze, Firenze, Italy, "Beyond Blowup", Sept. 20-24, 1993.

Special Session on Reaction-Diffusion, AMS Regional Meeting, Texas A&M, "More on Blowup", Oct. 22-24, 1993.

**Gregory Beylkin:**

AMS Short Course, "Wavelets and Fast Numerical Algorithms", Jan 11-12, 1993

NASA ICASE Short Course Lecturer, February 1993.

ONR Workshop on Methods of Shock Capturing and Image Processing, "Adaptive Algorithms for Numerical Solution of PDE's", April 30-May 1, 1993.

Physics Computing 93 Conference, "Wavelet Transforms and Fast Multiresolution Algorithms", June 3, 1993.

3rd AMS-SIAM Summer Seminar on the Mathematics of Tomography, Impedance Imaging, and Integral Geometry, Mt. Holyoke College, South Hardley, MA, "Mathematical Framework for Linearized Inverse Scattering Problems in Acoustics and Elasticity", June 1993.

SPIE's Annual Meeting, San Diego, "Techniques for Detecting Densely Wavelength-Multiplexed Solitons", July 15-16, 1993.

Martin Marietta workshop, on Advanced Topics in Wavelets and Adapted Waveform Analysis, "An Approach to Compression and Fast Processing of SAR Data", October 1993.

Automatic Target Recognition 93 Conference, MIT Lincoln Labs, Lexington, MA, "On Factored FIR Approximation of IIR Filters and Implementation of Operators Via Filter Banks", Nov. 1 - Nov. 4, 1993.

Tel-Aviv University, Israel, "A Simple Algorithm for Solving Two-Point Boundary Value Problem for Differential Operators", December 1993.

**Mary Brewster:**

University of Nebraska, Lincoln, "Wavelets-on-the-Interval and Applications", February 1993.

University of Colorado Center for Combustion Research, seminar on "Corrosion/Combustion of Alloys", April 1993.

Colorado State University, "Maintaining Dean Vortex Flow in a Spiral Porous Channel: A New Approach to Membrane Module Design", 1993.

**Sarbarish Chakravarty:**

St. Louis University--Parks College, Cahokia, Illinois, Mathematics Dept. seminar, "On Some Reductions of Self Dual Yang-Mills Equations and Nonlinear Integrable Systems", July 13, 1993.

Rocky Mountain Experience III, University of Colorado, Boulder, "A Class of Integrable Conformally Self-Dual Metrics", August 1993.

University of Exeter, England, Mathematics Department, "Integrable Systems--Their Classifications and Some Applications", October 26, 1993.

**Peter Clarkson:**

Los Alamos Days at Colorado, University of Colorado, Boulder, March 1993.

Conference: Nonlinear Evolution Equation, Solitons and the Inverse Scattering Transform, Oberwolfach, Germany, "Nonclassical Symmetry Reductions and Exact Solutions for Nonlinear Partial Differential Equations", July 1993.

Rocky Mountain Experience III, University of Colorado, Boulder, "The Fourth Painlevé Equation: A Nonlinear Harmonic Oscillator", August 1993.

Program in Applied Mathematics, University of Colorado, Boulder, "Symmetry Analysis for Partial Differential Equations", 10 lectures Feb.-May 1993.



Dept. of Mathematics, University of Maryland, College Park, "Symmetry Reductions of the Self-Dual Yang-Mills Equations", April 1993.

Dept. of Mathematics, SUNY Buffalo, "Nonclassical Symmetry Reductions of Nonlinear Partial Differential Equations", April 1993.

Program in Applied Mathematics, University of Colorado, "Symmetry Analysis for Partial Differential Equations: A Personal Perspective", May 1993.

Dept. of Mathematics, University of British Columbia, Vancouver, Canada, "Symmetry Analysis for Nonlinear Partial Differential Equations", June 1993.

**Yoshi Kimura:**

1993 Annual Meeting of the APS Division of Fluid Dynamics, Albuquerque, NM, "Relative Dispersion of Lagrangian Particles in Stably Stratified Turbulence" (with J.R. Herring), November 1993

Center for Combustion Research, Mechanical Engineering Dept, Univ. of Colorado, Boulder, "Probability Distribution of Passive Scalar with nonlinear mean gradient", December 1993.

The IMACS Workshop on "Computational and Theoretical aspects of turbulence" Rutgers University, Piscataway NJ., "Turbulence simulation in complex time", February 1994

**Kadir Kirkkopru:**

Division of Fluid Dynamics Meeting, American Physical Society, Albuquerque, NM; "Nonlinear Vorticity Generation by Acoustic Wave Interaction with an Injected Gas in a Tube: Formulation and Analysis", "Nonlinear Vorticity Generation by Acoustic Wave Interaction with an Injected Gas in a Tube: Computational Results"; with D.R. Kassoy and Q. Zhao, November 1993.

University of Colorado, Center for Combustion Research, seminar on "Unsteady Vorticity Generation in a Model of a Solid Rocket Engine Chamber", November 30, 1993.

Program in Applied Mathematics, University of Colorado, "Secondary Separation from a Slender Delta Wing", October 21, 1993.

**Congming Li:**

Joint Summer Research Conferences in the Mathematical Sciences, "What Kinds of Singular Surfaces Can Admit Constant Curvature?", July 10 - July 16, 1993.

Joint summer Research Conferences in the Mathematical Sciences, "A Note on the Kazdan-Warner Type Conditions", July 10-July 16, 1993.

**Elizabeth Mansfield:**

Los Alamos Day at Colorado, Program in Applied Mathematics, University of Colorado, "Algorithmic Aids for Analyzing Overdetermined Systems of PDE", March 1993.

Dept. of Mathematics, SUNY Buffalo, "Algorithmic Aids in the Analysis of Systems of PDE (with applications to nonclassical symmetries)", April 1993.

Dept. of Mathematics, University of British Columbia, Vancouver, Canada, "Algorithmic Aids in the Analysis of Systems of PDE (with applications to nonclassical symmetries)", June 1993.

**Tom Manteuffel:**

Copper Mountain Conference on Multigrid Methods, Copper Mountain, CO, April 4-9, 1993.

PAN AM Workshop on Applied and Computational Mathematics, Caracas, Venezuela, Jan. 10-15, 1993.

Computational Science Workshop, Los Alamos National Laboratories, Los Alamos, NM, Feb. 22-26, 1993.

**John Maybee:**

Lecture at Technion, Haifa, Israel, "Nearly Sign-Nonsingular Matrices", June 1993.

**Steve McCormick:**

First Pan American Conference on Computational Math, Caracas, Venezuela, January 2-16, 1993.

SIAM Conference on Fluids, Houston, March 18-20, 1993.

Computational Techniques and Applications Conference, Canberra, Australia, July 5-12, 1993.

Numerical Problems in Fluids, MHD, and Plasmas, Canberra, Australia, July 8-9.

Second International Conference on Maxwell's Equations, Washington, DC, Oct. 25-29, 1993.

Sixth Copper Mountain Conference on Multigrid Methods, Copper Mountain, CO, March 4-9, 1993.

AFOSR Contractors Meeting, St. Louis, July 27-30, 1993.

**James Meiss:**

Applied Math Dept. Colloquium, Colorado State University, "Chaotic Transport in Symplectic Maps", March 11, 1993.

Plasma Physics Seminar, "Chaotic Transport in Symplectic Maps", March 12, 1993.

Applied Mathematics Colloquium, DAMTP Cambridge University, "A Computational Study of Long Term Dynamics", Oct. 2, 1993.

Dynamics Seminar, University of Warwick, Mathematics Department, "Transient Measures for Area Preserving Maps", Oct 11, 1993.

Mathematics Seminar, Queen Mary and Westfield College, London, "Transient Measures for Area Preserving Maps", Nov. 9, 1993.

Nonlinear Dynamics Seminar, University College, London, "Phenomenology of Twist Maps", Oct 27, 1993.

Mediterranean Institute of Technology, Univ. of Marseille, France, "Transient Measures for Area Preserving Maps", Dec. 6, 1993.

**Monika Nitsche:**

Los Alamos Days at Colorado, Program in Applied Mathematics, University of Colorado, "Computation of Vortex Ring Formation", March 26, 1993.

SIAM 1993 Annual Meeting, Philadelphia, PA, "Vortex Ring Formation at the Edge of a Circular Tube", July 15, 1993.

Program in Applied Mathematics, University of Colorado "Singularity Formation in Vortex Sheets", Sept. 16, 1993.

**Constance Schober:**

2nd IMACS Conference on Computational Physics, Parks College of Saint Louis University, St. Louis, MO "Hamiltonian Integrators for the Nonlinear Schroedinger Equation", October 6-9, 1993.

**Chaotic Numerics, An international Workshop on the Approximation and Computation of Complicated Dynamical Behaviour, Deakin University, Geelong, Australia, "Effective Chaos in the NLS equation", July 12-16, 1993,**

**Discretization and Geometric Visualization, University of Kansas, Lawrence, KS, "The Phenomenology of Chaos in the NLS Equation", Sept. 24-26, 1993.**

**Los Alamos Days at Colorado, University of Colorado, Boulder, Roundoff Errors, Numerical Chaos and Homoclinic Manifolds, March 1993**

**Harvey Segur:**

**Technische Universität, Berlin, Germany "Periodic Waves in Shallow Water", July 8, 1993.**

**Conference on Nonlinear Evolution Equations, Oberwolfach, Germany, "Periodic Waves in Shallow Water", July 13, 1993.**

**John Williamson:**

**National Cancer Institute, Bethesda, Maryland, "Path Analysis and Sib-Pair Linkage", May 25, 1993**

**Institute of Biochemical and Evolutionary Genetics, University of Pavia, Pavia, Italy, "Path Analysis and Sib-Pair Linkage", June 22, 1993.**

**International Association for Statistical Education Meeting, Perugia, Italy, August 1993.**

### **C. Research Grants for Calendar Year 1993\***

**Mark Ablowitz:**

**NSF, Mathematics Division: 1991-97**

**AFOSR, Mathematics: 1991-96**

**ONR, Mathematics: 1992-97**

**Air Force AASERT: 1993-96**

**Sloan Foundation: 1993-94**

**Jerrold Bebernes:**

**NSF, Mathematics Division: 1991-94**

**NATO: 1993-95**

**Gregory Beylkin:**

**Chevron Oil: unrestricted grant**

**ONR, Mathematics Division: 1991-93**

**AASERT - ONR - Mathematics Division: 1992-95**

**ARPA: 1993-96**

**Mary Brewster:**

**NSF: 1992-93**

**ARPA: 1992-96**

**James Curry:**

**AASERT, ONR, Physics/Oceanography Div.: 1992-94**

**DOE Grant: 1993-95**

**NSF Statewide Systemic Initiative: 1993-96**

**Tom Manteuffel:**

DOE, Applied Mathematics: 1993-96

**John Maybee:**

ONR, Mathematics Division: 1990-93

**Steve McCormick:**

AFOSR, 93-94:

NSF, 92-94:

Sandia, 92-93

**James Meiss:**

NSF, Mathematics Division: 1993-96

NSF, Graduate Traineeship: 1993-98

NATO: 1993-95

CRCW: 1993-94

**Harvey Segur:**

NSF, Mathematics Division: 1993-96

ONR, Physics/Oceanography Division: 1992-94

AASERT, ONR, Physics/Oceanography Div.: 1992-94

**Total research funding for Program is over \$1 million.**

*NSF:	National Science Foundation
AFOSR	Air Force Office of Scientific Research
ONR:	Office of Naval Research
CRCW:	Committee on Research and Creative Work, University of Colorado
AASERT:	Augmentation Awards for Science and Engineering Research Training
ARPA:	Advanced Research Project Agency

**D. Miscellaneous for Calendar Year 1993**

**Mark Ablowitz:**

Editorial boards: *SIAM Journal on Applied Mathematics*; *Journal of Engineering Mathematics*

Advisory board: *Chaos, Inverse Problems*

Reviewer: NSF grants; Australian and Canadian Research Grants; *Physica D, Inverse Problems, Physical Review Letters*, Cambridge University Press

**Jerrold Bebernes:**

Editor: *Rocky Mountain Journal of Mathematics*

**Gregory Beylkin:**

Editorial boards: *Inverse Problems*; *SIAM Journal on Numerical Analysis*; *Applied and Computational Harmonic Analysis*

Reviewer: NSF proposals; US-Israel Binational Science Foundation; several journals

Member of Translation Committee of the Society of Exploration Geophysicists

**Mary Brewster:**

Reviewer: NSF proposals, *SIAM Journal on Mathematical Analysis* ; *SIAM Review*

**Sarbarish Chakravarty:**

Reviewer: *Journal of Mathematical Physics; Physics Letters A; Communications in Mathematical Physics; Physical Review Letters; Physical Review E.*

**James Curry:**

Colorado SSI

Designated President's Teaching Scholar, 1993-1995

Outstanding Advisor's Award, 1993

SOAR Teaching Award, 1993

Reviewer: *Journal of Atmospheric Science*

**Robert Easton:**

Reviewer: NSF; research journals, graduate text for Houghton-Mifflin

**Yoshi Kimura:**

Reviewer: *Physics of Fluids; Journal of Fluid Mechanics*

**Congming Li:**

Reviewer: NSF; *Rocky Mountain Journal of Mathematics; Communications in Pure and Applied Mathematics*

**Tom Manteuffel:**

Editorial boards: *SIAM Journal on Matrix Analysis; Journal on Numerical Linear Algebra and Applications; SIAM Journal on Scientific Computing; SIAM Journal on Numerical Analysis*

Reviewer: *SIAM Journal on Scientific Computing; SIAM Journal on Matrix Analysis; SIAM Journal on Numerical Analysis; Journal of Computational Physics; Mathematics of Computation; Linear Algebra and its Applications; Journal of Numerical Linear Algebra; Numerische Mathematica*

Stanislaw Ulam Scholar at the Center for Nonlinear Studies at Los Alamos National Laboratory

Co-Chair, Sixth Copper Mountain Conference on Multigrid Methods, 3/93

**Steve McCormick:**

Editor: *SIAM Journal on Scientific Computing*

Reviewer: grant proposals, research journals, *AMS Bulletin; SIAM Publications; Math Reviews; Zentralblatt*

Co-Chair, Sixth Copper Mountain Conference on Multigrid Methods, 3/93

Member of IMALS Technical Committee on CFD

**James Meiss:**

Editor: *Physica D*

Reviewer: Cambridge University Press, numerous journals

Co-organizer Midwest Dynamical Systems Conference held March 1993

**Harvey Segur:**

Reviewer: NSF; *Journal of Fluid Mechanics; Physica D; Physical Review Letters; Physics Letters A; Journal of Mathematical Physics; Methods and Applications of Analysis.*



## **6. PREPRINTS OF THE PROGRAM: 1993-94**

Following is a list of preprints developed by Program faculty and visitors during this academic year. If you would like a copy of any preprint, please request a copy in writing from Margy Lanham, Program in Applied Mathematics, Campus Box 526, University of Colorado, Boulder, CO 80309-0526.

No.

164. "Algorithms for Nonclassical Symmetries", P.A. Clarkson and E.L. Mansfield, July 1993.
165. "Wavelets and Fast Numerical Algorithms", G. Beylkin, July 1993.
166. "On the Numerical Integration of Ordinary Differential Equations by Symmetric Composition Methods", R.I. McLachlan, July 1993.
167. "Multigrid Solution of the Navier-Stokes Equations at High Reynolds-numbers", R.I. McLachlan, July 1993.
168. "The Flow of a Shear-thinning Fluid During Extrusion RPI Study Group with Industry, 17-21 May 1993", M. Brewster, J. Chapman, W. Dold, A. Fitt, and C. Please, August 1993.
169. "Solutions to the 2+1 Toda Equation", J. Villarroel and M.J. Ablowitz, August 1993.
170. "Transient Measures in the Standard Map", J.D. Meiss, September 1993.
171. "On a Shallow Water Wave Equation", P.A. Clarkson and E.L. Mansfield, August 1993.
172. "References for the Painlevé Equations", compiled by P.A. Clarkson, August 1993.
173. "Nonclassical Symmetry Reductions of the Boussinesq Equation", P.A. Clarkson, August 1993.
174. "On the Method of Solution of the Differential-Delay Toda Equation", J. Villarroel and M.J. Ablowitz, August 1993.
175. "Kazdan-Warner Type Conditions Are Not Sufficient", W. Chen and C. Li, September 1993.
176. "Remarks on the Inverse Scattering Transform Associated with Toda Equations", M.J. Ablowitz and J. Villarroel, September 1993.
177. "Two-dimensional Periodic Waves in Shallow Water. Part 2: Asymmetric Waves", J. Hammack, D. McCallister, N. Scheffner, and H. Segur, September 1993.
178. "Dean Vortices with Wall Flux in a Curved Channel Membrane System: 2. The Velocity Field in a Spiral Channel", K.Y. Chung, M.E. Brewster, and G. Belfort, October 1993.
179. "A Survey of Open Problems in Symplectic Integration", R.I. McLachlan and C. Scovel, October 1993.
180. "Homoclinic Manifolds and Numerical Chaos in the Nonlinear Schrödinger Equation", M.J. Ablowitz and C. Schober.
181. "On Factored FIR Approximation of IIR Filters", G. Beylkin, November 1993.
182. "Effective Chaos in the Nonlinear Schrödinger Equation", M.J. Ablowitz and C. Schober, November 1993.

183. "Hamiltonian Integrators for the Nonlinear Schrödinger Equation", M.J. Ablowitz and C. Schober, December 1993.
184. "Numerical Stochasticity, Hamiltonian Integrators and the Nonlinear Schrödinger Equation", M.J. Ablowitz and C. Schober, December 1993.
185. "Implementation of Operators Via Filter Banks, Autocorrelation Shell and Hardy Wavelets", G. Beylkin and B. Torrèsani, February 1994.
186. "Commentary on the Work of Martin D. Kruskal in Honor of The National Medal of Science", M. Ablowitz, J. Greene, and H. Segur, March 1994.
187. "A Multiresolution Strategy for Numerical Homogenization", M.E. Brewster and G. Beylkin, March 1994.
188. "Controlling Chaotic Transport Through Recurrence", E.M. Bollt and J.D. Meiss, April 1994.
189. "Order N Static and Quasi-Static Computations in Electromagnetics Using Wavelets", by G. Beylkin, J. Dunn, and D. Gines, April 1994.
190. "An Approximate Renormalization for the Break-up of Invariant Tori with Three Frequencies", by R.S. MacKay, J.D. Meiss, and J. Stark, April 1994.
191. "N-Soliton Interaction Effects in Wavelength-Division Multiplexing Systems", S. Chakravarty, M.J. Ablowitz, J.R. Sauer and R.B. Jenkins, April 1994.
192. "Multi-soliton Interactions and Wavelength-Division Multiplexing", S. Chakravarty, M.J. Ablowitz, J.R. Sauer and R.B. Jenkins, May 1994.
193. "A Numerical Study of Vortex Ring Formation at the Edge of a Circular Tube", M. Nitsche and R. Krasny, June 1994.
194. "The Guess LOD Approach: Sufficient Conditions for Robustness", J.A. Williamson and C.I. Amos, April 1994.
195. "On Fast Fourier Transform of Functions With Singularities", G. Beylkin, June 1994.
196. "Multilevel Projection Methods for First-Order System Least Squares", by T.A. Manteuffel and S. McCormick, May 1993
197. "Multilevel Adaptive Methods for Semi-Implicit Solution of Shallow Water Equations on a Sphere", J.W. Ruge, S.F. McCormick, and S.Y.K. Yee, September 1993.
198. "Accurate Discretization for Singular Perturbations: The One-Dimensional Case", X.C. Hu, T.A. Manteuffel, S. McCormick and T.F. Russell, July 1994.
199. "Multilevel Adaptive Methods for Laminar Diffusion Flames", C. Liu, Z. Liu, and S. McCormick, August 1993.
200. "A Semi-Lagrangian Approach to the Shallow Water Equations", J.R. Bates, S. McCormick, J. Ruge, D. Sholl and I. Yavneh, September 1993.
201. "Optimal Resolution in Maximum Entropy Image Reconstruction from Projections with Multigrid Acceleration", M.A. Limber, T.A. Manteuffel, S. McCormick and D. Sholl, July 1993.
202. "Schwarz Alternating Procedure for Elliptic Problems Discretized by Least Squares Mixed Finite Elements", Z. Cai and S. McCormick, September 1993.
203. "First-Order System Least Squares for Second-Order Partial Differential Equations: Part I," Z. Cai, R. Lazarov, T.A. Manteuffel and S.F. McCormick, September 1993.
204. "Multilevel Projection Methodology", S. McCormick, June 1994.