

PROGRAM IN APPLIED MATHEMATICS

UNIVERSITY OF COLORADO
AT BOULDER

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ANNUAL REPORT

1989-90

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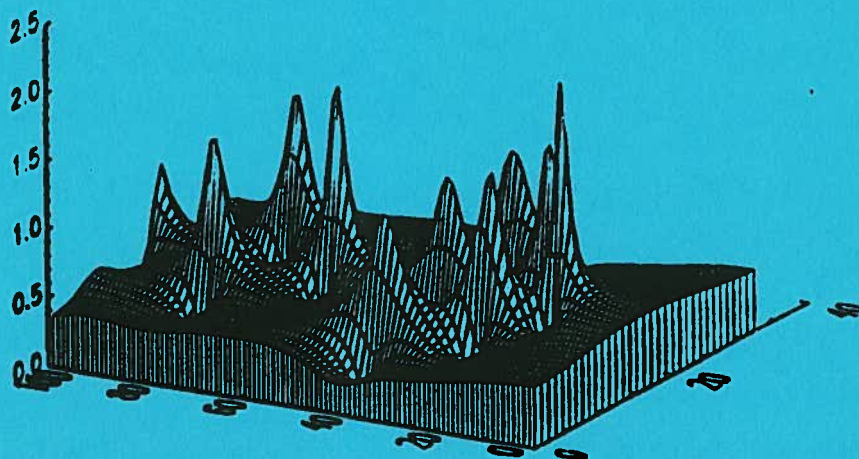




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1. OBJECTIVES

The objectives of the Program in Applied Mathematics at the University of Colorado at Boulder are varied. They are summarized below.

- a) To provide undergraduate and graduate students with excellent courses and training in applied and computational mathematics. Students will be given the necessary background to meet the demands of careers in business, industry, and the laboratory and academic professions.
- b) To offer and develop a broad curriculum that services the students of all departments 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 is of central importance and valued by the Program.

2. ORGANIZATION AND COMMENTS

A. Overview

The Program in Applied Mathematics is configured along two tracks. There is a core faculty who are actively involved in all aspects of applied mathematics with special emphasis directed toward service of the applied mathematics courses and the undergraduate major in applied mathematics. The first four undergraduate courses in applied mathematics taught by members of the program are taken by virtually all engineering students. Adequate preparation in applied mathematics for engineers and scientists is essential. Consequently, the task of providing high quality instruction is critical. The graduate level program in applied mathematics consists of core faculty as well as faculty who are actively engaged in applied mathematics research from a wide array of disciplines at the University. These faculty members can formally direct students toward a Ph.D. in applied mathematics. This year we have been extremely pleased by the interest and involvement by faculty and students here at the Boulder campus of the University, the Denver campus and nearby laboratories.

The program core has defined a number of areas of research focus. These include nonlinear dynamics, chaos theory, analysis of nonlinear equations arising in physical phenomena, nonlinear waves, soliton theory, computation and numerical analysis.

B. Core Faculty and Long Term Visitors

Mark J. Ablowitz, Director, Professor; PhD, M.I.T. Partial Differential Equations, Solitons, Nonlinear Waves.

Pau Atela, Instructor; PhD, Boston University. Dynamical Systems, Hamiltonian Mechanics and Complex Dynamics.

Priscilla Cehelsky, Visiting Assistant Professor; PhD, M.I.T. Fluid Mechanics, Applied Analysis.

Sarbarish Chakravarty, Visiting Assistant Professor; PhD, University of Pittsburgh. General relativity, Nonlinear Integrable Systems.

James H. Curry, Associate Director; Professor, PhD, University of California at Berkeley. Dynamical Systems, Numerical Methods, Nonlinear Equations.

Barend Herbst, Visiting Associate Professor; PhD, University of the Orange Free State, So. Africa, Computational Solutions of Differential Equations, Computational Methods in Dynamical Systems.

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

Dorit Ron, Visiting Instructor; PhD, Weizmann Institute in Israel. Numerical Analysis, numerical algorithms for large scale problems.

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

Javier Villaroel, Visiting Assistant Professor (Fulbright Fellow); PhD, University of Salamanca, Spain. Nonlinear Integrable Systems, Inverse Scattering.

SHORT TERM VISITORS: Peter Clarkson, Exeter University (August 1989); I.M. and T. Gel'fand, Moscow State University (April 1990); Nalini Joshi, Australian National University (April 1990); Martin Kruskal, Rutgers and Princeton Universities (Sept. 1989, April 1990); Leon Takhtajan, Steklov Institute of Mathematical Sciences, Leningrad, USSR (March 1990).

C. Affiliated Faculty - Graduate Program in Applied Mathematics

***Jerrold Bebernes**, Differential Equations, Reaction Diffusion Systems, Combustion Theory, Analysis.

William Blumen, Atmospheric Science, Nonlinear Waves, Fluid Dynamics.

Alberto Bressan, Differential Equations, Geometric Control Theory, Analysis.

Richard Byrd, Optimization, Nonlinear Data Fitting, Parallel Computation.

John Cary, Plasma Physics, Nonlinear Dynamics.

*Robert Easton, Dynamical Systems, Hamiltonian Mechanics.

Fred Glover, Discrete and Nonconvex Programming, Applied Artificial Intelligence, Large-Scale Systems.

Martin Goldman, Plasma Physics, Nonlinear Waves, Turbulence.

Vijay Gupta, Hydrology, Stochastic Processes, Fluid Dynamics.

Karl Gustafson, Computational Fluid Dynamics, Neurocomputing, Partial Differential Equations, Mathematical Physics.

Henry Hermes, Control Theory, Differential Equations, Analysis.

Elizabeth Jessup, Numerical Linear Algebra, Eigenvalue Problems, Parallel Computation.

William Jones, Mathematics of Computation, Approximation Theory, Special Functions.

David Kasso, Fluid Dynamics, Combustion Theory, Thermal Science.

Michael Lightner, VSLI, Discrete Mathematics, Graph Theory.

*John Maybee, Applied Combinatorics and Matrix Analysis.

Oliver McBryan, Large Scale Computation, Numerical Partial Differential Equations, Parallel Computations and Algorithms

Tom Mullis, Digital Signal Processing, Linear Systems.

Robert Sani, Computational Fluid Dynamics, Free and Moving Boundary Problems, Stability of Systems.

Duane Sather, Fluid Dynamics and Partial Differential Equations.

Robert Schnabel, Parallel Computational, Numerical Optimization, Programming Languages.

Rex Skodje, Quantum Chaos, Unimolecular Dynamics, Nonlinear Phenomena.

Renjeng Su, Control Theory, Robotics.

Juri Toomre, Astrophysics, Mathematical Modelling, Numerical Simulation.

Ellen Zweibel, Plasma Physics and Astrophysics.

*Member of the core faculty as of July 1, 1990.

D. Staff

Janet Horn - Staff Assistant
 Andrea Hennessy - Word Processing Operator
 Janet Key - Student Coordinator/Receptionist

E. General Comments

-For the program, its faculty and staff, this has been an extremely busy year requiring a great deal of time and effort by members of the program and interaction with many people throughout the University. We are extremely grateful for all the help we have received from the Office of the Vice Chancellor, the offices of the Dean of Arts and Sciences, the Dean of Engineering, the Dean of the Graduate School/Associate Vice Chancellor for Research and many faculty and staff throughout the university; a deep and sincere thank you.

-Early in the year a number of meetings were held with interested faculty regarding the undergraduate and graduate programs in applied mathematics. These meetings held on weekends and evenings allowed for wide-ranging discussion and broad interaction between interested parties. Based upon comments and suggestions, we developed courses and initiatives. Some of these are discussed later in this report.

-A number of committees were organized to carry out the basic functions within the program. These include: an undergraduate, a graduate, and two faculty search committees -- one in computational mathematics and one in analysis. We are grateful to all the faculty who served on these committees and who made so many valuable contributions.

-As most people in academia realize, the staff associated with programs and departments are absolutely crucial in the effective running and organization process. They take care of a myriad of activities and details, e.g. budgetary matters, faculty and student concerns, preparation of technical manuscripts, arrange for offices and furniture . . . At the beginning of the year we had but one staff assistant, Ms. Janet Horn. She had the nearly impossible task of satisfying all of the above needs for our students, faculty and visitors. Moreover, the program's offices were not ready until January. She had to coordinate the move, arrange for the renovation, moving of books, desks, computers, etc. from temporary locations. All of this was done in addition to her normal activities. Especially trying was the correspondence needed for our faculty search process which generated 500+ applications! This was a tour de force -- done with grace and aplomb. We are sincerely and deeply appreciative of all she has done. Additionally, during this year we hired a word processing operator, Andrea Hennessy. (Andrea replaced Sharon Foote, who resigned in March.) Andrea is an excellent typist, and has helped us in all of our activities. She is an accomplished

musician as well -- double bass! On June 11 we added a student coordinator/receptionist, Janet Key. Janet is also pursuing a graduate degree in communication disorders here at the University and comes to us from Norlin Library. We look forward to a long and fruitful collaboration with all of our staff.

-As mentioned above, the offices of the Program in Applied Mathematics and faculty in the Program were relocated in January. The permanent offices are on the second floor of the Engineering Center. Program office: OT 2-6, Janet Horn: OT 2-3, James Curry: OT 2-4, Mark Ablowitz: OT 2-1, Conference room: OT 2-5. The conference room also provides a location for informal discussion, reading room and area for coffee and tea before seminars and colloquia.

-Professor James Curry worked tirelessly this year as associate director of the program, chair of the graduate committee, director of computing within the program, advisor to numerous graduate and undergraduate students, director of the successful NSF program Research Experiences for Undergraduates, etc. Curry played a key and central role in the organization of the program. The program deeply appreciates his invaluable efforts.

-A workshop, "Los Alamos - Colorado Days", was held April 12-14. The purpose of the workshop (this was the first of an annual affair in alternating years to be held in Boulder and Los Alamos) is to provide a forum for active researchers in nonlinear science and applied mathematics from Los Alamos and Colorado to lecture and informally discuss recent results and directions in this rapidly changing field. Special thanks to the co-organizers Darrel Holm from Los Alamos National Laboratory and Harvey Segur from the Program in Applied Mathematics. This was Harvey's first year with the program. He came to us from SUNY at Buffalo. He is an invaluable faculty member.

- We are happy to announce that professors Jerrold Bebernes, Robert Easton and John Maybee will be joining the program as of July 1, 1990. They are well known applied mathematicians and bring a great deal of expertise and experience to PAM. The program will organize a small reception to officially welcome them in the early fall.

-We are pleased to note the support, interest and help our colleagues at the University of Colorado at Denver have provided, especially important during the beginning phases of the program's development. They have attended colloquia, seminars, the Los Alamos workshop, informal program meetings, assisted during our faculty search endeavors. We have a joint PhD program with Denver and appreciate their value to us and the university. Special thank yous to Chair

Richard Lundgren, Director of the Computational Math Group Tom Manteuffel, Achi Brandt (visiting from Israel), William Briggs, Jr., Ben Fox (colloquium chair) and Steven McCormick.

-We are pleased to note that Professor James Meiss was interviewed on Australian National television (along with B. Mandelbrot and R. May) as part of the conference Chaos in Australia during his visit to Australia this past winter. We are also most grateful for Jim's efforts in organizing our own internal computing (Macintosh) network. He spent innumerable hours doing this important and valuable task. This is Jim's first year in the program. He came to Colorado from the University of Texas at Austin. We are delighted to have him here.

F. Applied Mathematics Colloquia and Seminars

-An Applied Mathematics Colloquia series was organized this year. The time of the colloquia is Friday afternoons at 3:00 p.m. with coffee and tea preceding at 2:45 p.m. Additionally, the program maintains two weekly seminar series on Thursday afternoons. The Nonlinear Waves and Integrable Systems Seminar is at 2:00 p.m. and the Dynamical Systems and Chaos Seminar is at 4:00 p.m. This year we had a total of 42 off campus speakers at our colloquia and seminars. A list of visiting speakers and the titles of their talks follows:

Applied Mathematics Colloquia

Martin Kruskal, Rutgers and Princeton Universities Sept. 1, 1989: Surreal Numbers; What is the Cube Root of Infinity?

Darryl Holm, Los Alamos, Sept. 8, 1989: Hamiltonian Chaos in Nonlinear Oscillators

Greg Forest, Ohio State University, Sept. 15, 1989: Asymptotic Closure Models for Non-Newtonian Jets

Peter Clarkson, Exeter University, Sept. 22, 1989: Nonclassical Symmetry Reductions Associated with Nonlinear Evolution Equations

Achi Brandt, CU Denver and Weizmann Institute, Sept. 30, 1989: Multilevel Computational Methods; Survey and Recent Developments

Jerry Browning, NCAR, Oct. 6, 1989: Applications of the Bounded Derivative Principles to Meteorology and Oceanography

Norman Bleistein, Colorado School of Mines, Oct. 13, 1989: Inverse Methods for Reflector Imaging and Parameter Estimation

Richard Ewing, University of Wyoming, Oct. 20, 1989: Mathematical Modeling and Large-Scale Computing in Energy and Environmental Research

Eli Isaacson, University of Wyoming, Oct. 27, 1989: Exact Solutions of a Linearized Inverse Boundary Value Problem

Alberto Grunbaum, University of California, Berkeley, Nov. 3, 1989: Trying to Beat the Heisenberg Uncertainty Principle

Richard McGehee, University of Minnesota, Nov. 17, 1989: Singularities in Celestial Mechanics

John Dennis, Rice University, Dec. 1, 1989: A New Algorithm for Nonlinear Programming

Steven Wiggins, Los Alamos and Caltech, Dec. 8, 1990: Dynamics of the Damped and Driven Sine-Gordon Equation

Robert Krasny, University of Michigan, Feb. 16, 1990: Vortex Sheets; Singularity Formation and Roll-up

Robert Devaney, Boston University, Feb. 23, 1990: Exploding Julia Sets

James Sethian, University of California, Berkeley, March 2, 1990: Fluid Mechanics and Massively Parallel Processors

Leon Takhtajan, Steklov Institute, Leningrad, March 9, 1990: Introduction to Quantum Groups

Yannis Kevrekidis, Princeton University, March 16, 1990: Global Bifurcations in Maps of the Plane and in Rayleigh-Benard Convection

H. Knoblock, West Germany, April 6, 1990: Control Theory and the Applied Sciences

David Campbell, Los Alamos, April 13, 1990: New Directions in Nonlinear Science

Albert Libchaber, University of Chicago, April 20, 1990: Dynamics of a Moving Nematic Isotropic Interface

Victor Galaktionov, Keldysh Institute, Moscow, April 27, 1990: New Explicit Solutions of Nonlinear Heat Equations

Robert Dewar, Australian National University, May 4, 1990: Bifurcations in Resistive Magnetohydrodynamics

V.E. Zakharov, Landau Institute, Moscow, May 11, 1990: Extensions of the Dressing Method for Integrable Equations

Miki Wadati, University of Tokyo, May 18, 1990: Soliton Phenomena in Unstable Media

Seminar on Nonlinear Waves and Integrable Systems

- Peter Clarkson, Exeter University, Sept. 21, 1989: Solutions to Classical Nonlinear Differential Equations
- Olivier Thual, NCAR, Oct. 12, 1989: Pulse-like Solution for a Complex Ginsberg-Landau Type Equation
- Willy Hereman, Colorado School of Mines, Oct. 19, 1989: Solitary Wave Solutions of PDE's Using Macsyma
- Anil Deane, Princeton University, Nov. 2, 1989: Lyapunov Exponents, Attractor Dimension and the Proper Orthogonal Decomposition
- Robert Kerr, NCAR, Nov. 9, 1989: Three Dimensional Vortex Dynamics; Is There a Singularity In Finite Time?
- B.K. Shivamoggi, University of Central Florida, Dec. 7, 1989: On the Number of Effective Modes for the Nonlinear Schrödinger Equation in 2 and 3 Dimensions
- A. Perelomov, Fermi Laboratories and Institute of Theoretical and Exp. Physics, Moscow, Dec. 14, 1989: Integrable Models & Conformal Field Theories
- Robert Krasny, University of Michigan, Feb. 15, 1990: Vortex Sheets; Wakes, Dipoles and Roll-up at a Sharp Edge
- Robert McLachlan, Caltech, March 1, 1990: Multigrid Methods and High Reynolds Number Laminar Flows
- Leon Takhtajan, Steklov Institute, Leningrad, April 6, 1990: Quantum Groups
- Orlando Ragnisco, University of Rome, April 13, 1990: Discrete Hamiltonian Systems
- Bengt Fornberg, Exxon Research, April 20, 1990: Steady Incompressible Flow Past Blunt Bodies at High Velocities
- Sherwin Maslowe, McGill University, April 26, 1990: Critical Layers in Shear Flows; A New Approach via Wave Packets

Seminar on Dynamical Systems

- Diane Henderson, Scripps Institute of Oceanography, Sept. 28, 1989: Subharmonic and Superharmonic Resonances in Faraday Waves
- Christopher Golé, University of Minnesota, Oct. 19, 1989: The Energy Gradient Flow Attached to Twist Maps

Jeffrey Weiss, NCAR, Oct. 26, 1989: Point Vortex Dynamics in a Periodic Domain
Richard McGehee, University of Minnesota, Nov. 16, 1989: A Metric Approach to
Attractors
Stephane Laederich, University of Minnesota, Nov. 30, 1989: Qualitative Dynamics
of Free Chains
Robert Devaney, Boston University, Feb. 22, 1990: Dynamics of Complex
Polynomials and Automorphisms of the Shift
Ferenc Varadi, UCLA, March 1, 1990: Hamiltonian Perturbation Theory Applied to
Planetary Motions
Yannis Kevrekidis, Princeton University, March 15, 1990: Low-Dimensional
Dynamics and Inertial Manifolds for the Kuramoto-Shivashinski Equation

-In addition, we hosted a number of SPECIAL LECTURES. These included:
David Hughes, Cambridge University, Sept. 5, 1990, On a Coupled System of
Differential Equations.

Eduard Harabetian, University of Michigan, March 7, 1990: Analysis and
Computation of Free Boundary Value Problems.
Mary Brewster, RPI, March 12, 1990: Thinplates and Compressive Membrane
Solutions

Mary Brewster, RPI, March 13, 1990: Bifurcation Analysis of Free Boundary
Problems

Martin Kruskal, Princeton and Rutgers Universities, April 12, 1990: Integrability
and Differential Equations

I.M. Gel'fand, Moscow State University, April 23, 1990: Spectral Theory of Third
Order Ordinary Skew Symmetric Differential Equations

I. M. Gel'fand, Moscow State University, April 24, 1990: A-discriminant and
Determinants of a Cubic Matrix

Tanya Alekseyevskaya Gel'fand, Moscow State University, April 24, 1990: The
Investigation and a Class of Exact Solutions to a Quasi-Linear System
Governing Electrophoresis

We had a joint coffee and tea with the departments of Physics and
Astrophysical, Planetary and Atmospheric Sciences at 3:30 - 4:00 p.m. each
Thursday. We are certainly appreciative of the support of the staff of these
departments and the use of their seminar rooms during these periods.

3. COMMITTEES

The following committees were organized during the 1989-90 academic year: undergraduate, graduate and two recruiting committees -- one in computational mathematics and one in analysis. A brief summary of activities are described below.

A. Undergraduate Committee - Harvey Segur, Chair

The undergraduate program has two main parts: (i) an undergraduate major in Applied Mathematics, granted within the College of Engineering; (ii) service courses, primarily in calculus and differential equations, taught to the Engineering students.

Here are some statistics about the undergraduate majors:

	<i>Fall, 1989</i>
Freshmen	7
Sophomores	8
Juniors	14
Seniors	7
5th year seniors	3
Total	39

The main goal of the undergraduate committee this year was to revitalize the undergraduate program. There were several aspects to this task.

(i) Seven new, upper-division, undergraduate courses in Applied Mathematics were created and approved by the College of Arts & Sciences. A detailed listing is given later in this report. These included 2 service courses (3310, 3570), 3 courses that will be cross-listed with existing Math courses (3170, 4650, 4660), and 2 entirely new courses (4380, 4955). These courses will play an important role in a revised curriculum for the undergraduate major.

(ii) Revising the curriculum for the Applied Mathematics majors is now underway. We hope to complete these revisions within the next month, in time for the 1991-1992 catalogue.

(iii) A new option for the undergraduate major, based on Discrete Mathematics, has been discussed. It will be a major topic of discussion over the next year. Also for next year, a major concern of the committee will be to determine a vehicle for

satisfying the needs of undergraduates in Arts and Sciences who wish to pursue applied mathematics.

(iv) A new student chapter of SIAM (Society of Industrial and Applied Mathematics) was created.

B. Graduate Committee - James Curry, Chair

The graduate program had an extremely busy and productive year.

A total of nine graduate courses will be offered by the program as part of its educational mandate. The course offerings include opportunities for study in discrete applied mathematics, mathematical methods in applied mathematics, applied analysis, and computation. Several advanced courses and seminars will also be offered by the Program.

In addition to graduate courses, the degree requirements for the Ph.D. and M.S. degrees are also nearing a final form. These include the following requirements:

(i) graduate students in the Program must complete a year-long sequence of courses in an area where mathematics has a significant application;

(ii) students are expected to participate in seminars on a regular basis.

The Program has been successful in recruiting graduate students this year and it expects to do even better next year. The majority of the students who will begin graduate studies with the fall semester 1990 have grade point averages that exceed 3.5. Further, with the fall semester, there will be at least ten graduate students working towards the Ph.D. in the Program. The majority of new students will be supported by teaching assistantships and/or partial fellowships. The Program will experience additional growth when its full complement of seventeen TA positions are realized in the Fall semester 1991. New graduate students for 1990-91 are listed below.

Erik Boltt (University of California, Berkeley)

Jan Borichevsky (University of Vermont, Burlington)

Terry Chen (University of Colorado, Denver)

David Deininger (Furman University, Greenville, SC)

Diane Denny (New York University)

James Donahoe (University of Minnesota, Minneapolis)

John Evans (Montana State University, Bozeman)

Anna Kallergi (University of Crete, Greece)

Ma, Wenxiu (Computing Center of Academia Sinica, Beijing, China)

Matthew St. John (University of Colorado, Boulder)

Eduardo Tabacman (University of Minnesota, Minneapolis)

Among the key items which will foster further growth of the Graduate Program is external fellowship support for graduate students and in particular advanced graduate students. With the increased interest in mathematics at the national level we hope and anticipate that there will be new opportunities for graduate student support.

Another source of graduate student funds is provided by summer teaching/research experiences. For example, during the summer of 1990 the Program was able to place seven applied mathematics graduate students in such positions. In the case of the Program's own first year students one was supported by a generous fellowship, a second by a research grant and the third with a TA and supplement from a research grant. The Program understands that providing such summer support is vital to the overall health of the graduate program.

Finally, as mentioned earlier, a key item which will be necessary to investigate and develop over the upcoming few years will be external grants. The graduate committee will actively pursue various opportunities in the future.

C. Faculty Search Committees

During this academic year we received over 500 applications in response to our widely advertised announcements. We carried out the search process by circulating complete files (vita and letters of recommendation) to members of the relevant committees. Most applicants were divided into separate categories: (i) computational mathematics or (ii) analysis, although a few applicants were deemed suitable for both. Each committee member ranked files in three categories -- high, medium or low interest. A number of meetings were held to carefully discuss the candidates. Members of the committees:

(i) Computational Mathematics

Mark Ablowitz

Richard Byrd (Computer Science)

James Curry

Robert Easton (Mathematics)

Martin Goldman (Astrophysical, Planetary & Atmospheric Sciences)

Karl Gustafson (Mathematics)

Oliver McBryan (Computer Science)

James Meiss

Harvey Segur

(ii) Analysis

Mark Ablowitz

Jerrold Bebernes (Mathematics)

William Blumen (Astrophysical, Planetary & Atmospheric Sciences)

James Curry

Henry Hermes (Mathematics)

David Kassoy (Mechanical Engineering)

James Meiss

Duane Sather (Mathematics)

Harvey Segur

After a careful, exhaustive (and exhausting) search, the following people will be joining the program:

Dr. Mary Brewster; Assistant Professor. Mary got her Ph.D. from Caltech in 1987 and spent the past few years at R.P.I. Mary won the Richard DiPrima Award from the Society of Industrial and Applied Mathematics (SIAM) for the best Ph.D. thesis in 1988. Her fields of interest are classical analysis, asymptotic and computational methods of applied mathematics.

Dr. Robert McLachlan; Instructor. Robert just finished his Ph.D. at Caltech. His specialty is computational mathematics especially as applied to fluid dynamics.

Finally, **Dr. Yannis Kevrekidis** is expected to join the program in September, 1991 as Visiting Associate Professor. Yannis is a member of the Chemical Engineering faculty and Program in Applied Mathematics at Princeton University. His specialty is scientific computation, nonlinear dynamics and bifurcation analysis.

D. Faculty Service to the University, College and Societies

Mark Ablowitz: Member of Council on Research and Creative Work of The Graduate School, Organized the Applied Mathematics Colloquium series and Seminar on Nonlinear Waves and Integrable Systems;

Pau Atela: Co-organizer of the Dynamical Systems Seminars;

James Curry: Member of Dean's Personnel Committee, Chair of Program Graduate Committee, Liaison between Associate Dean's office and Program regarding development of new courses in applied mathematics;

James Meiss: Co-organizer of the Dynamical Systems Seminars;

Harvey Segur: Chair of Program Undergraduate Committee, Organizer of the Los Alamos Days Workshop.

4. TEACHING ACTIVITIES

A. Courses Taught by Program Faculty During Academic Year 1989-90

(i) UNDERGRADUATE COURSES

APPM 1350. Atela and Chakravarty, Calculus 1 for Engineers.

APPM 2350. Segur, Calculus 3 for Engineers.

APPM 2360. Ablowitz, Curry, Bebernes, Easton and Meiss, Linear Algebra and Differential Equations.

APPM 4350. Segur, Advanced Math for Engineers.

MATH 3130. Chakravarty, Linear Algebra.

MATH 4430. Meiss, Ordinary Differential Equations.

MATH 4650. Ron, Numerical Analysis 1.

MATH 4955. Curry, Undergraduate Seminar in Applied Mathematics.

(ii) GRADUATE COURSES

MATH 6600. Herbst, Numerical Analysis 1.

MATH 6610. Herbst, Numerical Analysis 2.

MATH 8805. Atela, Dynamical Systems.

B. New Courses Approved by University Curriculum Committee

(i) UNDERGRADUATE COURSES

- 3170. Discrete Applied Mathematics. (To be taught Spring '91.)
- 3310. Matrix Methods and Applications. (To be taught Fall '90.)
- 3570. Applied Probability and Statistics. (To be taught Fall '91.)
- 4380. Modelling in Applied Mathematics. (To be taught Spring '91.)
- 4650. Intermediate Numerical Analysis 1. (To be taught Fall '90.)
- 4660. Intermediate Numerical Analysis 2. (To be taught Spring '91.)
- 4955. Undergraduate Seminar in Applied Mathematics. (To be taught Spring '92.)

(ii) GRADUATE COURSES

- 5180. Discrete Applied Mathematics. (To be taught Fall '91.)
- 5440. Applied Analysis 1. (Real/complex analysis and applications. To be taught Fall '90.)
- 5450. Applied Analysis 2. Continuation of 5440. (To be taught Spring '91.)
- 5470. Methods of Applied Mathematics 3 (PDE's. To be taught Fall '90.)
- 5480. Methods of Applied Mathematics 4. (Asymptotic and perturbation methods. To be taught Spring '91.)
- 6620. Numerical Computation in Applied Math 1. (To be taught Fall '91.)
- 6630. Numerical Computation in Applied Math 2. (To be taught Spring '92.)
- 7100. Mathematics Methods in Dynamical Systems. (To be taught Spring '92.)
- 7300. Mathematical Methods in Nonlinear Waves & Integrable Equations. (To be taught Fall '91.)

C. Graduate Students

This year we had 9 students enrolled as graduate students in the Program in Applied Mathematics. They are:

Fathi Allan, Rolan Christofferson, Bruce Fast, Scott Herod, James Keiser, Arthur Mizzi, Elizabeth Ryan, Kervin Smith and Linda Sundbye.

In addition, there are 7 students working on graduate degrees with faculty in the Program. They are:

Ron Antweiler (Mathematics - Curry)
Chang, Yi-Hua (SUNY at Buffalo - Segur)

Garry Cox (Mathematics - Curry)
H.F.H. Khalfan (Mathematics - Meiss)
Martha Nesbitt (Mathematics - Curry)
Amy Solomon (Mathematics - Curry)
T. Weissert (Physics - Meiss)

5. RESEARCH ACTIVITIES (1989-90)

A. Research Publications

Mark Ablowitz:

Hodograph Transformations of Linearizable Partial Differential Equations, A.S. Fokas, P.A. Clarkson and M.J. Ablowitz, SIAM J. Appl. Math., **49**, 1988-1209, 1989.

Interaction of Simple Particles in Soliton Cellular Automata, A.S. Fokas, E.P. Papadopoulou, Y.G. Saridakis and M.J. Ablowitz, Stud. in Appl. Math, **81**, 153-180, 1989.

On Homoclinic Structure and Numerically Induced Chaos for the Nonlinear Schrödinger Equation, M.J. Ablowitz and B.M. Herbst, SIAM J. Appl. Math, **50**, 339-351, 1990.

Solitons, Inverse Problems and Nonlinear Equations, M.J. Ablowitz, J. Comp. and Appl. Math, March, 1990.

Painleve Equations and the Inverse Scattering and Inverse Monodromy Transforms, M.J. Ablowitz, Proc. on Solitons in Physics and Math, Springer-Verlag series for the IMA, **25**, 1990.

Nonlinear Evolution Equations, Inverse Scattering and Cellular Automata, M.J. Ablowitz, Proc. of IMA Workshop on Solitons in Nonlinear Optics and Plasma Physics, Springer-Verlag series for the IMA, **25**, 1990.

Nonlinear Evolution Equations and Cellular Automata, M.J. Ablowitz, Proc. Singular Behavior and Nonlinear Dynamics, Ed. S. Pneumatikos, World Sci., 1989.

On Numerical Chaos in the Nonlinear Schrödinger Equation; Integrable Systems and Applications, B.M. Herbst and M.J. Ablowitz, Eds. M. Balabane, P. Lochak and C. Sulem, Lecture Notes in Physics #342, Springer-Verlag, 1990.

James Curry:

On the Geometry of Factorization Algorithms, J.H. Curry and S. Blish, Lectures in Applied Math, **26**, 47-60, 1990.

Higher Order Iterative Methods from Data at a Point, J.H. Curry, Journal of Complexity Theory, **22**, 1989.

Barend Herbst:

On Homoclinic Structure and Numerically Induced Chaos for the Nonlinear Schrödinger Equation, M.J. Ablowitz and B.M. Herbst, SIAM J. Appl. Math, **50**, 339-351, 1990.

A Numerical Study of the Nonlinear Schrödinger Equation Involving Quintic Terms, A. Clout, B.M. Herbst and J.A.C. Weideman, J. Comput. Phys., **86**, 127-146, 1990.

On Numerical Chaos in the Nonlinear Schrödinger Equation; Integrable Systems and Applications, B.M. Herbst and M.J. Ablowitz, Lecture Notes in Physics #342, Eds. M. Balabane, P. Lochak and C. Sulem, Springer-Verlag, 1989.

James Meiss:

Application of Newton's Method to Lagrangian Dynamical Systems, H.T. Kook and J.D. Meiss, *Physica* **36D**, 317-326, 1989.

2. *Converse KAM Theory for Symplectic Twist Maps*, R.S. MacKay, J.D. Meiss and J. Stark, *Nonlinearity* **2**, 555, 1989.

3. *Diffusion in Symplectic Maps*, H.T. Kook and J.D. Meiss, *Physical Review A*, **41**, 4143, 1990.

Harvey Segur:

Two-Dimensional Periodic Waves in Shallow Water, H. Segur, J.L. Hammack and N. Scheffner, *J. Fluid Mech.* **209**, 567-589, 1989.

B. Invited Lectures and Meetings Attended

Mark Ablowitz:

SIAM Summer Meeting, San Diego, CA, July 19-21, 1989 -- Organized mini-symposium on: *Exactly Solvable Nonlinear Systems*

CRM Workshop on Hamiltonian Systems, U. of Montreal, Oct. 20-29, 1989 -- "*Computational Chaos and Integrability*"

Colorado School of Mines, Mathematics Department, Nov. 20, 1989 -- "*Solitons and All That Nonlinear Stuff*"

Oberwolfach, W. Germany, Jan 13-20, 1990 -- "*Aspects of Integrability and Chaos*"
Workshop on Chaos and Order, Australian National University, Canberra, Feb. 1-3, 1990 -- "*Integrability and Cellular Automata*"

Conference on Chaos, University of New South Wales, Sydney, Feb. 4-10, 1990 -- "*Numerically Induced Chaos*"

University of Colorado at Denver, Mathematics Department, Feb. 28, 1990 -- "*Solitons and All That Nonlinear Stuff*"

Conference on Recent Advances in General Relativity, University of Pittsburgh, May 3-5, 1990 -- "*Integrability, Reductions of Self Dual Yang Mills Fields and Classical Systems*"

University of Georgia, Physics Department, Athens, GA, May 6-9, 1990 -- "*Integrability, Chaos and Patterns*"

Pau Atela:

Midwest Dynamical Systems Conference, Northwestern University, Nov., 1989

Conformal Dynamics, SUNY Stony Brook, NY, Nov. 1-4, 1989

Colorado School of Mines, Jan., 1990 -- "*Dynamics of Complex Quadratic Polynomials*"

Slow Pitch Colloquium, Dept. of Mathematics, Jan., 1990 -- "*What is a Julia Set? What is the Mandelbrot Set?*"

Workshop on Twist Maps and their Applications, University of Minnesota, March, 1990 -- "*A Trip Around the Mandelbrot Set: Bifurcations of Dynamic Rays*"

Priscilla Cehelsky:

NCAR, Mesoscale and Microscale Meteorology Division, May 1990: "*Towards a Model for Lake Effect Storms*"

NCAR, Climate and Global Dynamics Division, June 1990: "*Nonlinear Baroclinic Adjustment*"

Fourth Conference on Mesoscale Processes, June 1990: *"A Consistent Mathematical Model for the Onset of Lake Effect Storms"*
Workshop attended: *"Long Range Numerical Weather Prediction"*; NCAR, June 1990.

James Curry:

University of California, Davis, CA, May, 1989 -- *"On the Geometry of Factorization Algorithms"*
University of Minnesota, April, 1990 -- *"On the Numerical Solutions of Two-Point Boundary Value Problems"*
Colorado School of Mines, April, 1990 -- *"On Iterative Methods for Solving Equations"*

Barend Herbst:

EXXON Corporate Research, *Numerically Induced Chaos*
Princeton University, *Chaos in Computations*
University of Kentucky, Lexington, KY, *Numerical Chaos*
Courant Institute, New York University, New York, NY, *Chaotic Phenomena in Computations*

James Meiss:

Nonlinear Dynamics of Classical and Quantum Mechanical Systems, Telluride, CO, July 4-8, 1989 -- *"Transport for Several Degree of Freedom Systems"*
US-Japan Workshop, Boulder, CO, July 24-28, 1989 -- *"Periodic Orbits for Four Dimensional Mappings"*
Plasma Physics Bag Lunch Seminar, APAS, Boulder, CO, Oct. 31, 1989 -- *"Canonical Coordinates for Guiding Center Motion in Tokamaks"*
Transport for Hamiltonian Systems, Cornell University, Nov. 17-19, 1989 -- *"Resonances and Transport in the Sawtooth Map"*
Chaos and Order Miniconference, Centre for Mathematical Analysis, Australian National University, Canberra, Feb. 1-3, 1990 -- *"Resonances and Cantori for Symplectic Mappings"*
Royal Children's Hospital, Melbourne, Australia, Jan. 26, 1990 -- *"Chaos Theory - Can It Be Applied to Human Development?"*
Australian Psychoanalytic Society, Sydney, Australia, Feb. 4, 1990 -- *"Chaos, an Introduction"*
Chaos in Australia: The Conference, Sydney, Australia, Feb. 4-9, 1990 -- *"Transport and Chaos in Symplectic Maps"*
Slow Pitch Colloquium, Mathematics Dept., Boulder, CO, Apr. 4, 1990 -- *"Chaos and Hamilton's Principle"*
Coherence and Chaos in Complex Dynamical Systems, Aspen, CO, May 28-June 8, 1990 -- *"Some Open Problems in Hamiltonian Chaos"*

Harvey Segur:

Centre for Water Research, Perth, Australia, Jan. 17, 1990 -- *"Two-dimensional Periodic Waves in Shallow Water"*
UWA, Perth, Australia, Jan. 19, 1990 -- *"Asymptotics Beyond All Orders"*
Chaos and Order, Australian National University, Canberra, Australia, Feb. 1-3, 1990 -- *"Two-dimensional Periodic Waves in Shallow Water"*
Chaos in Australia, University of New South Wales, Sydney, Australia, Feb. 4-9, 1990 -- *"Asymptotics Beyond All Orders"*
Kempner Colloquium, Mathematics Dept., Boulder, CO, Feb. 26, 1990 -- *"The Many Faces of Riemann Theta Functions"*

Colorado School of Mines, Golden, CO, Apr. 2, 1990 -- "*Two-dimensional Periodic Waves in Shallow Water*"

University of California, Santa Barbara, CA, May 18, 1990 -- "*Two-dimensional Periodic Waves in Shallow Water*"

Nonlinear Science: the Next Decade, Los Alamos, NM, May 21-25, 1990 -- "*Who Cares About Integrability?*"

C. Research Grants

Faculty support was obtained from the following agencies: Airforce Office of Scientific Research, Council on Research and Creative Work (C.U. Boulder), National Science Foundation, NATO (ARW) Office of Naval Research.

6. PREPRINTS OF THE PROGRAM: 1989-90

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 Jan Horn, staff assistant for the program.

No.

1. *On Homoclinic Structure and Numerically Induced Chaos for the Nonlinear Schrodinger Equation* by M.J. Ablowitz and B.M. Herbst, October, 1989.
2. *On Computing Solutions to the Kuramoto-Sivashinsky Boundary Value Problem* by J. Curry, Bruce A. Fast, Scott A. Herod, Mark Limber, Martha M. Nesbitt, David B. Sarrazin, Amy Beth Solomon, October, 1989.
3. *On Zero Finding Methods of Higher Order from Data at One Point* by James H. Curry, October, 1989.
4. *Two-dimensional Periodic Waves in Shallow Water* by Joe Hammack, Norman Scheffner and Harvey Segur [J. Fluid Mech., 209, pp. 567-589, 1989]
5. *Solitons* by Harvey Segur, October, 1989.
6. *Solitons, Numerical Chaos and Cellular Automata* by M.J. Ablowitz, B.M. Herbst, J.M. Keiser, November, 1989.
7. *On Homoclinic Boundaries in the Nonlinear Schrodinger Equation* by M.J. Ablowitz and B.M. Herbst, January, 1990.
8. *Nonlinear Evolution Equations, Solitons, Chaos and Cellular Automata* by M.J. Ablowitz, B.M. Herbst, J.M. Keiser, January, 1990.
9. *The Inverse Problem for Ward's System* by Javier Villarroel, February, 1990.

10. *On the Boundary Conditions of the Davey-Stewartson Equation* by M.J. Ablowitz, S.V. Manakov and C.L. Schultz, March, 1990.
11. *On the Complete Integrability of Certain Nonlinear Evolution Equations in One and Two Spatial Dimensions* by M.J. Ablowitz and Javier Villarroel, March, 1990.
12. *On the Initial Value Problem for the self dual Yang-Mills equations* by Javier Villarroel, April, 1990.
13. *One Dimensional Reductions of Self-Dual Yang-Mills Fields and Classical Equations* by S. Chakravarty, M.J. Ablowitz and P.A. Clarkson, March, 1990.
14. *A Note on the Intensity of Periodic Rip Currents* by Joe Hammack, Norman Scheffner and Harvey Segur, April, 1990.
15. *Stem Waves Along Breakwater* by Joe Hammack, Norman Scheffner and Harvey Segur, April, 1990.
16. *Toward a Quantum Liouville Theory with $C > 1$* by Feodor Smirnoff and Leon Takhtajan, April, 1990.
17. *Asymptotics Beyond All Orders - A Survey* by Harvey Segur, May, 1990.
18. *On the Geometry of Factorization Algorithms* by Sharon L. Blish and James H. Curry, May, 1990.
19. *Mel'nikov Analysis and Numerically Induced Chaos* by B.M. Herbst and M.J. Ablowitz, May, 1990.
20. *The Mandelbrot Set and σ - Automorphisms of Quotients of the Shift* by Pau Atela, June, 1990.
21. *Transport Through Chaos* by Robert W. Easton, June, 1990.
22. *The Kadomtsev-Pervashvili equation and water waves* by Harvey Segur, Joseph Hammack and Norman Scheffner, June, 1990.
23. *Relaxed Newton's Method and Complex Analytic Dynamics* by Bob Cramer, June, 1990.
24. *Contact Maps and Induced Differential Equations* by Henry Hermes, June, 1990.

25. *Asymptotically Stabilizing Feedback Controls and the Nonlinear Regulator Problem* by Henry Hermes, June, 1990.
26. *Nilpotent and High Order Approximations of Vector Field Systems* by Henry Hermes, June, 1990.
27. *Stabilization Via Optimization* by Henry Hermes, June, 1990.
28. *Nonlinear Baroclinic Adjustment* by Priscilla Cehelsky and Ka Kit Tung, June, 1990.
29. *Visualization and Computation of Hovering Mode Vortex Dynamics* by Peter Freymuth, Karl Gustafson and Robert Leben, June, 1990.
30. *Four Principles of Vortex Motion* by Karl Gustafson, June, 1990.
31. *Computation of Hovering Mode Vortex Dynamics* by Karl Gustafson and Robert Leben, June 1990.
32. *Hopf Bifurcation in the Driven Cavity* by John W. Goodrich, Karl Gustafson and Kadosa Halasi, June, 1990.
33. *Iterative Methods for Neural Net Architecture* by Karl Gustafson, Shelly D.D. Goggin and Kristina M. Johnson, June, 1990.
34. *Primacy and Recency Effects in Back Propagation Learning* by Shelly D.D. Goggin, Kristina M. Johnson and Karl Gustafson, June, 1990.
35. *Connectionist Nonlinear Over-Relaxation* by Shelly D.D. Goggin, Karl E. Gustafson and Kristina M. Johnson, June, 1990.
36. *Reversibility in Neural Processing Systems* by Karl Gustafson, June, 1990.
37. *Counting the Number of Solutions in Combustion and Reactive Flow Problems* by Ed Ash, Brian Eaton and Karl Gustafson, June, 1990.
38. *Cantori for Symplectic Maps* by Qi Chen, R.S. MacKay and J.D. Meiss, June, 1990.
39. *Diffusion in Symplectic Maps* by Hyung-tae Kook and J.D. Meiss, June, 1990.
40. *Periodic Orbits and Resonances for the Many Dimensional Sawtooth Mapping* by J.D. Meiss, June, 1990.

41. *Some Properties of a Class of Recursively Defined Digraphs* by Richard Lundgren and John S. Maybee, June, 1990.
42. *Minimum Boolean Factorizations of Tournament Codes* by Greg Bain, J. Richard Lundgren and John S. Maybee, June, 1990.
43. *Matrix Zero Elements, Vanishing Minors, and Inverses* by Charles R. Johnson and John Maybee, June, 1990.
44. *Qualitative Analysis of Schur Complements* by Charles R. Johnson and John Maybee, June, 1990.
45. *On Matrix Reducibility, Inverses and Minors* by Charles R. Johnson and John S. Maybee, June, 1990.
46. *Biclique Coverings of Bigraphs and Digraphs and Minimum Semiring Ranks of $\{0,1\}$ Matrices* by Kim Heffner, Teri Henson, J.R. Lundgren and John S. Maybee, June, 1990.
47. *Tournament Matrices and their Generalizations, I.* by John S. Maybee and Norman J. Pullman, June, 1990.
48. *Biclique Covers and Partitions of Unipathic Digraphs* by Kim Hefner, J. Richard Lundgren and John S. Maybee, June, 1990.
49. *Partly Zero Eigenvectors* by John S. Maybee, D.D. Olesky and P. van den Driessche, June, 1990.
50. *An Application of Generalized Competition Graphs to the Channel Assignment Problem* by J. Richard Lundgren, Craig Rasmussen and John Maybee, June, 1990.
51. *Interval Competition Graphs of Symmetric Digraphs* by J. Richard Lundgren, Craig W. Rasmussen and John S. Maybee, June, 1990.
52. *Bifurcations of Dynamic Rays in Complex Polynomials of Degree Two* by Pau Atela, June, 1990.
53. *Symplectic Maps, Variational Principles, and Transport* by J.D. Meiss, June, 1990.
54. *On the Kadomtsev-Petviashvili Equation and Associated Constraints* by Mark J. Ablowitz and Javier Villaroel, July 1990
55. *Action Angle Variables Associated with the Davey-Stewartson System* by Javier Villaroel and Mark J. Ablowitz, July 1990.
56. *Asymptotics Beyond All Orders in a Model of Crystal Growth* by Martin D. Kruskal and Harvey Segur, July 1990

Current Affiliated Faculty

William Blumen (APAS)	David Kassoy (Mechanical Engineering)
Alberto Bressan (Mathematics)	Michael Lightner (Electrical Engineering)
Richard Byrd (Computer Science)	Oliver McBryan (Computer Science)
John Cary (APAS)	Tom Mullis (Electrical Engineering)
Thomas DeGrand (Physics)	Robert Sani (Chemical Engineering)
Fred Glover (College of Business)	Duane Sather (Mathematics)
Martin Goldman (APAS)	Robert Schnabel (Computer Science)
Vijay Gupta (Geological Sciences)	J. Michael Schull (APAS)
Henry Hermes (Mathematics)	Rex Skodje (Chemistry, JILA)
Elizabeth Jessup (Computer Science)	Renjeng Su (Electrical Engineering)
William Jones (Mathematics)	Juri Toomre (APAS)
	Ellen Zweibel (APAS)

Prospective Members

Gary Stormo (Molecular, Cellular, and Developmental Biology)
Claudio Cioffi-Revilla (Political Science)
Patrick Weidman (Mechanical Engineering)

DeGrand

Current Assistant Faculty

David Kasper (Mechanical Engineering)
Thomas Linnert (Electrical Engineering)
Drew Roberts (Computer Science)
Tom White (Electrical Engineering)
Robert Lee (Electrical Engineering)
James Smith (Mathematics)
Robert Johnson (Computer Science)
A. Michael Smith (Ph.D.)
Patricia Smith (Ph.D.)
Richard Smith (Ph.D.)
John Smith (Ph.D.)
John Smith (Ph.D.)

William Johnson (Ph.D.)
Albert Johnson (Ph.D.)
Richard Lee (Computer Science)
John Lee (Ph.D.)
James Smith (Ph.D.)
Fred Smith (Ph.D.)
Robert Johnson (Ph.D.)
A. Michael Smith (Ph.D.)
Patricia Smith (Ph.D.)
Richard Smith (Ph.D.)
John Smith (Ph.D.)
John Smith (Ph.D.)

Visiting Faculty

Ray Smith (Ph.D.)
John Smith (Ph.D.)
John Smith (Ph.D.)