Society for Industrial and Applied Mathematics

Final Program

SIAM Conference on Dynamical Systems

May 7–11, 1990

Marriott Hotel
Orlando, FL

CONFERENCE THEMES

Geometric Theory and Dynamical Systems
Computation
Modeling Complex Dynamical Systems
Dynamical Systems and Fluid Mechanics
Modeling and Control of Mechanical Systems
Applications in Engineering and Physical Sciences
Applications in Biological/Natural Sciences

Sponsored by the SIAM Activity Group on Dynamical Systems

CONTENTS

ORGANIZING COMMITTEE

Shui-Nee Chow, *Co-Chair*
Center for Dynamical Systems and Nonlinear Studies
Georgia Institute of Technology

Harlan W. Stech, *Co-Chair*
Department of Mathematics and Statistics
University of Minnesota, Duluth

J. Doyne Farmer
Center for Nonlinear Studies
Los Alamos National Laboratory

Avner Friedman
Institute for Applied Mathematics and Its Applications
University of Minnesota, Minneapolis

Celso Grebogi
Laboratory for Plasma and Fusion Energy Studies
University of Maryland, College Park

Ira B. Schwartz
Optical Sciences Division
U. S. Naval Research Laboratory

FUNDING AGENCY

SIAM is conducting this conference with the partial support of the Air Force Office of Scientific Research.

PROGRAM-AT-A-GLANCE

Sunday, May 6

6:00 PM - 9:00 PM/Ballroom Foyer
Registration Opens

7:00 PM - 9:00 PM/Orange Room
Welcoming Reception
Cash Bar

Monday, May 7

7:00 AM/Citrus Ballroom Foyer
Registration Opens

8:15 AM - 8:30 AM/Lemon-Lime Room
Opening Remarks
Henry D.I. Abarbanel
University of California, San Diego

8:30 AM - 10:00 AM
Invited Presentations 1 and 2
Chair:

8:30 AM - 9:15 AM/Lemon-Lime Room
Invited Presentation 1
Resonant Stimulation and Control of Complex Systems
Alfred Hubler
University of Illinois, Urbana

9:15 AM - 10:00 AM/Lemon-Lime Room
Invited Presentation 2
Simulating Science with Coupled Map Lattices
Kunihiko Kaneko
University of Tokyo

10:00 AM - 10:30 AM/Orange Room
Coffee

10:30 AM - 12:30 PM/Lemon-Lime Room
Minisymposium 1
Control of Chaos 1
Modeling and Control of Low Dimensional Chaos
Chair: Alfred Hubler
University of Illinois, Urbana

10:30 AM - 12:30 PM/Tangerine A Room
Minisymposium 2
Applications of Population Biology 1
Chair: Paul Waltman
Emory University

10:30 AM - 1:00 PM/Tangerine B Room
Minisymposium 3
Mathematical Models for Microstructural Evolution: Tools For the Intelligent Processing of Materials
Chair: Helena S. Wisniewski
Lockheed Corporation

10:30 AM - 12:30 PM/Magnolia Room
Minisymposium 4
Magnetic Dynamos 1
Chair: Ittai Kan
George Mason University

10:30 AM - 12:30 PM/Oleander A Room
Minisymposium 5
Graphics, Imaging and Vision 1
Chair: Marc A. Berger
Georgia Institute of Technology

10:30 AM - 12:30 PM/Oleander B Room
Contributed Presentations 1
Fractal Sets
Chair: Hans Othmer
University of Utah

12:30 PM - 2:00 PM
Lunch

2:00 PM - 3:30 PM
Special Lecture and Invited Presentation 3
Chair: Peter Bates
Brigham Young University

2:00 PM - 2:45 PM/Lemon-Lime Room
Special Lecture
Air Force Interest and Funding in Nonlinear Dynamical Systems
Arje Nachman
Air Force Office of Scientific Research

2:45 PM - 3:30 PM/Lemon-Lime Room
Invited Presentation 3
Generating Wavelets vs Attractors of Random Dynamical Systems
Marc A. Berger
Georgia Institute of Technology

3:30 PM - 4:30 PM/Orange Room
Poster Session

4:00 PM - 4:30 PM/Orange Room
Coffee

4:30 PM - 6:30 PM/Tangerine A Room
Minisymposium 6
Modeling and Forecasting Time Series: A Dynamical Systems Approach
Chair: Martin Casdagli
Santa Fe Institute

4:30 PM - 6:30 PM/Tangerine B Room
Minisymposium 7
Understanding Biological Dynamics: The Nonlinear Perspective 1
Chair: Michael C. Mackey
McGill University, Montreal, Canada

4:30 PM - 6:30 PM/Oleander A Room
Minisymposium 8
Graphics, Imaging and Vision 2
Chair: Marc A. Berger
Georgia Institute of Technology

4:30 PM - 6:30 PM/Oleander B Room
Minisymposium 9
The Computation of Dynamical Systems 1
Chair: Mitchell Luskin
California Institute of Technology

4:30 PM - 6:30 PM/Magnolia Room
Minisymposium 10
Application of Dynamical Systems to the Understanding of Earthquakes
Chairs: Donald L. Turcotte, Cornell University, and John B. Rundle, Sandia National Laboratories

4:30 PM - 6:30 PM/Lemon-Lime Room
Minisymposium 11
Fractal Basin Boundaries
Chair: Kathleen Alligood
George Mason University

5:00 PM/Ballroom Foyer
Registration Desk Closes

6:30 PM - 8:00 PM/Poolside
SIAM Idea Exchange

PROGRAM-AT-A-GLANCE

Tuesday, May 8

7:30 AM/Ballroom Foyer
Registration Desk Opens

8:00 AM - 9:30 AM
Invited Presentations 4 and 5
Chair: Shui-Nee Chow
Georgia Institute of Technology

8:00 AM - 8:45 AM/Lemon-Lime Room
Invited Presentation 4
Diffusional Phase Transformations In Solids
John W. Cahn
National Institute of Standards and Technology

8:45 AM - 9:30 AM/Lemon-Lime Room
Invited Presentation 5
Dynamics for Thin Domain
Jack K. Hale
Georgia Institute of Technology

9:30 AM - 10:00 AM/Orange Room
Coffee

10:00 AM - 12:00 AM/Lemon-Lime Room
Minisymposium 12
Control of Chaos 2
Control of High Dimensional Nonlinear Systems
Chair: Alfred Hubler
University of Illinois, Urbana

10:00 AM - 12:00 PM/Tangerine A Room
Minisymposium 13
Applications to Population Biology 2
Chair: Paul Waltman
Emory University

10:00 AM - 12:30 PM/Tangerine B Room
Minisymposium 14
Aerospace Design 1
Chair: Helena S. Wisniewski
Lockheed Corporation

10:00 AM - 12:00 PM/Oleander A Room
Minisymposium 15
Statistical Methods in Image Processing and Computer Vision
Chair: Basilis Gidas
Brown University

10:00 AM - 12:00 PM/Oleander B Room
Minisymposium 16
Magnetic Dynamos 2
Chair: Ittai Kan
George Mason University

10:00 AM - 12:00 PM/Hybiscus Room
Minisymposium 17
Nonlinearities in the Atmospheric Sciences
Chair: Thomas Warn
McGill University, Montreal, Canada

10:00 AM - 12:00 PM/Azalea Room
Contributed Presentations 2
Bifurcation Theory
Chair: Martin Golubitsky
University of Houston

12:00 PM - 1:30 PM
Lunch

1:30 PM - 3:30 PM/Tangerine A Room
Minisymposium 18
Stochastic Chaos - State Space Modeling From Empirical Data
Chair: Wallace E. Larimore
Computational Engineering, Inc.

1:30 PM - 3:30 PM/Oleander B Room
Minisymposium 19
Nonlinear Models in Image Processing
Chair: Jayant Shah
Northwestern University

1:30 PM - 3:30 PM/Hybiscus Room
Minisymposium 20
Applications of Dynamical Systems in Combustion Theory
Chair: Stephen B. Margolis
Sandia National Laboratories

1:30 PM - 3:30 PM/Tangerine B room
Contributed Presentations 3
Population Biology
Chair: Hal Smith
Arizona State University

1:30 PM - 3:30 PM/Oleander A Room
Contributed Presentations 4
Forced Systems
Chair: P. R. Sethna
University of Minnesota, Minneapolis

1:30 PM - 3:30 PM/Azalea Room
Contributed Presentations 5
General Theory and Software
Chair: Brian Hassard
SUNY at Buffalo

1:30 PM - 3:30 PM/Lemon-Lime Room
Contributed Presentations 6
Applications 1
Chair: Ben Wilcox
Defense Advanced Research Projects Agency

3:30 PM - 4:00 PM/Orange Room
Poster Session

3:30 PM - 4:00 PM/Orange Room
Coffee

4:00 PM - 6:00 PM/Tangerine A Room
Minisymposium 21
Noise Reduction and Models of Dynamical Systems
Chair: Eric Kostelich
Arizona State University

4:00 PM - 6:00 PM/Tangerine B Room
Minisymposium 22
Understanding Biological Dynamics: the Nonlinear Perspective 2
Chair: Michael C. Mackey
McGill University, Montreal, Canada

4:00 PM - 6:00 PM/Oleander A Room
Minisymposium 23
Metastable Dynamics in Physical Systems 1
Chair: Peter W. Bates
Brigham Young University

4:00 PM - 6:00 PM/Oleander B Room
Minisymposium 24
The Computation of Dynamical Systems 2
Chair: Mitchell Luskin
California Institute of Technology

4:00 PM - 6:00 PM/Hybiscus Room
Minisymposium 25
Nonlinear Dynamics of Rotating Fluid Flows
Chair: J. Brindley
University of Leeds, United Kingdom

4:00 PM - 6:00 PM/Lemon-Lime Room
Minisymposium 26
Fractals and Their Dimensions
Chair: Jeffrey Geronimo
Georgia Institute of Technology

4:00 PM - 6:00 PM/Azalea Room
Contributed Presentations 7
Applications 2
Chair: Ann Castelfranco
University of Minnesota, Duluth

4:30 PM/Ballroom Foyer
Registration Desk Closes

6:00 PM - 6:15 PM/Hotel Lobby
Board Buses for Dinner at Sea World

Wednesday, May 9

8:00 AM/Ballroom Foyer
Registration Opens

8:30 AM - 10:00 AM
Invited Presentations 6 and 7
Chair: Harlan Stech
University of Minnesota, Duluth

8:30 AM - 9:15 AM/Lemon-Lime Room
Invited Presentation 6
Tracking Invariant Manifolds in Singularly Perturbed Systems
Nancy Kopell
Boston University, and Christopher K.R.T. Jones
University of Maryland, College Park

9:15 AM - 10:00 AM/Lemon-Lime Room
Invited Presentation 7
Global Properties of Delay - Differential Equations
John J. Mallet-Paret
Brown University

10:00 AM - 10 - 30 AM/Orange Room
Coffee

10:30 AM - 12:30 PM/Lemon-Lime Room
Minisymposium 27
Control of Chaos 3
Adaptive Control of Nonlinear Dynamics
Chair: Alfred Hubler
University of Illinois, Urbana

10:30 AM - 12:30 PM/Tangerine A Room
Minisymposium 28
Mathematical Epidemiology 1
Chair: Herbert W. Hethcote
University of Iowa

10:30 AM - 1:00 PM/Tangerine B Room
Minisymposium 29
Aerospace Design 2
Chair: Helena S. Wisniewski
Lockheed Corporation

10:30 AM - 12:30 PM/Oleander A Room
Minisymposium 30
Dynamical Systems in Crystalline Structures
Chair: John A. Simmons
National Institute of Standards and Technology

10:30 AM - 12:30 PM/Orange Room
Minisymposium 31
Metastable Dynamics in Physical Systems 2
Chair: Peter W. Bates
Brigham Young University

10:30 AM - 12:30 PM/Oleander B Room
Minisymposium 38
Nonlinear Mechanical Systems
Chair: Steven M. Shaw
Michigan State University

10:30 AM - 12:30 PM/Azalea Room
Contributed Presentations 9
Applied Fluid Modeling
Chair: Francis Sullivan
National Institute of Standards and Technology

12:00 PM/Ballroom Foyer
Registration Desk Closes

PROGRAM-AT-A-GLANCE

Thursday, May 10

8:00 AM/Ballroom Foyer
Registration Desk Opens

8:30 AM - 10:00 AM
Invited Presentations 8 and 9
Chair: Celso Grebogi
University of Maryland, College Park

8:30 AM - 9:15 AM/Lemon-Lime Room
Invited Presentation 8
Approximation Dynamics: Inerterial Manifolds and Hyperbolic Sets
George R. Sell
University of Minnesota, Minneapolis

9:15 AM - 10:00 AM/Lemon-Lime Room
Invited Presentation 9
The Dynamics and Geometry of Unconfined Flows
Katepalli R. Sreenivasan
Yale University

10:00 AM - 10:30 AM/Orange Room
Coffee

10:30 AM - 12:30 AM/Lemon-Lime Room
Minisymposium 32
Control of Chaos 4
Nonlinear Resonance Spectroscopy
Chair: Alfred Hubler
University of Illinois, Urbana

10:30 AM - 12:30 PM/Tangerine A Room
Minisymposium 33
Mathematical Epidemiology 2
Chair: Herbert W. Hethcote
University of Iowa

10:30 AM - 12:30 PM/Tangerine B Room
Minisymposium 34
Hyperbolicity in Dynamical Systems 1
Chair: Kenneth Palmer
University of Miami

10:30 AM - 12:30 PM/Jasmine Room
Minisymposium 35
Geometric Theory and Dynamics of Model Systems
Chair: Robert Cawley
Naval Surface Warfare Center

10:30 AM - 1:00 PM/Oleander B Room
Minisymposium 36
The Dynamics of Neural Networks and Their Applications
Chair: Helena S. Wisniewski
Lockheed Corporation

10:30 AM - 12:30 PM/Azalea Room
Contributed Presentations 10
Control and Optimization
Chair: Jong Uhn Kim
Virginia Polytechnic Institute and State University

10:30 AM - 12:30 PM/Hybiscus Room
Contributed Presentations 11
Chaos and Turbulence
Chair: John Lavery
Office of Naval Research

12:30 PM - 2:00 PM
Lunch

2:00 PM - 4:00 PM/Tangerine A Room
Minisymposium 37
Fractal Time Dynamics
Chair: Michael F. Shlesinger
Office of Naval Research

2:00 PM - 4:00 PM/Tangerine B Room
Contributed Presentation 8
Control
Chair: John Burns
University of Southern California and Virginia Tech

2:00 PM - 4:00 PM/Oleander B Room
Minisymposium 39
Dimensional Estimates and Extractions of Low Dimensional Models
Chair: Katepalli R. Sreenivasan
Yale University

2:00 PM - 4:00 PM/Azalea Room
Contributed Presentations 12
Biological Oscillators
Chair: G. Bard Ermentrout
University of Pittsburgh

2:00 PM - 4:00 PM/Hybiscus Room
Contributed Presentations 13
Integrable Systems
Chair: Jacques Belair
University of Montreal and
McGill University, Canada

2:00 PM - 4:00 PM/Jasmine Room
Contributed Presentations 14
Applications 3
Chair: Terry Herdman
Virginia Polytechnic Institute and State University

2:00 PM - 4:00 PM/Lemon-Lime Room
Contributed Presentations 15
Reaction Diffusion Equations
Chair: Joseph Mahaffy
San Diego State University

4:00 PM - 4:30 PM/Orange Room
Coffee

4:30 PM - 6:30 PM/Tangerine B Room
Minisymposium 40
Understanding Biological Dynamics: The Nonlinear Perspective 3
Chair: Michael C. Mackey
McGill University, Montreal, Canada

4:30 PM - 6:30 PM/Jasmine Room
Minisymposium 41
Computer Programs for Dynamical Systems
Chair: Hoseyin Kocak
University of Miami

4:30 PM - 6:30 PM/Hybiscus Room
Minisymposium 42
Fractals in Fluids
Chair: Celso Grebogi
University of Maryland, College Park

4:30 PM - 6:30 PM/Lemon-Lime Room
Minisymposium 43
Lie and Differential Algebraic Methods in Accelerator Physics
Chair: Alex J. Dragt
University of Maryland, College Park

4:30 PM - 6:30 PM/Tangerine A Room
Contributed Presentations 16
Modeling, Prediction, and Chaos
Chair:

4:30 PM - 6:30 PM/Azalea Room
Contributed Presentations 17
Applications 4
Chair: Terry Herdman
Virginia Polytechnic Institute and State University

4:30 PM - 6:30 PM/Oleander B Room
Contributed Presentations 17a
Late Contributions
Chair: David Green, Jr.
GMI Engineering and Management Institute

5:00 PM/Ballroom Foyer
Registration Desk Closes

Friday, May 11

8:00 AM/Ballroom Foyer
Registration Desk Opens

8:30 AM - 10:00 AM
Invited Presentations 10 and 11
Chair: Ira B. Schwartz
U.S. Naval Research Laboratory

8:30 AM - 9:15 AM/Lemon-Lime Room
Invited Presentation 10
Multiple Time Scales in Biological Bursting Oscillations
John Rinzel
National Institutes of Health

9:15 AM - 10:00 AM/Lemon-Lime Room
Invited Presentation 11
Do Computer Trajectories of Chaotic Systems Represent True Trajectories?
James A. Yorke
University of Maryland, College Park

10:00 AM - 10:30 AM/Orange Room
Coffee

10:30 AM - 12:30 PM/Lemon-Lime Room
Minisymposium 44
Dynamical Systems and Stochastic Processes
Chair: Thomas J. S. Taylor
Arizona State University

10:30 AM - 12:30 PM/Tangerine A Room
Minisymposium 45
Mathematical Epidemiology 3
Chair: Herbert W. Hethcote
University of Iowa

10:30 AM - 12:30 PM/Tangerine B Room
Minisymposium 46
Hyperbolicity in Dynamical Systems 2
Chair: Kenneth Palmer
University of Miami

10:30 AM - 12:30 PM/Oleander B Room
Minisymposium 47
Chaotic Scattering
Chair: Edward Ott
University of Maryland, College Park

10:30 AM - 12:30 PM/Hybiscus Room
Minisymposium 48
The Role of Coherent Structures in Two Dimensional Turbulence
Chair: George F. Carnevale
Scripps Institute of Oceanography

10:30 AM - 12:30 PM/Azalea Room
Contributed Presentations 18
Qualitive Theory of Differential Equations
Chair: Natalia Sternberg
Clark University

10:30 AM - 12:30 PM/Orange Room
Contributed Presentations 18a
Late Contributions
Chair:

12:00 PM
Registration Desk Closes

12:30 PM
Conference Adjourns

CONFERENCE PROGRAM

Sunday, May 6

6:00 PM - 9:00 PM/Ballroom Foyer
Registration Opens

7:00 PM - 9:00 PM/Orange Room
Welcoming Reception
Cash Bar

Monday, May 7

7:00 AM/Citrus Ballroom Foyer
Registration Opens

8:15 AM - 8:30 AM/Lemon-Lime Room
Opening Remarks
Henry D.I. Abarbanel
University of California, San Diego

Monday, May 7/8:30 - 9:15 AM
Invited Presentation 1/Lemon-Lime Room

Resonant Stimulation and Control of Complex Systems

Chair:

The characterization of turbulence and similar nonequilibrium states in Chemistry, Biology and Physics is a topic with many unsolved problems. Recent developments in nonlinear dynamics provide powerful tools to investigate and to handle certain classes of those systems. The emphasis of the talk is to illustrate that it is possible to control certain chaotic and turbulent systems by special driving forces. These driving forces have a complicated time dependence and space dependence, but they can be easily calculated numerically without any feedback from the experiment. Further, it is possible to show that the response of nonlinear oscillators to special aperiodic driving forces is many orders of magnitude larger than the response to sinusoidal perturbations. This effect can be used to improve models for nonlinear systems.

Alfred Hubler
Center for Complex Systems Research,
Department of Physics
Beckman Institute
University of Illinois, Urbana

Attention Attendees:

Twenty minutes are allowed for each contributed presentation. Presenters are requested to spend a maximum of 17 minutes for their presentations and 3 minutes for questions and answers.

A minisymposium session is approximately 2-hour long. In a session with 3 presenters, presentations are spaced 40 minutes apart (35 minutes for presentation and 5 minutes for questions and answers); if there are 4 presenters, presentations are spaced 30 minutes apart (25 minutes for presentation plus 5 minutes for questions and answers).

Please note:

(a) For presentations with more than one author, an underlineation is used to denote the author who will give the talk.

(b) The numbers in italics, which precede the title of the talk e.g., 10:30/A1 denote the time the presentation is being given and the page-location of the abstract, respectively.

Monday, May 7/9:15 - 10:00 AM
Invited Presentation 2/Lemon-Lime Room

Simulating Science with Coupled Map Lattices

Chair:

Modeling and characterization of complex dynamical phenomena in space are important in the study of turbulence not only in fluid dynamics, but also in solid-state physics, optics, chemical reaction with diffusion, and biological information processing. This class of phenomena, called spatio-temporal chaos, can be described as chaos with many degrees of freedom.

Several years ago the speaker proposed a simple model for spatio-temporal chaos, called coupled map lattice (CML). CML is a dynamical system with discrete time, discrete space, and continuous state. In the presentation, the speaker will review the pattern dynamics in CML and discuss applications of CML to pattern formation, fluid dynamics, excitable media, and Josephson junction arrays. Novel biological information processing in globally coupled maps is also discussed with the emphasis on clustering, hierarchical coding, information flow, and dynamical switching.

Kunihiko Kaneko
Institute of Physics
University of Tokyo

10:00 AM - 10:30 AM/Orange Room
Coffee

Monday, May 7/10:30 AM - 12:30 PM
Minisymposium 1/Lemon-Lime Room

Control of Chaos (part 1 of 4) Modeling and Control of Low Dimensional Chaos

Recently it has been shown that it is possible to control chaotic and turbulent systems. The corresponding driving forces have a complicated time dependence and space dependence, but they can be easily calculated numerically without any feedback from the experiment.

Applications of these results can be found in the control of nonlinear dynamics like oscillations of mechanical systems, vibrations of molecules, on the dynamics of Josephson junctions, the control of systems with a complicated spatial structure e.g., turbulent flows and dendritic growth, the prediction and control of catastrophes, e.g., ruptures, earthquakes, the control of neural networks, and in nonlinear resonance spectroscopy.

In particular, nonlinear resonance spectroscopy is an area with good potential for applications. It is possible to show that the response of nonlinear oscillators to special chaotic driving forces is many orders of magnitude larger than the response to sinusoidal perturbations. Therefore, the stimulation by chaotic driving forces is a very sensitive tool in order to investigate nonlinear systems, like acoustic or electromagnetic excitations in solids, microscopic and macroscopic biological systems, oscillatory chemical systems or the dynamics of a highly stimulated nucleus.

Organizer: Alfred Hubler
Beckman Institute, University of Illinois, Urbana

10:30/A1
On Controlling Complex Dynamic Systems
E. A. Jackson, University of Illinois, Urbana

11:10/A1
Control of Nonlinear Continuous Systems Based on Poincare Maps
R. Georgii, Technical University of Munich, W. Germany

11:50/A1
Modeling and Control of Dynamical Systems with Hidden Variables
J. Breeden, University of Illinois, Urbana

Monday, May 7/10:30 AM - 12:30 PM
Minisymposium 2/Tangerine A Room

Applications to Population Biology (part 1 of 2)

The presentations in this minisymposium describe the applications of dynamical systems to various aspects of population biology. These include models of population growth, resource competition, persistence and extinction, spread of diseases, microbial ecology, and tumor chemotherapy. The presentations emphasize both the modeling aspects and the use of techniques from dynamical systems and ergodic theory.

Organizer: Paul Waltman
Emory University

10:30/A1
Is Intraspecific Competition Between Juveniles and Adults Stabilizing or Destabilizing?
J. M. Cushing, University of Arizona; and Jia Li, Los Alamos National Laboratory

11:00/A1-2
Permanence and the Ergodic Theorem
Josef Hofbauer, Universitat Wien, Austria

11:30/A2
Competition in the Gradostat
Hal L. Smith, Arizona State University

12:00/A2
Effect of an Internal Nutrient Pool on Growth of Microorganisms in the Chemostat
Betty Tang, Wake Forest University; and Gail S. K. Wolkowicz, McMaster University, Hamilton, Ontario

Monday, May 7/10:30 AM - 1:00 PM
Minisymposium 3/Tangerine B Room

Mathematical Models for Microstructural Evolution: Tools for the Intelligent Processing of Materials

The dynamics of solidification and subsequent annealing of multicomponent materials are only qualitatively understood for multicomponent systems. Understanding the evolution of the microstructure of materials during the processing of multicomponent materials and developing materials is an ad hoc, time-consuming, and costly process. To speed design and development and to meet the challenges of the rapidly advancing field of advanced high temperature materials, material scientists need to simulate this process, to predict the evolution of the microstructures, to develop methods to control materials processing, and to determine structural stability for long periods of time. However, mathematical difficulties have delayed the intelligent processing of materials. Dynamical systems hold the key to resolving some of these difficulties and some investigators have begun to do so. For example, the Chan-Hilliard non-linear reaction diffusion equation describes the evolutionary dynamics of microstructure occurring during solidification and subsequent annealing of metallic alloys for multicomponent alloys. Previous techniques involved linearization producing solutions which only described the initial states in the annealing process. In contrast, dynamical systems techniques such as inertial manifolds reduce the infinite dimensional system to a finite dimensional one that retains the original dynamics.

This minisymposium will begin with an overview of intelligent processing of materials emphasizing the need for dynamical system techniques and their potential and current impact. The presentations that follow will expand upon the topics presented in the overview and will include applications by industry.

Organizer: Helena S. Wisniewski
Lockheed Corporation

10:30/A2
An Overview of the Intelligent Processing of Materials
Hayden Wadley, University of Virginia

10:55/A2
An Overview of New Materials
Ben Wilcox, Defense Advanced Research Projects Agency

11:20/A2
Numerical Solutions of Front Propagation Problems
Stan Osher, University of California, Los Angeles

11:45/A3
Pattern Selection During Crystal Growth
Herbert Levine, University of California, San Diego

12:10:A3
Evolution of Microstructure Welds
John Goldak, M.J. Bibby, P. Khoral, and M. Gu, Carleton University, Ottawa

12:35/A3
Simulation of Residual Stress Effects on the Mechanical Behavior of Metal Matrix Composites
Alan Neddleman, G. Povirk and S. Nutt, Brown University

Monday, May 7/10:30 AM - 12:30 PM
Minisymposium 4/Magnolia Room

Magnetic Dynamos (part 1 of 2)

Flowing, conducting fluids, such as those in the Sun, the Earth's core, and other astrophysical objects, are often observed to have magnetic fields. An approach to explaining this is through fast kinematic dynamo action, wherein an initially unmagnetized fluid is perturbed by the addition of a small magnetic field which then grows exponentially. In astrophysical situations, the magnetic Reynolds number is typically very large. For example, $R_m \sim 10^8$ for the Sun. So it is useful to consider the singular limit $R_m \rightarrow \infty$. Dynamo action in this limit serves as a prototype of other singular problems in which singularities of fractals occur, e.g. fully developed turbulence. Recently there has been a flurry of progress made by applying the techniques of dynamical systems to understand fast magnetic dynamos in smooth physical chaotic flows. In particular, it seems that chaos is necessary but not sufficient for fast dynamo action in the $R_m \rightarrow \infty$ limit.

Organizer: Ittai Kan
George Mason University

10:30/A3
Rigorous Results on Fast Magnetic Dynamos
John M. Finn, University of Maryland, College Park; James D. Hanson, Auburn University; Ittai Kan, George Mason University; and Edward Ott, University of Maryland, College Park

11:10/A3
Fast Kinematic Magnetic Dynamos and Chaotic Flows
Edward Ott, University of Maryland, College Park

11:50/A3
Nonlinear Stability for Magnetic Flows
Susan Friedlander, University of Illinois, Chicago; and M. M. Vishik, Institute of Physics of the Earth, Moscow, U.S.S.R.

Monday, May 7/10:30 AM - 12:30 PM
Minisymposium 5/Oleander A Room

Graphics, Imaging and Vision (part 1 of 2)

This minisymposium concerns 3-D graphics applications, random geometries and problems in 3-D imaging and vision. With the advent of high-speed computing and the capability of processing large amounts of data, great progress is being made in the areas of imaging and vision; and scientific visualization is having a tremendous impact on applied research. Presentations will focus on advanced 3-D graphics and animation software, 3-D medical imaging, visual perception, and random geometries.

Organizer: Marc A. Berger
Georgia Institute of Technology

10:30/A4
Focal Attention and its Function in Early Vision
Jochen Braun, California Institute of Technology, and Dov Sagi, The Weizmann Institute of Science, Rehovot, Israel

11:00/A4
Texture Discrimination Learning: Implications for the Functional Architecture of Early Vision
Avi Karni, The Weizmann Institute of Science, Rehovot, Israel and Chaim Sheba Medical Center, Tel-Hashomer, Israel; and Dov Sagi, The Weizmann Institute of Science, Rehovot, Israel

11:30/A4
Necessary and Sufficient Global Computations in Texture Segmentation
Dov Sagi and Barton S. Rubenstein, The Weizmann Institute of Science, Rehovot, Israel

12:00/A4-5
Data Structures and Algorithms for Volumetric Brain Imaging
Scott B. Berger, Robert D. Leggiero, Jason J. Orefice and Gregory F. March, Cornell University

Monday, May 7/10:30 AM - 12:30 PM
Contributed Presentations 1/Oleander B Room

Fractal Sets

Chair: Hans Othmer, University of Utah

10:30/A5
Classification of Strange Attractors by Integers
Gabriel B. Mindlin, Xin-Jun Hou, Hernan G. Solari, and R. Gilmore, Drexel University; and N. B. Tufillaro, Bryn Mawr College

10:50/A5
Dependence of Hausdorff and Fractal Dimensions on a Metric of a Phase Space
Victor I. Shubov, Texas Tech University

11:10/A5
Box-Counting with Base b Numerals
Stuart C. Bingham, University of Tennessee, Knoxville

11:30/A5
Fingerprints for Strange Sets
Nicholas B. Tufillaro, Bryn Mawr College, H. G. Solari and R. Gilmore, Drexel University

11:50/A50
Analytical Models for Phase Transition
Artur O. Lopes, University of Maryland, College Park

12:30 PM - 2:00 PM
Lunch

Monday, May 7/2:00 - 2:45 PM
Special Lecture/Lemon-Lime Room

Air Force Interest and Funding in Nonlinear Dynamical Systems

Chair: Peter Bates, Brigham Young University

Early work in nonlinear dynamical systems provided some convincing evidence that a reappraisal of our perspectives on both classical physics and iterative maps was warranted. Such major sea changes are rare and merit support simply as a seminal idea whose impact on Air Force mission capability would surely follow.

Such was the thinking of the speaker's AFOSR predecessor, Dr. Robert Buchal. It is clear that he was right. What is currently exciting are the amazing variety of impacts of dynamical systems. The speaker will describe several of them.

Arje Nachman
Directorate of Mathematical and Information Sciences
Air Force Office of Scientific Research

Monday, May 7/2:45 AM - 3:30 PM
Invited Presentation 3/Lemon-Lime Room

Generating Wavelets as Attractors of Random Dynamical Systems

Chair: Peter Bates, Brigham Young University

Wavelets are special functions with the property that their translations by integers and dilations by powers of two are all orthogonal. They have the unique feature of being local in space and frequency. Wavelets are constructed via recursive algorithms involving three traversal. The purpose of this talk is to show how wavelets, along with B-splines, Bezier curves and other interpolants, arise as attractors for random dynamical systems (affine iterated function systems). This means that these curves can be generated by running a single trajectory of a simple Markov chain—a chain which is generated through compositions of i.i.d. affine transformations. Effectively ergodic theory is being used to replace tree-traversal. This random algorithm is very fast, involving only affine arithmetic, and lends itself naturally to parallel processing.

Marc A. Berger
School of Mathematics
Georgia Institute of Technology

Monday, May 7/3:30 - 4:30 PM; and Tuesday, May 8/3:30 - 4:30 PM/Orange Room
Poster Session

A24
Laser with Injected Signal: Perturbation of an Invariant Circle
Hernan G. Solari, Drexel University; and Gian-Luca Oppo, University of Strathclyde, Strathclyde, Scotland

A24
Large Time Behavior of Viscoelastodynamics in Many Dimensions
Piotr Rybka, Courant Institute of Mathematical Sciences, New York University

A24
An Application of the Phase-Variable Canonical Form of Time-Invariant Linear Dynamic Systems
Ala Al-Humadi, Embry-Riddle Aeronautical University

A25
The Effect of Hysteresis on Bifurcation Phenomena in Ferroresonant Circuit
Nozomi Morioka, Kokushikan University, Tokyo, Japan

A25
Relaxation and Bifurcation in Brownian Motion Driven by a Chaotic Force
Toshihiro Shimizu, Kokushikan University, Tokyo, Japan

A25
The Invertebrate Heart as a Chaotic Oscillator
Andrew D. Arsenault, T. E. Keliher and M. Edwin DeMont, St. Francis Xavier University, Nova Scotia, Canada

A25
Loss of Chaos in Quasiperiodically Forced Nonlinear Oscillator
Tomasz Kapitaniak, University of Leeds, Leeds, United Kingdom

A25
Dynamic Theory of Multimass Systems Vibrating with Impacts
Shu Zhonghou, Southwestern Jiaotong University, Sichuan, People's Republic of China

A26
Nonlinearity, Perturbation Techniques, and Equations of the Atmospheric Sciences
Igor G. Malyshev, San Jose State University

A54
Quantum Ergodicity: A Numerical Test of a Recent Conjecture
Paolo Bellomo, Antonio Scotti and Fabio Zanzucchi, University of Parma, Italy

A26
Centre of Mass and Moment of Inertia of Random, Fractals, and Fractal Attractors
Miguel Angel Martin, Universidad Politecnica de Madrid, Spain

A26
Fourier Analysis on the Fractal Sets
Miguel Reyes, Universidad Politecnica de Madrid, Spain

4:00 PM - 4:30 PM/Orange Room
Coffee

Monday, May 7/4:30 - 6:30 PM
Minisymposium 6/Tangerine A Room

Modeling and Forecasting Time Series; A Dynamical Systems Approach

There has been much recent interest in forecasting algorithms that attempt to analyze a time series by fitting nonlinear models. The purpose of this minisymposium is to present ongoing research addressing the following three questions from both a theoretical and practical point of view. How do the forecasting algorithms compare to well-known dimension calculations? What are the theoretical limitations to forecasting in the presence of noise? Now are forecasting algorithms modified for analyzing randomly forced systems, such as vibration testing?

Organizer: Martin Casdagli
Santa Fe Institute

4:30/A5 - 6
Using Prediction Algorithms to Improve Dimension Estimation
James Theiler, MIT Lincoln Laboratory

5:10/A6
Analysis of Nonlinear and Chaotic Models in Vibrating Systems
Norman Hunter, Los Alamos National Laboratory

5:50/A6
Noise Amplification and Takens Embedding Theorem
(To be presented by organizer)

Monday, May 7/4:30 - 6:30 PM
Minisymposium 7/Tangerine B Room

Understanding Biological Dynamics; The Nonlinear Perspective (part 1 of 3)

Over the past decade, the application of concepts and techniques from the rapidly expanding field of nonlinear dynamics has yielded insight into a variety of basic biological phenomena as well as applied medical problems that are just as exciting as those in the physical and engineering sciences. The speakers in this minisymposium will illustrate, drawing on their own varied research, the ways in which a combination of realistic biomathematical modeling and mathematical analysis has increased our comprehension of the functioning of biological systems in fields as diverse as neurobiology, cardiology, renal physiology, hematology, and cell kinetics.

Organizer: Michael C. Mackey
McGill University, Montreal, Quebec

4:30/A6
Nonlinear Dynamics of Endocrine Regulation
Uwe an der Heiden, University of Witten/Herdecke, Witten, West Germany

5:00/A6
The Effect of Noise on Oscillation Onset in the Pupil Light Reflex
Andre Longtin, Los Alamos National Laboratory

5:30/A6 - 7
Delayed Mixed Feedback and the Complexity of Neural Dynamics
John Milton, University of Chicago

6:00/A7
Nonlinear Dynamics of Electronic Neural Networks
R. M. Westervelt, Harvard University

Monday, May 7/4:30 - 6:30 PM
Minisymposium 8/Oleander A Room

Graphics, Imaging and Vision (part 2 of 2)

(see previous description)

Organizer: Marc A. Berger
Georgia Institute of Technology

4:30/A7
Cyclic Particle Systems and Cyclic Cellular Automata
Robert Fisch, University of North Carolina at Charlotte

4:55/A7
Some Computations on Parameters of Random Polygons by Simulation
S. Bercovich and E. Merzbach, Bar-Ilan University, Ramat Gan, Israel

5:20/A7
Graphics and Visualization at the Pittsburgh Supercomputing Center
Joel Welling, Mellon Institute

5:45/A7 - 8
Image Generation via Iterated Function Systems and the Propagation of Rounding Errors
Mario Peruggia, Carnegie-Mellon University

6:10/A8
Multi-scale Algorithm for an Image Segmentation Problem
Yang Wang, Georgia Institute of Technology

Monday, May 7/4:30 - 6:30 PM
Minisymposium 9/Oleander B Room

The Computation of Dynamical Systems (part 1 of 2)

Computation has emerged as a powerful tool in the study of dynamical systems both as an aid to the development of new qualitative theories and as the means to obtaining quantitative information from existing theory. Detailed numerical studies of dynamical systems can be done for iterations of mappings and several of the presentations will focus on this theme. The dynamics of ordinary differential equations are important in many areas of application. Several presentations will focus on the effectiveness of new numerical methods and codes for ordinary differential equations. Applied mathematicians and scientists have become increasingly interested in the dynamics of partial differential equations. The need for accurate computation of the long-time dynamical behavior of partial differential equations has recently motivated the development of new techniques in numerical analysis which will be presented in the minisymposium.

Organizer: Mitchell Luskin
California Institute of Technology

4:30/A8
Symmetry Creation in Nonlinear Systems
Mike Field, University of Sydney, Sydney, Australia; and Martin Golubitsky,The University of Houston

4:55/A8
The Dynamics of Coupled Pendula
D. G. Aronson, University of Minnesota, Minneapolis, E. G. Doedel, Concordia University, Montreal, Quebec, and Hans G. Othmer, University of Utah

5:20/A8
Computation of Invariant Manifolds
Jens Lorenz, The University of New Mexico

5:45/A8 - 9
Computer Algebra and Elliptic Functions
Richard H. Rand, Cornell University

6:10/A9
Numerical Explorations of a Simple Model for Cardiac Echo
G. B. Ermentrout, University of Pittsburgh

Monday, May 7/4:30 - 6:30 PM
Minisymposium 10/Magnolia Room

Application of Dynamical Systems to the Understanding of Earthquakes

The deformation of the continental crust is a complex phenomena. Superimposed on the complexity is considerable order. For example, the frequency-magnitude statistics of earthquakes are fractal. The formulation of the full deformation problem remains beyond the scope of present understanding. However, simplified models based on friction laws often yield chaotic solutions.

Organizers: Donald L. Turcotte, Cornell University, and John B. Rundle, Sandia National Laboratories

4:30/A9
Failure of Hierarchical Distributions of Fiber Bundles: Statics and Dynamics
William I. Newman, University of California, Los Angeles; Andrei M. Gabrielov, U.S.S.R. Academy of Sciences; S. Leigh Phoenix and Donald L. Turcotte, Cornell University

4:50/A9
A Demonstration that Seismicity is an Example of Deterministic Chaos
Donald L. Turcotte and J. Huang, Cornell University

5:10/A9
Self-Organization, and Scaling in Earthquakes and Automata Models
John B. Rundle, Sandia National Laboratories

5:30/A9 - 10
Nonlinear Convection in the Earth's Mantle
Cheryl A. Stewart, Cornell University

5:50/A10
Fractals in Nucleation in Magnetic Systems and Crystals
William Klein, Boston University

6:10/A10
Earthquakes as a Self-Organized Critical Phenomenon
Per Bak, Brookhaven National Laboratory

Monday, May 7/4:30 - 6:30 PM
Minisymposium 11/Lemon-Lime Room

Fractal Basin Boundaries

When a dynamical system has more than one attractor, the boundaries between different basins of attraction are often fractal, making final state prediction extremely difficult. Fractal basin boundaries can be viewed as chaotic repellers. As such, their structure is analogous to that of chaotic attractors. This minisyposium will address crises of attractors, metamorphoses (i.e., sudden lumps) of basin boundaries, and the dimension of basin boundaries.

Organizer: Kathleen Alligood
George Mason University

4:30/A10
Changes in Accessible Orbits at Crises and Metamorphosis
(to be presented by organizer)

5:10/A10
Basic Sets: Sets that Determine the Dimension of Basin Boundaries
Celso Grebogi, University of Maryland, College Park

5:50/A10-11
Experimental Observation of Crises-Induced Intermittency and its Critical Exponent
Steve Rauseo, W. L. Ditto, and R. Cawley, Naval Surface Warfare Center; C. Grebogi, University of Maryland, College Park; G. H. Hsu, Naval Surface Warfare Center; E. Ott and E. Kostelich, University of Maryland, College Park; H. T. Savage, Naval Surface Warfare Center; R. Segman, American University; M. L. Spano Naval Surface Warfare Center; J. A. Yorke, University of Maryland, College Park.

5:00 PM/Ballroom Foyer
Registration Desk Closes

6:30 PM-8:00 PM/Poolside
SIAM Idea Exchange

Tuesday, May 8

7:30 AM/Ballroom Foyer
Registration Desk Opens

Tuesday, May 8/8:00-8:45 AM
Invited Presentation 4/Lemon-Lime Room

Diffusional Phase Transformations in Solids

Chair: Shui-Nee Chow, Georgia Institute of Technology

The simplest kinds of phase changes in solids result from the diffusional interchanges of atoms in a crystal that either leave the crystal structure unchanged, or at most create new crystals with a one-to-one correspondence of atom sites between old and new. Such phase changes are quite common and are classified by easily made observations, e.g. according to whether or not spatial variations develop, whether space group symmetry changes occur, etc. Modeling of such phenomena usually begins with an energy functional and a kinetic model, and leads to a set of differential difference equations, a set of nonlinear PDEs, or a set of functional equations. Important features of such equations are that the parameters or coefficients change with temperature, and that a solution stable at one temperature becomes unstable at another, leading to a phase change. The modeling of one well-studied phase change suggests that, while it basically results from a change of sign of the diffusion coefficient, the model must include other factors if there is to be a well-posed problem.

The presentation will begin with qualitative observations, try to identify those that should lead to interesting dynamical systems, and discuss the various formulations that have been proposed. Open problems are not just those of solution in three space, but also of experimental verification of the model and of the application of the theoretical results.

John W. Cahn
Institute for Material Science and Engineering
National Institute of Standards and Technology

Tuesday, May 8/8:45-9:30 AM
Invited Presentation 5/Lemon-Lime Room

Dynamics for Thin Domains

Chair: Shui-Nee Chow, Georgia Institute of Technology

Given a PDE on a thin domain in $\mathbb{R}^3$ we discuss the problem of finding a PDE on a lower dimensional domain which will carry the same dynamics. Applications are given to parabolic and hyperbolic problems.

Jack K. Hale
Center for Dynamical Systems and Nonlinear Studies
Georgia Institute of Technology

9:30 AM-10:00 AM/Orange Room
Coffee

Tuesday, May 8/10:00 AM-12:00 PM
Minisymposium 12/Lemon-Lime Room

Control of Chaos (part 2 of 4) Control of High Dimensional Nonlinear Systems

(See previous description)

Organizer: Alfred Hubler
Beckman Institute, University of Illinois, Urbana

10:00/A11
Aperiodic Perturbations for Optimal Bond Breaking
Gottfried Mayer-Kress, University of California, Santa Cruz

10:40/A11
Control of the Dynamics of Shock Waves and Complicated Flows by Aperiodic Perturbations
R. Shermer, Beckman Institute, University of Illinois, Urbana

11:20/A11
Description of the Dynamics of Karman Vortex Streets by Low Dimensional Differential Equations
E. Roesch, F. Ohle, H. Eckelman, Institut fur Angewandte Mechanik und Stromungsphysik der Universitat Gottingen, W. Germany and A. Hubler, University of Illinois, Urbana

Tuesday, May 8/10:00 AM-12:00 PM
Minisymposium 13/Tangerine A Room

Applications to Population Biology (part 2 of 2)

(See previous description)

Organizer: Paul Waltman
Emory University

10:00/A11
A Dynamical Systems Analysis of a Model of Learning in Population Genetics
Steven R. Dunbar, University of Nebraska, Lincoln

10:30/A12
A Heterosexual Model for the AIDS Epidemic with Biased Social Mixing
James Hyman and E. Ann Stanley, Los Alamos National Laboratory

11:00/A12
Pioneer-Climax Models of Difference and Differential Equations
James F. Selgrade and Gene Namkoong, North Carolina State University

11:30/A12
A Model of Tumor Growth with Application to Chemotherapy Scheduling
G. F. Webb, Vanderbilt University

Tuesday, May 8/10:00 AM-12:30 PM
Minisymposium 14/Tangerine B Room

Aerospace Design (part 1 of 2)

The aircraft design process and the design of space structures involves many aspects of dynamical systems. These include fluid dynamics and structural dynamics for stability and active control. This minisymposium will present two overviews: the aircraft design process with a focus on fluid dynamics and the design of space structures with a focus on stability and active control. This will set the stage for the presentations that follow. One focus of fluid dynamics will be on turbulence modeling. This will include not only new models such as a renormalization group methods (RNG) and its application by industry, but also a comparison of various models being used currently. The design of space structures will include various structural dynamic problems such as stability, and how active control can provide a solution. The active control methods will include the use of innovative materials, such as magnetostristrictive materials and how dynamical systems have helped to understand and predict the behavior of these materials.

Organizer: Helena S. Wisniewski
Lockheed Corporation

10:00/A12
Aircraft Design: A Conceptual Approach
Daniel P. Raymer, Lockheed Aeronautical Systems Co.

10:25/A12
Compressible Turbulence Theory
Steven A. Orszag, Princeton University

10:50/A12-13
Advanced Large Eddy Simulation on Highly Parallel Computers
Jay Boris, Naval Research Laboratory

11:15/A13
A Comparison of Turbulence Models
Manuel Salas, NASA Langley Research Center

11:40/A13
Computational Aerodynamics and Control Theory Approach to the Design Problem
Tony Jameson, Princeton University

12:05/A13
Overview of Adoptive Techniques—Using Unstructured Grids
Rainald Lohner, George Washington University

Tuesday, May 8/10:00 AM-12:00 PM
Minisymposium 15/Oleander A Room

Statistical Methods in Image Processing and Computer Vision

The four talks in this minisymposium will be organized so as to give a representative picture of the Bayesian statistical framework for Image Processing and Computer Vision tasks. Three of the talks will address applications to image processing (segmentation, deconvolution, texture analysis), computer tomography, and recognition in robotics vision. The fourth talk will address theoretical aspects of the underlying computational and inference algorithms such as annealing, multigrid and renormalization group methods, and statistical inference for Markov random fields.

Organizer: Basilis Gidas
Brown University

10:00/A13
Image Restoration with Implicit and Explicit Representation of Discontinuities
Don Geman and George Reynolds, University of Massachusetts, Amherst

10:30/A13
A Comprehensive Statistical Model for Medical Emission Tomography
Stuart Geman, Donald E. McClure and Kevin Manbeck, Brown University

11:00/A14
Data and Model Driven Multiresolution
Ruud M. Bolle, Andrea Califano and Rick Kjeldsen, IBM T. J. Watson Research Center

11:30/A14
Computational and Estimation Algorithms in Computer Vision
(to be presented by organizer)

Tuesday, May 8/10:00 AM - 12:00 PM
Minisymposium 16/Oleander B Room
Magnetic Dynamos (part 2 of 2)

(See previous description)

Organizer: Ittai Kan
George Mason University

10:00/A14
Magnetic Field Generation by the Motion of a Highly Conducting Fluid
M. M. Vishik, Institute of Physics of the Earth, Moscow, U.S.S.R., and University of Illinois at Chicago

10:40/A14
Stable and Unstable Manifolds in Chaotic Fast Dynamos
Isaac Klapper, Courant Institute of Mathematical Sciences, New York University

11:20/A14
Fast Dynamo Action in Chaotic Webs
S. Childress, Courant Institute of Mathematical Sciences, New York University; A. Gilbert, DAMTP, Cambridge, United Kingdom; and U. Frisch, Observatoire de Nice, Nice, France

Tuesday, May 8/10:00 AM - 12:00 PM
Minisymposium 17/Hybiscus Room
Nonlinearities in the Atmospheric Sciences

A fundamental problem in the atmospheric sciences is existence of a wide range of time and space scales in nonlinear geophysical flows—from small scale turbulent fluctuations to long-term variations in the climate—suggesting the involvement of an enormous number of degrees of freedom. By contrast, theoretical studies and weather prediction models assume that the atmosphere can be represented by a relatively low-order (i.e., manageable) dissipative dynamical system, an assumption which is being investigated. Various approaches including the construction of "weather" and "climate" attractors from data, the effects of truncation, and the search for invariant or nearly invariant manifolds will be discussed.

Organizer: Thomas Warn
McGill University

10:00/A15
Chaos and Predictability in Atmospheric Flows with Two Scales of Motion
V. Krishnamurthy, University of Maryland, College Park

10:30/A15
Applying Chaos Theory to Weather and Climate
Anastasios A. Tsonis, University of Wisconsin, Milwaukee

11:00/A15
An Attractor Preserving Algorithm for Truncating Pre-Chaotic Hydrodynamic Systems
Hampton N. Shirer, and Robert Wells, Pennyslvania State University

11:30/A15
1-D Models of 2- and 3-D Turbulence with Many Scales
Peter Bartello, Route Trans-Canadienne, Dorval, Quebec and Thomas Warn, McGill University, Montreal, Quebec

Tuesday, May 8/10:00 AM - 12:00 PM
Contributed Presentations 2/Azalea Room
Bifurcation Theory

Chair: Martin Golubitsky, University of Houston

10:00/A15-16
Hopf Bifurcation Coefficients by Power Series Methods
Brian Hassard and Hao Zhou, SUNY at Buffalo

10:20/A16
A Perturbed Hopf Bifurcation with Reflection Symmetry
Wayne Nagata, University of British Columbia

10:40/A16
Degenerated Hopf Bifurcation of A Stochastically Disturbed System
C. W. S. To and D. M. Li, University of Western Ontario, London, Canada

11:00/A16
Global Bifurcations in the Disturbed Hamiltonian Vector Field Approaching 3:1 Resonant Poincare Map (I)
Jibin Li, Kunming Institute of Technology, Kunming Uynnan, People's Republic of China

11:20/A16
Bifurcation Into Sphere
Jyun-Horng Fu, Wright State University

11:40/A16
Monotone and Antimonotone Behavior in the Cubic Map
Silvina Ponce Dawson, Celso Grebogi and James A. Yorke, University of Maryland, College Park

12:00 PM - 1:30 PM
Lunch

Tuesday, May 8/1:30 - 3:30 PM
Minisymposium 18/Tangerine A
Stochastic Chaos—State Space Modeling from Empirical Data

Recently, empirical methods have been successful in reconstructing the nonlinear dynamics of deterministic systems. However, these methods can behave poorly in the presence of noise in the observations or process excitation. Addressing the general problem including stochastic terms involves several fundamental issues. The embedding problem involves the selection of a state for the process that contains adequate information from the past for prediction of the future of the process. The embedding problem is directly addressed by canonical variate analysis of past and future. The determination of the process dynamics given the state embedding is related to statistical regression in high dimensional spaces. This minisymposium gives an overview of the issues, presentations of the state space embedding approach, canonical variate analysis, and nonlinear regression in high dimensions.

Organizer: Wallace E. Larimore
Computational Engineering, Inc.
Overview of Issues
(15-minute presentation by organizer)

2:00/A17
State Space Reconstruction in the Presence of Noise
Stephen Eubank, Los Alamos National Laboratory

2:30/A17
Canonical Variate Analysis of Stochastic Chaos
(to be presented by organizer)

3:00/A17
Approximating Noisy Functions in High Dimensions
Jerome H. Friedman, Stanford University

Tuesday, May 8/1:30 - 3:30 PM
Minisymposium 19/Oleander B Room
Nonlinear Models in Image Processing

Nonlinear models in Image Processing provide a powerful way for incorporating global constraints. This minisymposium features such models based on four different approaches: (i) variational methods, (ii) nonlinear heat equation, (iii) shock waves and (iv) stochastic methods.

Organizer: Jayant Shah
Northeastern University

1:30/A17
Feature Oriented Image Enhancement Using Nonlinear Partial Differential Equations
Stanley Osher, University of California, Los Angeles and Cognitech, Inc., Leonid Rudin and Emad Fatemi, Cognitech, Inc.

2:00/A18
A Nonlinear Filter that Enhances Edges
Mark Nitzberg and Takahiro Shiota, Harvard University

2:30/A18
Image Reconstruction and Recognition Through Deformable Templates
Yali Amit, Brown University

3:00/A18
Hierarchical Image Segmentation by Variational Methods
Thomas Richardson, Massachusetts Institute of Technology

Tuesday, May 8/1:30 - 3:30 PM
Minisymposium 20/Hybiscus Room
Applications of Dynamical Systems in Combustion Theory

Dynamical systems of nonlinear partial differential equations arise in the mathematical description of propagating reaction fronts in the combustion of solids, liquids and gases. Using examples from flame theory, combustion synthesis and solid/liquid propellant deflagration, the speakers demonstrate various types of nonlinear stability phenomena that lead to the bifurcation of a variety of nonsteady (periodic, quasi-periodic, chaotic) and/or nonplanar combustion waves.

Organizer: Stephen B. Margolis
Sandia National Laboratories

1:30/A18
Applications of Nonlinear Stability Theory in Premixed Combustion Systems
(to be presented by organizer)

2:00/A18
Patterns in Time-Periodic Laminar Premixed Flames
Martin Golubitsky and Michael Gorman, The University of Houston

2:30/A19
Bifurcation, Pattern Formation and Chaos in Combustion
Bernard J. Matkowsky, Northwestern University

3:00/A19
Bifurcations in a Burner-stabilized Flame
D. O. Olagunju, University of Delaware, and Bernard J. Matkowsky, Northwestern University

Tuesday, May 8/1:30 - 3:30 PM
Contributed Presentations 3/Tangerine B Room
Population Biology

Chair: Hal Smith, Arizona State University

1:30/A19
Invariant Manifolds in a Predator-Prey Model
Alfredo Somolinos, Mercy College; and Alfonso Casal, Madrid University, Madrid, Spain

1:50/A19
Intermittency and Quasiperiodicity in Age-Structured Population Models with Constrained Total Biomass
Rebecca S. Sample and Susan R. McKay, University of Maine

2:10/A20
Global Stability and Uniform Persistence of Diffusive Food Chains
Yang Kuang, Arizona State University

2:30/A20
A Solution Semiflow with a Nondiscrete Rest Point Set
Georg Hetzer, Auburn University

CONFERENCE PROGRAM

2:50/A20
Coexistence of Two Types on a Single Resource in Discrete Time
Frederick R. Adler, Cornell University

Tuesday, May 8/1:30-3:30 PM
Contributed Presentations 4/Oleander A Room
Forced Systems

Chair: P. R. Sethna, University of Minnesota, Minneapolis

1:30/A20
Coplanar and Nonplanar Forcing of a Damped Pendulum
Peter J. Bryant, University of Canterbury, Christchurch, New Zealand

1:50/A20
A Model of a Damped Spherical Pendulum Horizontally Forced Near Resonance
Bradford D. Bond, Cornell University

2:10/A21
Large Amplitude Quasi Periodic Motions for Certain Forced Nonlinear Dynamical Systems
Melvyn S. Berger, University of Massachusetts, Amherst

2:30/A21
Homoclinic Chaos in Systems Perturbed by Weak Langevin and Multiplicative Noise
William C. Schieve, University of Texas, Austin; and A. R. Bulsara, Naval Ocean Systems Center

2:50/A21
Synchronization in Chaotic Systems
Louis M. Pecora and Thomas L. Carroll, Naval Research Laboratory

3:10/A21
Response of Self-Oscillating Flows to Time-Harmonic Forcing
George S. Triantafyllou, Massachusetts Institute of Technology

Tuesday, May 8/1:30-3:30 PM
Contributed Presentatons 5/Azalea Room
General Theory and Software

Chair: Brian Hassard, SUNY, Buffalo

1:30/A21
A Graph Method to Solve Partial Differential Equations The M-Tree Algorithm
Yves de Montaudouin, IBM Watson Research Center

1:50/A22
Decomposition Solution of Nonlinear Boundary-Value Problems
G. Adomian, University of Georgia

2:10/A22
Universal Algebras For Discrete Event Dynamic Systems
Charles R. Giardina, CUNY at Mahwah

2:30/A22
On the Geometry of a Class of Dynamical Systems and Differential Automata
Mladen Luksic, Digital Equipment Corporation

2:50/A22
Mathematical Software for Dynamical Systems with Delays
Skip Thompson, Radford University

3:10/A22
Towards the Dynamic Systems of ESSAP
Moustafa El-Arabaty, Cairo, Egypt

Tuesday, May 8/1:30-3:30 PM
Contributed Presentations 6/Lemon-Lime Room
Applications 1

Chair: Ben Wilcox, Defense Advanced Research Projects Agency

1:30/A22
Steady States and Dynamics of the Moving Bed Catalytic Reactor: A Geometric Analysis
Dmitry A. Altshuller, McDonnell Aircraft Company

1:50/A22-23
Hopf Bifurcations in Power Systems
A. Semlyen and M. R. Iravani, University of Toronto, Toronto Canada

2:10/A23
Nonlinear Near-Steady Dynamics of an Aerospace Plane
Kenneth D. Mease and Hwa-Jin Chang, Princeton University

2:30/A23
A Mathematical Model of the Dynamical Processes in an End-Pumped Solid State Laser System
Lila F. Roberts, Georgia Southern College; A. Martin Buoncristiani, Christopher Newport College; and John J. Swetits, Old Dominion University

2:50/A23
A Moving Boundary Problem in Plasma Physics
Valery Godyak, GTE Laboratories; and Natalia Sternberg, Clark University

3:10/A23
Using Fractals to Detect Partial Gas Saturation of Sand/Shale Sequences
David H. Carlson, B P Exploration

3:30 PM-4:00 PM/Orange Room
Poster Session

3:30 PM-4:00 PM/Orange Room
Coffee

Tuesday, May 8/4:00-6:00 PM
Minisymposium 21/Tangerine A Room
Noise Reduction and Models of Dynamical Systems

Considerable progress has been made in the analysis of data from experiments or other systems whose behavior can be characterized as low dimensional deterministic chaos. This minisymposium focuses on ways to approximate the dynamical behavior when the underlying equations are unknown. The emphasis is on applications, including new methods for noise reduction, nonlinear prediction, and computational models of dynamical systems.

Organizer: Eric Kostelich
Arizona State University

4:00/A26-27
Noise Reduction in Chaotic Experimental Data
(to be presented by organizer)

4:20/A27
A Noise Reduction Method for Chaotic Systems
Stephen M. Hammel, Naval Surface Warfare Center, Silver Spring, Maryland

4:40/A27
Signal Processing on Strange Attractors
Henry D. I. Abarbanel, Scripps Institute of Oceanography, University of California, San Diego

5:00/A27
Optimal Shadowing and Noise Reduction
John J. Sidorowich, Los Alamos National Laboratory

5:20/A27
Inferring Statistical Complexity
James P. Crutchfield, University of California, Berkeley

5:40/A27
Symbolic Models for Chaotic Dynamics
Sheldon Newhouse, University of North Carolina, Chapel Hill

Tuesday, May 8/4:00-6:00 PM
Minisymposium 22/Tangerine B Room
Understanding Biological Dynamics; The Nonlinear Perspective (part 2 of 3)

Over the past decade, the application of concepts and techniques from the rapidly expanding field of nonlinear dynamics has yielded insight into a variety of basic biological phenomena as well as applied medical problems that are just as exciting as those in the physical and engineering sciences. The speakers in this minisymposium will illustrate, drawing on their own varied research, the ways in which a combination of realistic biomathematical modeling and mathematical analysis has increased our comprehension of the functioning of biological systems in fields as diverse as neurobiology, cardiology, renal physiology, hematology, and cell kinetics.

Organizer: Michael C. Mackey
McGill University, Montreal, Quebec

4:00/A28
A Differential Equation with Two-Time Delays to Model the Platelet Regulatory System
Jacques Belair, Universite' de Montreal, and McGill University Montreal, Quebec

4:30/A28
Oscillations in Tubuloglomerular Feedback
Harold Layton, Duke University and E. Bruce Pitman, State University of New York, Buffalo

5:00/A28
Models for Synchrony in Populations of Fireflies
G. Bard Ermentrout, University of Pittsburgh

5:30/A28
Cellular Control Models with Diffusion and Delays
Joseph M. Mahaffy, San Diego State University

Tuesday, May 8/4:00-6:00 PM
Minisymposium 23/Oleander A Room
Metastable Dynamics in Physical Systems (part 1 of 2)

Dynamic physical systems are usually modeled by partial differential equations which in turn may be viewed as dynamical systems in function space. When the PDE is singularly perturbed, as often happens when modeling physical systems, the dynamical system may have solutions that move extremely slowly. Motion is so slow that for all practical purposes these solutions appear to be stable equilibria, hence the term Metastability. The speakers will discuss the general theory for these dynamical systems and examine analytically and numerically the phenomenon of metastability in certain models of physical importance.

Organizer: Peter W. Bates
Brigham Young University

4:00/A28
Phase Transitions and Singular Perturbations
Jack K. Hale, Georgia Institute of Technology

4:40/A29
Motion by Mean Curvature as the Singular Limit of Certain Reaction-Diffusion Equations
Lia Bronsard, Institute for Advanced Study, Princeton, NJ

5:20/A29
Manifolds of Metastable States for the Cahn-Hilliard Equation
Peter W. Bates, Brigham Young University; Nicholas Alikakos, University of Tennessee, Knoxville; and Giorgio Fusco, University of Rome II, Italy

Tuesday, May 8/4:00-6:00 PM
Minisymposium 24/Oleander B Room
The Computation of Dynamical Systems (part 2 of 2)

(See previous description)

Organizer: Mitchell Luskin
California Institute of Technology

4:00/A29
Determining Nodes, Finite Difference Method and Inertial Manifolds
Ciprian Foias, Indiana University, Bloomington; Roger Temam, Indiana University, Bloomington, and Universite Paris-Sud, Orsay, France; and Edriss S. Titi, University of California, Irvine

4:25/A29
Preserving Dissipation in Approximate Inertial Forms
Michael S. Jolly, University of Minnesota, Minneapolis, and Indiana University, Bloomington; Ioannis G. Kevrekidis, Princeton University; and Edriss S. Titi, University of California, Irvine

4:50/A29-30
Common Dynamic Features of Coupled Chemical Reactors
Ioannis G. Kevrekidis and M. A. Taylor, Princeton University

5:15/A30
A Kinematic Theory of Spiral Waves in Excitable Media
Hans G. Othmer, University of Utah

5:40/A30
A Study of Spurious Steady-State Numerical Solutions of Nonlinear Ordinary Differential Equations
Helen C. Yee, NASA Ames Research Center; P. K. Sweby, University of Reading, United Kingdom; and D. F. Griffiths, University of Dundee, Scotland

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Tuesday, May 8/4:00-6:00 PM
Minisyposium 25/Hybiscus Room

Nonlinear Dynamics of Rotating Fluid Flows

The transition to disorder in closed rotating fluid flows appears to follow routes which may be well represented in terms of finite dimensional dynamical systems. This is in marked contrast to open flow situations where less well structured processes tend to occur. One possible reason for this difference between the two cases is that the geometrical constraints impose a coherent modal structure in closed flows which organizes the dynamics. Notwithstanding this special property, the study of flow in closed systems is of significance since it is a situation where direct comparison can be made between mathematics and exacting experiment. The minisymposium will explore these comparisons.

Organizer: J. Brindley
University of Leeds, United Kingdom

4:00/A30
Finite Dimensional Dynamics in Taylor-Couette Flow
T. Mullin, University of Oxford, Oxford, United Kingdom

4:30/A30
The Transition to Chaos Near to a Homoclinic Orbit in Rotational Taylor-Couette Flow
Gerd Pfister, Universitat Kiel, Kiel, W. Germany

5:00/A30
Chaotic Regimes and Transitions in a Thermally-Driven, Rotating, Stratified Fluid
P. L. Read, Robert Hooke Institute, Oxford, United Kingdom

5:30/A31
Nonlinear Mode Competition and Co-existence and the Approach to Turbulence in Closed Rotating Flows
(To be presented by organizer)

Tuesday, May 8/4:00-6:00 PM
Minisymposium 26/Lemon-Lime Room

Fractals and Their Dimensions

In many dynamical systems there is an attractor associated with the system, i.e., Julia sets associated with the iteration of rational maps or the attractors associated with nonlinear ODE's and PDE's. Many times these attractors are fractal in nature. An imporant problem for attractors associated with dynamical systems is to try to compute the various dimensions associated with these attractros in order to help characterize them. Another important problem is to find a simple dynamical system whose attractor will approximate a given fractal set in some appropriate metric. These and related problems will be discussed at this minisymposium.

Organizer: Jeffrey Geronimo
Georgia Institute of Technology

4:00/A31
Combinatorial Analysis of Fractal Physical Ramified Patterns
X. Viennot, Universite Bordeaux 1, Telence Cedex, France

4:25/A31
Analogues of the Lebesque Density Theorem for Fractal Sets of Reals and Integers
T. Bedford, Delft University of Technology, The Netherlands

4:50/A31
Universal Cantor Sets and Iterated Function Systems
Douglas P. Hardin, Vanderbilt University

5:15/A31
Nonlinear Dynamics and Propagation of Round-Off Error
Francis Sullivan and Isabel Beichl, National Institute of Standards and Technology

5:40/A31
On the Inverse Fractal Problem
(to be presented by organizer)

Tuesday, May 8/4:00-6:00 PM
Contributed Presentations 7/Azalea Room

Applications 2

Chair: Ann Castelfranco, University of Minnesota, Duluth

4:00/A32
Dynamics of an Operator Semigroup Model of G1-Threshold Regulation of Cell Cycle
Marek Kimmel and Ovide Arino, University of Pau, Pau, France

4:20/A32
Perturbation and Approximation Techniques for Models of Bursting Electrical Activity in Pancreatic B-Cells
Mark Pernarowski, University of Washington; Robert M. Miura, University of British Columbia; and J. Kevorkian, University of Washington

4:40/A32
Phase Entrainment in Biological Oscillators
Diana E. Woodward, Southern Methodist University

5:00/A32-33
Low Frequency Dispersive Waves in Neural Networks
S. Vishnumhatla, Bellcore

5:20/A33
Neural Networks for Constrained Scheduling Optimization in a Time Window
Jurn-Sun Leung and Yel-Chiang Wu, General Purpose Machines Laboratory, Inc.

5:40/A33
A Dynamical Systems Perspective for Mathematical Programming
Terry L. Friesz, G. Anandalingam and Nihal J. Mehta, University of Pennsylvania; and Roger L. Tobin, GTE Laboratories

4:30 PM/Ballroom Foyer
Registration Desk Closes

6:00 PM-6:15 PM/Hotel Lobby
Board Buses for Dinner at Sea World

Wednesday, May 9

8:00 AM/Ballroom Foyer
Registration Opens

Wednesday, May 9/8:30-9:15 AM
Invited Presentation 6/Lemon-Lime

Tracking Invariant Manifolds in Singularly Perturbed Systems

Chair: Harlan Stech, University of Minnesota, Duluth

Singularly perturbed systems often have singular solutions that are the union of solutions to simpler subsets of the equations. To investigate when there is an actual solution close to the singular one, geometric techniques are used to track invariant manifolds as they pass close to a slow manifold. This approach can be applied to problems involving trajectories joining critical points, including problems involving families of nerve conduction equations.

Nancy Kopell
Department of Mathematics
Boston University
Christopher K.R.T. Jones,
University of Maryland, College Park

Wednesday, May 9/9:15-10:00 AM
Invited Presentation 7/Lemon-Lime Room

Global Properties of Delay-Differential Equations

Chair: Harlan Stech, University of Minnesota, Duluth

Delay differential equations arise as models in numerous areas of science. Among these are physiology (populations of cells and organisms in diseases), optics (transmission of light through nonlinear media) and economics (models of commodity markets). Although these models are infinite dimensional dynamical systems, much progress has been made in understanding the global dynamics of the attractor by using the delay structure of the equations. The speaker will describe the theory behind such results and their connection to applications.

John Mallet-Paret
Department of Applied Mathematics
Brown University

10:00 AM-10-30 AM/Orange Room
Coffee

Wednesday, May 9/10:30 AM-12:30 PM
Minisymposium 27/Lemon-Lime Room

Control of Chaos (part 3 of 4) Adaptive Control of Nonlinear Dynamics

(See previous description)

Organizer: Alfred Hubler
Beckman Institute, University of Illinois, Urbana

10:30/A33
Adaptive Control of Chaotic Systems
M. Welge, University of Illinois, Urbana

11:10/A33
Dynamics of Adaptive Systems
E. Lumer and B. Huberman, Xerox Palo Alto Research Center

11:50/A33-34
Optimal Control of Catastrophes
Kodogeorgiou Athanasios, University of Illinois, Urbana

CONFERENCE PROGRAM

Wednesday, May 9/10:30 AM - 12:30 PM
Minisymposium 28/Tangerine A Room
Mathematical Epidemiology (part 1 of 3)

Tremendous advances have occurred in the past decade in the formulation,mathematical analysis, and application of mathematical models for the spread of infectious diseases. The presentations cover dynamical systems aspects of these models. Mathematical analysis has led to an understanding of which model formulations have thresholds, endemic equilibria, periodic solutions, period-doubling bifurcations and chaotic behavior. The models have been useful in the study of diseases such as measles, rubella, mumps, pertussis, influenza and malaria and also for sexually transmitted diseases such as gonorrhea and AIDS.

Organizer: Herbert W. Hethcote
University of Iowa

10:30/A34
Epidemiologcal Models with Varying Population Size
Pauline van den Driessche, University of Victoria, Victoria, British Columbia

11:00/A34
Oscillations in Age-Structured Epidemic Models
Horst R. Thieme, Arizona State University

11:30/A34
A Gonorrhea Model with Sensitive and Resistant Strains
Paul Pinsky and Ron Shonkwiler, Georgia Institute of Technology

12:00/A34
Mathematical Models for Dengue
Kenneth L. Cooke, Pomona College; C. Castillo-Chavez, Cornell University; and C. Vargas, CINVESTAV, Mexico, D.F.

Wednesday, May 9/10:30 AM - 1:00 PM
Minisymposium 29/Tangerine B Room
Aerospace Design (part 2 of 2)

(see previous description)

Organizer: Helena S. Wisniewski
Lockheed Corporation

10:30/A34
Developing CFD Tools for Design of Commercial Airplanes
Wen-Huei Jou. Boeing Commercial Airplane

11:00/A35
Computational Fluid Dynamics on the Massively Parallel Connection Machine
Mohammad Khan, Lockheed Aeronautical Systems Company

11:30/A35
Application of CFD Methods to High-Speed Airline Design
Doug Dwoyer, NASA Langley Research Center

12:00/A35
Some Problems in the Transition from Laminar to Turbulent Flows
Joseph T.C. Liu, Brown University

12:30/A35
CFD for Aircraft Design: Present Capabilities and Future Requirements
Pradeep Raj, Lockheed Aeronautical Systems Company

Wednesday, May 9/10:30 AM - 12:30 PM
Minisymposium 30/Oleander A Room
Dynamical Systems in Crystalline Structures

Ceramic, polymer and metal alloy systems are subject to phase changes controlled by diffusion both on the atomic and macroscopic scales. Such processes can be described by means of non-equilibrium statistical mechanics and give rise to reaction-diffusion type evolution equations. These equations reflect the point group symmetries, binding energies and kinetic mechanism models of the underlying crystalline structures. The microstructures encountered during the processing of such materials thus provide specific three dimensional analog approximations to a variety of attractors in such dissipative dynamical systems.

Organizer: John A. Simmons
United States Department of Commerce National Institute of Standards and Technology

10:30/A35-36
Extension of the Cahn-Hilliard Equation to Ordered Systems with Multiple Length Scales,
Samuel M. Allen, Massachusetts Institute of Technology

11:10/A36
Evaluation Equation for Ordered Systems Using the Path Probability Method
Ryoichi Kikuchi, University of California, Los Angeles

11:50/A36
Morphological Dynamics of Crystal Surfaces
Andrew Zangwill, Georgia Institute of Technology

Wednesday, May 9/10:30 AM - 12:30 PM
Minisymposium 31/Orange Room
Metastable Dynamics In Physical Systems

(see previous description)

Organizer: Peter W. Bates
Brigham Young University

10:30/A36
Invariant Manifolds for Metastable Patterns in the Bistable Reaction-Diffusion Equation
Jack Carr, Heriot-Watt University, Edinburgh, Scotland; and Robert Pego, University of Michigan, Ann Arbor

11:10/A36
Optimal High Order in Time Approximations for the Cahn-Hilliard Equation
William McKinney, North Carolina State University; and Ohannes Karakashian, University of Tennessee, Knoxville

11:50/A37
Computations on the Cahn-Hilliard Model for Solidification
Donald A. French, Carnegie-Mellon University

Wednesday, May 9/10:30 AM - 12:30 PM
Minisymposium 38/Oleander B Room
Nonlinear Mechanical Systems

This minisymposium will contain four presentations on the dynamic behavior of nonlinear mechanical systems. The focus will be on the application of perturbation methods, bifurcation theory, physical experiments and computer simulations to mechanical structures.

Organizer: Steven M. Shaw
Michigan State University

10:30/A37
Global Bifurcation and Chaos in Parametrically Forced Systems with One-One Resonance
Z. C. Feng and P. R. Sethna, University of Minnesota, Minneapolis

11:00/A37
Lyapunov Exponents for Stochastic Mechanical Systems
N. Sri Namachchivaya, University of Illinois, Urbana

11:30/A37
Nonlinear Dynamics of a Parametrically Excited Inextensional Elastic Beam
Jim M. Restuccio, California Institute of Technology; Charles M. Krousgrill, and Anil K. Bajaj, Purdue University

12:00/A37-38
Center Manifold Approach to Post-Hopf Behavior
Richard H. Rand, Cornell University

Wednesday, May 9/10:30 AM - 12:30 PM
Contributed Presentations 9/Azalea Room
Applied Fluid Modeling

Chair: Francis Sullivan, National Institute of Standards and Technology

10:30/A38
Quasi-recurrent Motions with the Two-Dimensional Nonlinear Schrodinger Equation for Deep-water Modulated Gravity Wavetrains
Bhimsen K. Shivamoggi, University of Central Florida

10:50/A38
Chaos and Acoustic Remote Sensing in the Straits of Florida
D. R. Palmer, AOML/NOAA; L. M. Lawson, East Tennessee State University; T. M. Georges and R. M. Jones, WPL/NOAA

11:10/A38
Dynamical Systems for Inverse Ocean Modelling
Richard S. Segall, Arthur H. Copeland, Chris D. Ringo and Berrien Moore, III, University of New Hampshire

11:30/A39
Dynamics of Flows in Complex Geometries
Anil E. Deane, George E. Karniadakis and Ioannis G. Kevrekidis, Princeton University

12:00 PM/Ballroom Foyer
Registration Desk Closes

Thursday, May 10

8:00 AM/Ballroom Foyer
Registration Desk Opens

Thursday, May 10/8:30 - 9:15 AM
Invited Presentation 8/Lemon-Lime Room
Approximation Dynamics; Inertial Manifolds and Hyperbolic Sets

Chair: Celso Grebogi, University of Maryland, College Park

First the speaker will present a general theory of approximate inertial manifolds (AIMS) for nonlinear dissipative dynamical systems on infinite dimensional Hilbert spaces. The goal of this theory is to prove the Basic Theorem of Approximation Dynamics, wherein it is shown that there is a fundamental connection between the order of the approximating manifold and the amount of long-time dynamical information that is preserved by the approximation. Second, the speaker will present a new general method for the construction of an AIM. Finally, the speaker will show that this construction applies to the Navier Stokes equations on any bounded region in 2D (and on certain thin 3D regions) as well as to reaction diffusion equations in any space dimension. All these equations have good AIMS which preserve the essential dynamics of the global attractor.

George R. Sell
Department of Mathematics
University of Minnesota

Thursday, May 10/9:15 - 10:00 AM
Invited Presentation 9/Lemon-Lime Room
The Dynamics and Geometry of Unconfined Flows

Chair: Celso Grebogi, University of Maryland, College Park

At least in the early stages of transition to turbulence, highly confined fluid flows seem to share 'universal' features characteristic of low-dimensional dynamical systems. The situation is more complex in unconfined flows of practical interest in many contexts of engineering. The speaker will present a broad survey encompassing the following topics: universality in a class of low Reynolds number flows, fractal and multifractal structure in physical space of fully turbulent flows, and transition from one to the other.

Katepalli R. Sreenivasan
Engineering and Applied Science Department
Yale University

10:00 AM - 10:30 AM/Orange Room
Coffee

Thursday, May 10/10:30 AM - 12:30 PM
Minisymposium 32/Lemon-Lime Room

Control of Chaos (part 4 of 4) Nonlinear Resonance Spectroscopy

(See previous description)

Organizer: Alfred Hubler
Beckman Institute, University of Illinois, Urbana

10:30/A39
Stimulation of Quantum Systems
P. Milonni, and Bala Sundaram, Los Alamos National Laboratory

11:00/A39
Resonances of Nonlinear Systems
T. Eisenhammer, Technical University of Munich, Munich, W. Germany

11:30/A39
Nonlinear Resonance Spectroscopy
D. Bensen, University of Illinois, Urbana

12:00/A39
Generalized Resonance Spectroscopy
K. Chang, University of Illinois, Urbana

Thursday, May 10/10:30 AM - 12:30 PM
Minisymposium 33/Tangerine A

Mathematical Epidemiology (part 2 of 3)

(See previous description)

Organizer: Herbert W. Hethcote
University of Iowa

10:30/A39-40
Epidemic Models with Distributed Delays
Fred Brauer, University of Wisconsin, Madison

11:00/A40
Nonlinear Dynamical Features of Seasonally Driven Epidemics
Ira B. Schwartz, U.S. Naval Research Laboratory

11:30/A40
Epidemic Cycles in Africa
Joan L. Aron, Johns Hopkins School of Hygiene and Public Health

12:00/A40
Chaos in Childhood Diseases
William Schaffer, University of Arizona

Thursday, May 10/10:30 AM - 12:30 PM
Minisymposium 34/Tangerine B

Hyperbolicity in Dynamical Systems (part 1 of 2)

Hyperbolicity (or exponential dichotomy) is a fundamental concept in dynamical systems theory and is especially important in applications to bifurcations and chaos. Both geometrical and analytical methods are used in its study. The emphasis in this minisymposium is on homoclinic solutions and the associated chaotic behavior. Numerical aspects of the calculation of homoclinic orbits or the orbits of chaotic dynamical systems will also be an important topic.

Organizer: Kenneth Palmer
University of Miami

10:30/A40
Strange Attractors of Homeomorphism Having Noncompact Domains
Bo Deng, University of Nebraska, Lincoln

11:00/A40-41
Numerical Analysis and Efficient Computation of Heteroclinic Orbits
Mark Friedman, University of Alabama, Huntsville

11:30/A41
Breakdown of Stability and Bifurcating Invariant Sets
Russell Johnson, University of Minnesota, Minneapolis and University of Southern California

12:00/A41
Generalization of Shadowing Lemmas and Chaos Near Homoclinic Orbits
Xiao-Biao Lin, North Carolina State University

Thursday, May 10/10:30 AM - 12:30 PM
Minisymposium 35/Jasmine Room

Geometric Theory and Dynamics of Model Systems

Insight into general principles of dynamics can be gained from elucidation of properties of simple model systems. The minisymposium presents results of four such studies. Two of these concern simple maps of the cylinder. In one, an invariant repellor occurs which is a graph on the cylinder of a Weierstrass function, and in the second an invariant attracting continuum occurs. The third study involves a Hamiltonian system, the kicked Morse oscillator, possessing an involution symmetry. Rigorous results are known. In addition, numerical investigations have revealed a remarkable fractal set in parameter space, dividing bound and unbound motion. Finally, the fourth study involves a simple application of Bernoulli shift dynamics to produce a rigorous construction and generalization of the multifractal decomposition for Moran fractals with infinite product measure.

Organizer: Robert Cawley
Naval Surface Warfare Center

10:30/A41
Smooth Dynamics on Weierstrass Nowhere Differentiable Curves
Brian R. Hunt, Naval Surface Warfare Center, and University of Maryland, College Park; and James A. Yorke, University of Maryland, College Park

11:00/A41
Invariant Attracting Continua in Cylinder Maps
Patricia H. Carter, Naval Surface Warfare Center; and R. Daniel Mauldin, University of North Texas

11:30/A41
Dynamics of an Impulsively Driven Morse Oscillator
James F. Heagy, Naval Surface Warfare Center

12:00/A41-42
A New Multifractal Theory for Moran Fractals
Robert Cawley, Naval Surface Warfare Center and R. Daniel Mauldin, University of North Texas, and Naval Surface Warfare Center

Thursday, May 10/10:30 AM - 1:00 PM
Minisymposium 36/Oleander B Room

The Dynamics of Neural Networks and Their Applications

This is an exciting field with problems that impact research, development, and implementation. A neural network is a dynamical system. Therefore, dynamical systems hold the key to resolving many of the open problems. In particular, nonlinear dynamics and chaos can be used to develop theory, modeling, and training of neural networks as well as to understand their behavior and to determine their convergence and stability. This minisymposium will provide an overview of the field. The presentations will describe open questions and research papers illustrating the use of dynamical systems in neural networks, the application of neural networks and how dynamical systems will impact such applications, as well as a comparison of various approaches to neural networks. These applications include: pattern and speech recognition, vision, adaptive learning systems, neural networks on computer chips, and adding adaptive learning capabilities to robotic systems.

Organizer: Helena S. Wisniewski
Lockheed Corporation

10:30/A42
Overview of Neural Nets
Barbara Yoon, Defense Advanced Research Projects Agency

10:55/A42
Emerging Neural Network Technology— Overview of Learning Theories
Harold Szu, Naval Research Laboratory

11:20/A42
Creative Dynamics
Jacob Barhen, Jet Propulsion Laboratory, California Institute of Technology

11:45/A42
Dynamical Behavior of Feedback Networks Implemented in Analog Hardware
William A. Fisher, Lockheed Missiles and Space Co.

12:10/A42
Neural Networks for Invariant Image Recognition
Sheldon Gardner, Naval Research Laboratory

12:35/A43
An Automata Network for Visual Cognition: Why Dynamics is Important
Raghu Raghavan, Lockheed Missiles and Space Co.

Thursday, May 10/10:30 AM - 12:30 PM
Contributed Presentations 10/Azalea Room

Control and Optimization

Chair: Jong Uhn Kim, Virginia Polytechnic Institute and State University

10:30/A43
Discrete Approximations for Nonlinear Optimal Control Systems
Boris S. Mordukhovich, Wayne State University

10:50/A43
Global Optimization With a Lattice Dynamical System
Jean-Claude Perez, IBM, Montpellier, France; Jean-Michel Bertille, Montpellier University and IBM, Montpellier, France; and Jerry Magnan, Florida State University

11:10/A43
Robust Output Feedback and Observer Based Controller for Decentralized Interconnected Systems
Rajab Challoo, Texas A & I University; and Edwin Sawan, Wichita State University

11:30/A44
The Optimal Control of Pricing Problem
Moustafa El-Arabaty, Cairo, Egypt

11:50/A44
Innovative Control Design Methodologies: A Smart Structures/Neurocontroller Approach
Fredric M. Ham, Wassim M. Haddad and Samuel P. Koziatis, Florida Institute of Technology

Thursday, May 10/10:30 AM - 12:30 PM
Contributed Presentations 11/Hybiscus Room

Chaos and Turbulence

Chair: John Lavery, Office of Naval Research

10:30/A44
Chaotic Vortex-Body Interaction
E. A. Novikov, University of California, San Diego

10:50/A44
An Experimental Study of Stability and Transition to Turbulence of Flow Between Two Rotating Disks
Anuvat Sirivat, University of Pittsburgh

11:10/A44-45
Couette Flow of Granular Materials Spatio-Temporal Coherence and 1/f Noise
Stuart B. Savage, McGill University, Montreal, Canada

11:30/A45
Upper Semicontinuous Global Attractors for Viscous Flow
Yuh-Roung Ou, ICASE NASA Langley Research Center; and S. S. Sritharan, University of Southern California

11:50/A45
Intermittency Corrections to Spectra of Temperature Fluctuations in Isotropic Turbulence
Bhimsen K. Shivamoggi, Ronald L. Phillips and Larry C. Andrews, University of Central Florida

12:10/A45
Period Doubling Cascade to Chaos in Numerical Hydrodynamic Modeling of Stellar Pulsations
J. Robert Buchler, University of Florida

12:30 PM-2:00 PM
Lunch

Thursday, May 10/2:00-4:00 PM
Minisymposium 37/Tangerine A Room
Fractal Time Dynamics

The focus of this minisymposium is on systems whose temporal behavior is so complex that it cannot be described by any characteristic time scale. We dub such dynamics as "Fractal Time". A wide variety of natural systems (from earthquakes to semiconductor voltage fluctuations) fall into this category. One signature of such systems is a power spectral density which scales with frequency, and its understanding is called the "l/f Noise Problem". Three of the presentations are devoted to aspects of this problem. A special emphasis is placed on the self-organizing of systems into critical states where small perturbations can cascade into intermittent large scale changes. The fourth presentation illustrates how the universal stretched exponential law for relaxation in disordered solids, is really a probability limit distribution connected to the l/f movement of defects.

Organizer: Michael F. Shlesinger
Office of Naval Research

2:00/A45
Probability Limit Distributions in Glassy Dynamics
(to be presented by organizer)

2:30/A45-46
On the Ubiquity of l/f Noise
Bruce J. West, University of North Texas

3:00/A46
Avalanche Dynamics in a Droplet Growth Model with Sliding
Fereydoon Family, Emory University

3:30/A46
Self-Organized Criticality: A Status Report
Kurt Wiesenfeld, Georgia Institute of Technology

Thursday, May 10/2:00-4:00 PM
Contributed Presentations 8/Tangerine B Room
Control

Chair: John A. Burns, Virginia Polytechnic Institute and State University and University of Southern California

2:00/A47
Exact Internal Controllability of a One-Dimensional Aeroelastic Plate
Jong Uhn Kim, Virginia Polytechnic Institute and State University

2:20/A47
On the Global Dynamics of Adaptive Control Systems
Martin Espana, Centro Atomico Bariloche, Rio Negro, Argentina

2:40/A47
Quantum Mechanical Control Systems
En-Bing Lin, University of Toledo

3:00/A47
Morse Decomposition and Maximal Transitive Sets for Bilinear Control Systems
Fritz Colonius, Universitat Augsburg, Augsburg, West Germany

3:20/A47-48
The Lyapunov Spectrum of Bilinear Control Systems
Wolfgang Kliemann, Iowa State University; and Fritz Colonius, Universitat Augsburg, Augsburg, West Germany

3:40/A48
Stability of Large-Scale Discrete Dynamical Systems
Shu Huang, Southwestern Jiaotong University, Sichuan, People's Republic of China

Thursday, May 10/2:00-4:00 PM
Minisymposium 39/Oleander B Room
Dimensional Estimates and Extraction of Low-Dimensional Models

The symposium is intended to present low-dimensional description of complex systems, including fluid dynamics. The work to be presented includes analysis as well as numerical experiments. There will be three speakers in the symposium-each presenting complementary but related studies.

Organizer: K. R. Sreenivasan
Yale University

2:00/A46
Finite Dimensional Attractors, Inertial Manifolds, Weak Turbulence and Strong Turbulence
Charles R. Doering, Clarkson University

2:40/A46
On the Characterization of Complicated Phenomena by Low Dimensional Systems
Lawrence Sirovich, Brown University

3:20/A47
Remarks on the Navier-Stokes Equations
Peter Constantin, University of Chicago

Thursday, May 10/2:00-4:00 PM
Contributed Presentations 12/Azalea Room
Biological Oscillators

Chair: G. Bard Ermentrout, University of Pittsburgh

2:00/A48
Isolated Periodic Solutions and Analysis of Degenerate Hopf Bifurcation in the Hodgin-Huxley Model
Lie June Shiau, University of Houston, Clear Lake; and Brian Hassard, SUNY at Buffalo

2:20/A48
Periodic Solutions in Models of Neuronal Excitability
Ann M. Castelfranco, University of Minnesota, Duluth

2:40/A49
Long Distance Coupling in a Chain of Oscillators as a Model of the Lamprey Spinal Generator for Swimming
Tim Kiemel, Cornell University

3:00/A49
Singular Perturbation Analysis of a Neuron Model
Humberto Carrillo, University Nac Autonoma de Mexico, Mexico, D.F.

Thursday, May 10/2:00-4:00 PM
Contributed Presentations 13/Hybiscus Room
Integrable Systems

Chair: Jacques Belair, Universite de Montreal, and McGill University, Canada

2:00/A49
Integrability Aspects of the Lorenz Equations
Bhimsen K. Shivamoggi and Ram N. Mohapatra, University of Central Florida

2:20/A49-50
Chaotic Numerics From an Integrable Hamiltonian System
Kevin G. Hockett, George Washington University

2:40/A50
Chaotic Scattering in Several Dimensions
Qi Chen, M. Ding and E. Ott, University of Maryland, College Park

Thursday, May 10/2:00-4:00 PM
Contributed Presentations 14/Jasmine Room
Applications 3

Chair: Terry Herdman, Virginia Polytechnic Institute and State University

2:00/A50
An Iterated Function Systems Approach to LMS Filtering and Noise Reduction
Ira B. Schwartz, U S Naval Research Laboratory; and Laurie Reuter, George Washington University

2:20/A50-51
Preliminary Concepts in the Use of Chaotic Nonlinear Dynamics to Model Random Behavior in Signal Processing Applications
William W. Taylor, The RTA Corporation

2:40/A51
Dynamics of Pulses in Birefringent Optical Fibers
David J. Muraki, Tetsuji Ueda, and William L. Kath, Northwestern University

3:00/A51
A Model for Radially Symmetric Phase Transitions
Kenneth A. Heimes, Iowa State University

3:20/A51
Global Instability and Pattern Formation in Dendritic Solidification of a Dilute Binary Alloy
Jian-Jun Xu, McGill University, Montreal, Canada

3:40/A51
On the Dynamics of Fine Structure in One Dimension
Pieter J. Swart, Cornell University

Thursday, May 10/2:00-4:00 PM
Contributed Presentations 15/Lemon-Lime Room
Reaction Diffusion Equations

Chair: Joseph M. Mahaffy, San Diego State University

2:00/A51-52
Periodic Structures in A Reaction-Diffusion System with Diffusion Instability
Q. S. Lu and C. W. S. To, University of Western Ontario, London, Canada

2:20/A52
Asymptotic Behavior of Strongly Monotone Time-Periodic Dynamical Processes with Symmetry
Peter Takac, Vanderbilt University

2:40/A52
Numerical Approximation of Invariant Tori
Luca Dieci, Georgia Institute of Technology

3:00/A52
Absorbing Sets and a Global Attractor for a Reaction-Diffusion System from Climate Modeling
Georg Hetzer and Paul G. Schmidt, Auburn University

3:20/A52
An Explicit Procedure for Solution of Dynamical Systems
G. Adomian, University of Georgia

4:00 PM - 4:30 PM/Orange Room
Coffee

Thursday, May 10/4:30 - 6:30 PM
Minisymposium 40/Tangerine B Room
Understanding Biological Dynamics; The Nonlinear Perspective (part 3 of 3)

(See previous description)

Organizer: Michael C. Mackey
McGill University, Montreal, Quebec

4:30/A52
Nonlinear Dynamics of Cardiac Arrhythmias
Leon Glass, McGill University, Montreal, Quebec

5:00/A53
Initiation of Ventricular Fibrillation in the Heart Caused by a Nonlinear Response to Electrical Stimulation
Raymond E. Ideker, David W. Frazier, and William M. Smith, Duke University Medical Center

5:30/A53
A Symmetry Breaking Model that Regulates Ovarian Follicle Development
Michael Lacker, CUNY-Mount Sinai School of Medicine

6:00/A53
Dynamics of Scroll Wave Filaments
James P. Keener, University of Utah

Thursday, May 10/4:30 - 6:30 PM
Minisymposium 41/Jasmine Room
Computer Programs for Dynamical Systems

Computer experiments have played a prominent role in research and teaching of dynamical systems. The recent emergence of several general-purpose computer programs promises to make dynamical systems computations readily accessible and ease the often tedious programming efforts. The purpose of this minisymposium is to discuss the role of computations in dynamical systems and explore the use of several general-purpose computational packages with modest resource requirements for dynamical systems.

As a means of providing hands-on access to the types of software discussed in this minisymposium, the conference organizers intend to pursue with various computer manufacturers the possibility of configuring a laboratory for small-scale computing (personal computers/workstations). Such a laboratory would likewise provide an opportunity for interested conference participants to become better acquainted with the state-of-the-art in lower end hardware.

Organizer: Hoseyin Kocak
University of Miami

4:30/A53
Software for Bifurcation Problems
E. G. Doedel, Concordia University

5:10/A53
KAOS: A (Prototype) Environment for Exploring Dynamical Systems
John Guckenheimer, Cornell University

5:50/A54
Dynamics: An Interactive Program With A Bag of Tools
James A. Yorke, University of Maryland, College Park

Thursday, May 10/4:30 - 6:30 PM
Minisymposium 42/Hybiscus Room
Fractals in Fluids

The understanding of fractal structures arising in fluids might aid in understanding the more difficult problem of turbulence, where it is known that the vorticity squared tends to concentrate on a fractal set. Two of the speakers in this minisymposium will address the motion of particles convected by fluids. The other two speakers will describe fractal structures in turbulence and in cloud radiance.

Organizer: Celso Grebogi
University of Maryland, College Park

4:30/A54
Expirements on Turbulence at Low Reynolds Numbers
Walter I. Goldburg, and H. K. Pak, University of Pittsburgh

5:00/A54
Fractal Measures of Passively Convected Scalar Gradients in Chaotic Fluid Flows
Edward Ott and Thomas M. Antonsen, Jr., University of Maryland, College Park

5:30/A54
Fractal Characterization of Cloud Radiance
Patricia M. Carter and Robert Cawley, Naval Surface Warfare Center, Silver Spring, MD

6:00/A54
Fractal Structure in the Dispersal of Aerosols and Bubbles in Fluids
(to be presented by organizer)

Thursday, May 10/4:30 - 6:30 PM
Minisymposium 43/Lemon-Lime Room
Lie and Differential Algebraic Methods in Accelerator Physics

Hamiltonian flows give rise to symplectic maps. Such maps form an infinite dimensional group, and can be represented, manipulated, and approximated using differential and Lie algebraic methods. These methods will be reviewed with an emphasis on applications to the design of high energy particle accelerators and the long term stability of orbits.

Organizer: Alex J. Dragt
University of Maryland, College Park

4:30/A55
Overview of Mapping Methods in Accelerator Physics
(to be presented by organizer)

5:10/A55
The Use of Maps in Circular Accelerators
Ettiene Forest and John Irwin, Lawrence Berkeley Laboratory

5:50/A64
Infinitely Small Numbers and Big Accelerators
Martin Berz, University of California, Berkeley

Thursday, May 10/4:30 - 6:30 PM
Contributed Presentations 16/Tangerine A Room
Modeling, Prediction and Chaos

Chair:

4:30/A55
Weak Turbulence in Coupled-Map Lattices
Dimitris Stassinopoulos and Greg Huber, Boston University; and Preben Alstrom, Boston University and University of Copenhagen, Copenhagen, Denmark

4:50/A55
Sudden Change in Size of Chaotic Attractor: How Does it Occur?
Yingcheng Lai, Celso Grebogi, and James A. Yorke, University of Maryland, College Park

5:10/A55 - 56
Transition to Chaotic Scattering
Mingzhou Ding, Celso Grebogi, Edward Ott and James A. Yorke, University of Maryland, College Park

5:30/A56
Quantifying Local Predictability in Phase Space
Jon M. Nese, Pennsylvania State University, Beaver Campus

5:50/A56
Modeling and Prediction with Low-Dimensional Representations of Nonlinear Dynamic Processes
Stefan Mittnik, SUNY at Stony Brook

6:10/A56
Estimation of Lyapunov Exponents Using a Semi-discrete Formulation
Joseph S. Torok, Rochester Institute of Technology

Thursday, May 10/4:30 - 6:30 PM
Contributed Presentations 17/Azalea Room
Applications 4

Chair: Terry Herdman, Virginia Polytechnic Institute and State University

4:30/A56
Dynamics of a Suspended Railway Axle
Hans True, Rasmus Feldberg and Carsten Knudsen, Technical University of Denmark, Lyngby, Denmark

4:50/A56
Power Flow in Coupled Mechanical Systems: New Results Using M-Matrix Theory
David C. Hyland and Dennis S. Bernstein, Harris Corporation

5:10/A57
Dynamics of Cross-Flow-Induced Vibrations of Heat-Exchanger Tubes Impacting on Loose Supports
G. X. Li and M. P. Paidoussis, McGill University, Montreal, Canada

5:30/A57
Effects of Joint Flexibility on the Motion of a Flexible-Arm Robot
T. Singh, M. F. Golnaraghi and R. N. Dubey, University of Waterloo, Waterloo, Canada

5:50/A57
Simulation of Constrained Mechanical Systems Using Bond Graph Techniques
J. Felez and I. San Jose, ITA, Zaragosa, Spain

6:10/A57
Bond Graph Simulation of Flexible Multibody Systems
C. Vera, J. Felez, and F. Buil, ITA, Zaragoza, Spain

Thursday, May 10/4:30 - 6:30 PM
Contributed Presentations 17a/Oleander B Room

Chair: David Green Jr., GMI Engineering and Management Institute

4:30/A57 - 58
An Approximate Stress Field Equations for the Solutions of Arbitrary Oriented Cracks
M. Sayeed Hasan, Adirondack Community College

4:50/A58
Stabilization of Nonlinear Systems by Linearizing Feedback Controls
Efthimios Kappos, City University, London, United Kingdom

5:10/A58
Fluxon Dynamics in Long Josephson Junctions with Inhomogeneities
Tassos Bountis, University of Patras, Greece and Stephanos Pnevmatokos, Research Center of Crete, Greece

5:30/A58
Vibration Characteristics of Shell Structures: Formulation Based on Plate Analogy
Dong H. Kim and Jeung T. Kim, Korea Standards Research Institutes, Korea

5:50/A58
A Method of Solution of Same Functional Equations of Theory Dynamical Systems
Vladimir S. Berman, Academy of Science of USSR, Moscow, USSR

5:00 PM/Ballroom Foyer
Registration Desk Closes

Friday, May 11

8:00 AM/Ballroom Foyer
Registration Desk Opens

Friday, May 11/8:30-9:15 AM
Invited Presentation 10/Lemon-Lime Room

Multiple Time Scales in Biological Bursting Oscillations

Chair: Ira B. Schwartz, U.S. Naval Research Laboratory

Many cells (e.g., neurons and some muscle and secretory cells) exhibit activity in the form of complex bursting oscillations, slow alternations between phases of near steady state behavior and phases of rapid spike-like oscillations. Mathematical models for such phenomena have been dissected numerically by applying singular perturbation concepts to exploit the differences in fast and slow time scales. During a burst, the slow variables follow a trajectory over which the fast subsystem has attractors which may be steady states or periodic orbits. In some cases, these attracting manifolds coexist and rapid transitions between them at the end of the active and silent phases give the burst pattern a relaxation appearance. Examples of different types of bursting systems and their biological and mathematical significance will be described.

John Rinzel
Mathematical Research Branch, NIDDK
National Institutes of Health

Friday, May 11/9:15-10:00 AM
Invited Presentation 11/Lemon-Lime Room

Do Computer Trajectories of Chaotic Systems Represent True Trajectories?

Chair: Ira B. Schwartz, U.S. Naval Research Laboratory

Many systems of differential equations have been found to be chaotic. These systems have the property that numerical errors tend to grow exponentially fast, at least as long as they remain relatively small. If, for example, errors double every iterate and the calculations are accurate to 15 digits (about 50 bits) then, due to errors on the first iterate, the true trajectory through a point can be expected to have no correlation with the numerical trajectory beyond 50 iterates. Numerical studies, on the other hand, often involve hundreds of thousands of iterates.

Anosov and Bowen have shown that systems that are sufficiently uniformly hyperbolic will have the shadowing property, that is, if the numerical errors are small enough, each numerical trajectory will remain close to the noisy trajectory for all time. Unfortunately, the chaotic systems typically studied do not have the required properties of uniform hyperbolicity, and shadowing fails.

The speaker will report results obtained in collaboration with S. Hammel and C. Grebogi in which trajectories are apparently typically shadowed by true trajectories for very long periods of time. The results are based on rigorous numerical studies of typical trajectories of the logistic and the Henon maps.

James A. Yorke
Institute for Physical Science and Technology
University of Maryland, College Park

10:00 AM - 10:30 AM/Orange Room
Coffee

Friday, May 11/10:30 AM - 12:30 PM
Minisymposium 44/Lemon-Lime Room

Dynamical Systems and Stochastic Processes

The speakers in this minisymposium present a sampling of some of the current research taking place in the intersection of the fields of dynamical systems and stochastic processes. One area of discourse will be the application of stochastic process theory to study the generation of approximately random motion by deterministic systems with complicated dynamics. Concepts such as Lyapunov exponents, entropy, stable and unstable manifolds, hyperbolicity have natural application in the theory of stochastic dynamical systems and will be addressed.

Organizer: Thomas J. S. Taylor
Arizona State University

10:30/A59
Coalescing Stochastic Flows in Dimensions One, Two and Three
Richard Darling, University of South Florida

11:00/A59
Common Techniques in Dynamical and Stochastic Systems: Invariant Bundles, Invariant Manifolds and Spectra
Wolfgang Kliemann, Iowa State University and Universitat Bremen, Bremen, West Germany

11:30/A59
On the Dynamical Generation of Noise
(To be presented by organizer)

12:00/A65
On the Lyapunov Spectrum of Nilpotent Systems
Volker Wihstutz, University of North Carolina, Charlotte

Friday, May 11/10:30 AM - 12:30 PM
Minisymposium 45/Tangerine A Room

Mathematical Epidemiology (part 3 of 3)

(See previous description)

Organizer: Herbert W. Hethcote
University of Iowa

10:30/A59
Epidemiological Models for STD's with Variable Population Size
Carlos Castillo-Chavez, Cornell University

11:00/A59
Epidemic Models for Populations with Age and Risk Level Structure
Stavros Busenberg, Harvey Mudd College

11:30
Nonlinear Incidence in Epidemiological Models
(To be presented by organizer)

12:00/A60
Stability Conditions, Thresholds and Reproduction Numbers for Epidemiological Models
John Jacquez and Carl Simon, University of Michigan, Ann Arbor

Friday, May 11/10:30 AM - 12:30 PM
Minisymposium 46/Tangerine B Room

Hyperbolicity in Dynamical Systems (part 2 of 2)

(See previous description)

Organizer: Kenneth Palmer
University of Miami

10:30/A60
Dimension Problems in Ordinary Differential Equations
Yi Li and James S. Muldowney, University of Alberta, Edmonton, Alberta

11:00/A60
The Shadowing Lemma and Numerical Computation of Orbits of Dynamical Systems
(To be presented by organizer)

11:30/A60
Simultaneous Equilibrium and Heteroclinic Bifurcation
Stephen Schecter, North Carolina State University

12:00/A60
Averaging for Almost Identical Maps and Weakly Attractive Tori
Daniel Stoffer, University of California, Los Angeles

Friday, May 11/10:30 AM - 12:30 PM
Minisymposium 47/Oleander B Room

Chaotic Scattering

In the classical Hamiltonian scattering problem, one asks how scattered trajectories depend on incident trajectories. Recently, it has been found that due to chaos this dependence can be very intricate. In particular, the scattering function can be singular on a fractal set. This can make the prediction of outgoing trajectories from incoming trajectories very difficult if there is small uncertainty in the latter. Applications where these phenomena arise include chemical reactions, celestial mechanics, quantum scattering, and fluid dynamics. Some areas of current research in the field relate to the multifractal properties of the chaotic set, to how chaotic scattering comes about as a parameter is varied (i.e., bifurcations to chaotic scattering), and to the effect of finite wavelength for wave equation problems whose corresponding ODE ray equations have chaotic scattering solutions.

Organizer: Edward Ott
University of Maryland, College Park

10:30/A60-61
Bifurcations to Chaotic Scattering
(to be presented by organizer)

11:10/A61
Multifractal Properties of Chaotic Scattering
Tamas Tel, IFF, Zentrum Julich, Julich, West Germany (on leave from Eötvös University, Budapest, Hungary

11:50/A61
Quantum Chaotic Scattering
Reinhold Blumel, University of Pennsylvania, and Uzi Smilansky, The Weizmann Institute, Rehovot, Israel

Friday, May 11/10:30 AM - 12:30 PM
Minisynposium 48/Hybiscus Room

The Role of Coherent Structures in Two-Dimensional Turbulence

High resolution simulations of two-dimensional turbulence have revealed that coherent structures play a far more important role in the evolution of turbulence than previously believed. There is evidence that for some questions, the full system representing infinite degrees of freedom may be reduced to some tens of degrees of flow. The emergence, structure, distribution and interaction of these vortices will be discussed. In geophysical applications, the effect of differential rotation rate is of great importance. The role that this effect plays on modifying these vortices and in creating other turbulent flow structures will also be addressed.

Chair: George F. Carnevale
Scripps Institute of Oceanography

10:30/A61
The Statistics of Vortex Merger in Two-Dimensional Turbulence
(To be presented by organizer)

11:00/A61
The Coherent Structures of Two-dimensional Turbulence
Paolo Santangelo, IBM European Center for Scientific and Engineering Computing, Rome, Italy

11:30/A62
Coherent Jets in Geophysical Turbulence
Lee Panetta, Texas A&M University

12:00/A62
Coherent Structures in Two-Dimensional Geophysical Turbulence
Mathew E. Maltrud, Scripps Institution of Oceanography, and Geoffrey K. Vallis, University of California, Santa Cruz

Friday, May 11/10:30 AM - 12:45 PM
Contributed Presentations 18/Azalea Room

Qualitative Theory of Differential Equations

Chair: Natalia Sternberg, Clark University

10:30/A62
A New Kind of Stability
Ian Melbourne, University of Houston

10:50/A62
Separatrix Crossing
F. Jay Bourland, University of Washington; and Richard Haberman, Southern Methodist University

11:10/A62
Canards and Excitability of Lienard Equations
Morten Brons, Technical University of Denmark, Lyngby, Denmark

11:30/A63
Normalization and Behavior of Flows in the Main Problem of Artificial Satellite Theory
Shannon Coffey, Naval Research Laboratory; Andre Deprit, National Institute of Standards and Technology; and Liam Healy, Naval Research Laboratory

11:50/A63
Floquent Equations
Yulin Cao, University of Georgia

12:10/A63
Time Dependent Normal Form Theory to Schrodinger Initial Value Problem
Raghu R. Gompa, Indiana University, Kokomo

12:30/A63
Quasiperiodic Systems and Their Linearization
Shui-Nee Chow, Georgia Institute of Technology; Kening Lu, University of Minnesota, Minneapolis; and Yun-Qiu Shen, Western Washington University

Friday, May 11/10:30 A - 12:30 PM
Contributed Presentations 18a/Orange Room

Chair:

10:30/A63
Transitions Between Attractors of Coupled Map Lattices
Gottfried Mayer-Kress, University of California, Santa Cruz

10:50/A64
Chaos and Order in the Fisheries System in Lake Superior
Yosef Cohen, University of Minnesota, St. Paul

11:10/A64
Continuation Principle for Second Order Systems on Manifolds
Beatrice Venturi, Universita di Cagliari, Italy

11:30/A64
Digital Simulation Technique for Modelling and Testing of Speed Control Systems
V. Y. Tawfik, Mosul University, Iraq and Hameed H. Hashem, Institute of Technology, Iraq

11:50/A64
Stability of Estimation Algorithms for Large Sparse Systems
Migdat I. Hodzic, Banja Luka, Yugoslavia

12:00 PM
Registration Desk Closes

12:30 PM
Conference Adjourns

ABSTRACTS: MINISYMPOSIA, CONTRIBUTED AND POSTER PRESENTATIONS (in chronological order)

MONDAY, 10:30 AM

MONDAY, MAY 7 - 10:30 AM-12:30 PM
Room: Lemon-Lime
Minisymposium 1
Control of Chaos 1
Chair: Alfred Hubler

10:30 AM
On Controlling Complex Dynamic Systems

It is proved that a class of dynamic systems can be entrained to follow any prescribed governing dynamic behavior, G(T), within a limited region of its phase space. The autonomous system may have any complex dynamics, X(T), but if it possesses a "local contracting" behavior in some region of its phase space, entrainment

$$(\lim_{t\to\infty} |X(T) - G(T)| = 0)$$

can be established in this region. This method does not rely on precise knowledge of X(0), when the control is initiated, nor on the feedback of information at later times. When the modelling of the dynamics is not exact, near-entrainment can be proved in a more restricted region.

E. Atlee Jackson
Dept. of Physics; 1110 W. Green St.
and Center for Complex Systems Research
Beckman Institute; 405 N. Mathews
University of Illinois at Urbana-Champaign
Urbana, IL 61801

11:10 AM
Control of Nonlinear Continuous Systems Based on Poincaré-Maps

A new method for control of nonlinear oscillators by nonlinear entrainment is presented. The corresponding driving forces are calculated from Poincare-maps of the continuous system. The magnitude of the driving forces depend on the type of the goal dynamics and can be very small. If the Poincaré-map of the continuous system is known, no feedback is necessary for the control. We discuss the effect of imperfect system identification and the effect of noise. The method is illustrated with experimental and numerical examples. The driving forces are aperiodic.

Robert Georgii
Physikdepartment Institut E13
Technische Univeritaet Muenchen
James-Franck-Str.
8046 Garching
West Germany

11:50 AM
Modelling and Control of Dynamical Systems with Hidden Variables

Techniques are presented for the reconstruction of differential equations from experimental data even when some of the dynamical variables are not observable. Once these hidden variables have been reconstructed, the differential equations can be used for non-linear control of the experimental system without feedback. Noise will be discussed in relation to this modelling procedure.

Joseph L. Breeden
Center for Complex Systems Research
Department of Physics
405 North Mathews Avenue
Urbana, Illinois 61801

MONDAY, MAY 7 - 10:30 AM-12:30 PM
Room: Tangerine A
Minisymposium 2
Applications of Population Biology 1
Chair: Paul Waltman

10:30 AM
Is Intraspecific Competition between Juveniles and Adults Stabilizing or Destabilizing?

One type of resource competition that can take place between individuals of the same species occurs between juveniles and adults. In this talk, the question in the title (which has been raised and studied in several recent papers) will be investigated by means of the general McKendrick/von Foerster equations. Two types of such competition are modeled: adult suppressed fertility due to juvenile competition and increased juvenile mortality due to adult competition. The sensitivities of equilibrium levels and of equilibrium resilience to changes in competition coefficients are studied. It is found that the first type of competition is destabilizing while the latter may or may not be destabilizing (depending upon a derived criterion).

J.M. Cushing, Department of Mathematics, U. of Arizona, Tucson, AZ 85721

Jia Li, Center for Nonlinear Studies, Los Alamos National Laboratories, MS-B258, Los Alamos, NM 87545

11:00 AM
Permanence and the Ergodic Theorem

We consider a flow f on the nonnegative orthant R^n_+, on a halfspace, or on a manifold M with boundary, such that both bdM and intM are invariant. f is called permanent if f|intM has a global compact attractor in intM. The interpretation of permanence for population models is that all species will

survive indefinitely.
Permanent flows will be characterized in terms of time-averages, and invariant measures of the flow on bdM.

Josef Hofbauer

Institut für Mathematik, Universität Wien
Strudlhofgasse 4
A-1090 Vienna, Austria

11:30 AM

Competition in the Gradostat

The talk will focus on a mathematical model of exploitative competition between species of microorganisms in a gradostat. A gradostat consists of several chemostats (CSTR's) connected together so that material flow occurs between vessels and to and from the external environment. Such devices provide spatially heterogeneous environments for competition which are simple enough that the qualitative analysis of the corresponding mathematical model is tractable. The fundamental question is whether or not two or more species can coexist in such an environment. Positive results on this question will be presented and the question of the robustness of coexistence to various perturbations in the gradostat will be discussed.

Hal L. Smith
Department of Mathematics
Arizona State University
Tempe, AZ 85287-1801

12:00 AM

Effect of an Internal Nutrient Pool on Growth of Microorganisms in the Chemostat

Phytoplankton populations in natural environments are often limited by the scarcity of some nutrient, but the relationship between the environmental concentration of the limiting nutrient and the instantaneous growth rate of the organisms is not completely understood. In an attempt to better understand the relationship, a mathematical model of growth and competitive interaction of microorganisms in the chemostat, in which nutrient uptake and conversion to viable cellular component are not directly coupled, is analyzed. Uptake is assumed to depend on external nutrient concentration while growth of viable cellular component is assumed to depend on the concentration of an internal nutrient pool.

Betty Tang, Department of Mathematics and Computer Science, Wake Forest University, Winston-Salem, NC 27109, U.S.A.

Gail S. K. Wolkowicz, Department of Mathematics and Statistics, McMaster University, Hamilton, Ontario, Canada L8S 4K1

MONDAY, MAY 7 - 10:30 AM-1:00 PM
Room: Tangerine B
Minisymposium 3
Mathematical Models for Microstructural Evolution
Chair: Helena S. Wisniewski

10:30 AM
H. Wadley
No abstract submitted.

10:55 AM
B. Wilcox
No abstract submitted.

11:20 AM

Numerical Solutions of Front Propagation Problems

New numerical algorithms for following fronts propagating with speed depending on curvature and/or other geometric and coupled physical properties have been devised. The equations of motion resemble Hamilton-Jacobi equations. The algorithms handle kinks, cusps, topological breaking and merging naturally, work in any number of space dimensions, and do not require that the front be written as a function. This work is largely joint with J. Sethian.

Stanley Osher
Department of Mathematics
UCLA
Los Angeles, CA 90024

11:45 AM

Pattern Selection During Crystal Growth

We review recent developments in the theory of pattern formation with specific application to the formation of solidification microstructures. Examples include cellular patterns, lamellar eutectic arrays and the dendritic growth morphology. Emphasis is placed on the critical microscopic parameters which govern the length scales of the final structure.

Herbert Levine
Department of Physics
and
Institute for Nonlinear Science
University of California
La Jolla, CA 92093

12:10 PM

Evolution of Microstructure in Welds

In fusion welds the heat-affected-zone (HAZ) is a region adjacent to the molten pool that experiences significant metallurgical change but does not melt. The HAZ is usually the weakest link in the joint. A mathematical model for computing the evolution of microstructure in the HAZ of low alloy steels is presented. During welding, the HAZ is heated rapidly; phase transformations from ferrite-pearlite to austenite are assumed to occur at equilibrium, i.e. superheating is ignored. ODEs from metal physics describing austenite grain growth and the decomposition of austenite are integrated using LSODE with asymptotic starting solutions. The transient temperature field is computed with 3D transient non-linear finite element analysis. The microstructure is interpolated with the FEM basis functions as a field in space-time.

J. Goldak, M.J. Bibby, P. Khoral & M. Gu
Mechanical & Aerospace Engineering
Carleton University, Ottawa, Canada K1S 5B6

12:35 PM

Simulation of Residual Stress Effects on the Mechanical Behavior of Metal-Matrix Composites

Fiber reinforced composites frequently have increased stiffness, strength, and creep resistance in comparison to unreinforced materials. Unfortunately, these composites typically exhibit low ductility and low fracture toughness. A better understanding of failure mechanisms is needed to develop thermo-mechanical processing strategies that minimize these problems, while maintaining desirable properties. Numerical studies of factors affecting the processing induced residual stresses that develop due to the mismatch in thermal expansion between the fiber and the matrix are reviewed. Effects of residual stresses on mechanical properties and ductility are illustrated. Some general issues associated with failure at interfaces in composites are also discussed.

Alan Needleman, Gary L. Povirk and Steven R. Nutt
Division of Engineering
Brown University
Providence, Rhode Island 02912

MONDAY, MAY 7 - 10:30 AM-12:30 PM
Room: Magnolia
Minisymposium 4
Magnetic Dynamos 1
Chair: Ittai Kan

10:30 AM

Rigorous Results on Fast Magnetic Dynamos

The problem of whether or not steady fast kinematic dynamos exist for typical smooth velocity fields has remained an open question in the origin of magnetic fields in nature (e.g., the observed magnetic fields in stars and in galaxies). (Here by a steady flow we mean that the fluid velocity v depends on position x but is independent of time t,i.e., $v = v(x)$.) Recently a condition has been specified on the velocity field v such that a fast kinematic dynamo is produced. Flows satisfying this condition are called D-flows. We show how to construct a class of steady D-flows, and we investigate the properties of this class of flows. Implications for time-periodic and randomly time varying dynamos are also discussed. Also, the large magnetic Reynolds number limit and the stability of the dynamo action under small perturbations of the flow are discussed.

John M. Finn
Laboratory for Plasma Research
University of Maryland, College Park, MD 20742

James D. Hanson
Department of Physics
Auburn University, Auburn AL 36849

Ittai Kan
Department of Mathematical Sciences
George Mason University, Fairfax, VA 22030

Edward Ott
Laboratory for Plasma Research, Department of Electrical Engineering, and Department of Physics
University of Maryland, College Park, MD 20742

11:10 AM

Fast Kinematic Magnetic Dynamos and Chaotic Flows

In this talk[1] the kinematic dynamo problem is considered in the astrophysically relevant limit of infinite magnetic Reynolds number (the "fast" kinematic dynamo). It appears that an important ingredient for a kinematic dynamo in this limit is that the orbits of fluid elements in the flow be chaotic. It is shown that the magnetic field tends to concentrate on a fractal set, and, in addition, tends to exhibit arbitrarily fine-scaled oscillations between parallel and antiparallel directions.[1] Idealized analyzable examples exhibiting these properties are presented, along with numerical computations on more typical examples. The relation of the dynamo growth rate to the topological entropy of the chaotic flow is discussed.

1. J. M. Finn and E. Ott, Phys. Rev. Lett. **60**, 760 (1988); Phys. Fluids **31**, 2992 (1988).

Edward Ott
Laboratory for Plasma Research
University of Maryland
College Park, MD 20742

11:50 AM
Nonlinear Stability for Magnetic Flows

The Lyapunov method for Hamiltonian Systems developed by Arnol'd gave sufficient conditions for nonlinear stability which were applied to 2D stationary flows of an ideal fluid. We apply the treatment of Arnol'd to study the stability of general steady axisymmetric equilibria in 3D magnetic flows. We obtain an explicit expression in terms of the equilibrium flow for a quadratic form whose positivity gives sufficient conditions for nonlinear stability. We interpret this MHD analogue of the Rayleigh criteria in the context of the dynamics of the Earth's fluid core.

Susan Friedlander
Department of Mathematics, Statistics, and Computer Science
University of Illinois at Chicago
Chicago, IL 60680

M.M. Vishik
Institute of Physics of the Earth
10 Bolshaya Gruzinskaya
Moscow, 123810 USSR

MONDAY, May 7 - 10:30 AM-12:30 PM
Room: Oleander A
Minisymposium 5
Graphics, Imaging and Vision 1
Chair: Marc A. Berger

10:30 AM
Focal Attention and its Function in Early Vision

One may probe the function of the visual system by confronting an observer with an ensemble of stimulus patterns, varying between themselves in certain aspects, and by assigning the task of reporting on one of these aspects as each pattern is shown. The present talk concerns conflicts that arise when an observer is asked to report simultaneously on more than one aspect of the pattern. In many instances, such conflicts are caused by competition for a process known as "focal attention". An investigation of those stimulus aspects that are seen (and reported) without conflict, and of those that are not, suggests that focal attention makes a specific contribution to the sensory processing within early vision.

Jochen Braun, California Institute of Technology, Division of Biology 216-76, Pasadena, CA 91125

Dov Sagi, The Weizmann Institute of Science, Department of Applied Mathematics and Computer Science, Rehovot 76100, Israel

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11:00 AM
Texture Discrimination Learning: Implications for the Functional Architecture of Early Vision

For some perceptual tasks, performance improves with practice (learning). This has important implications for modeling sensory processing, as the dependence of learning on specific input parameters is an effective probe to the functional architecture of the sensory system. We discovered remarkable long-term learning in a texture discrimination task - the separation of a target object from background. Using discrete input parameter changes we found that learning was specific for visual-field locality; background, but not target, element orientation; and was task dependent. Texture segregation is performed per visual-field locality by disparity sensitive mechanisms, but learning is "gated" by global processing. This can be modeled by Hebb like single cell interactions.

Avi Karni[1,2] and Dov Sagi[1]

[1]The Department of Applied Mathematics and Computer Science, The Weizmann Institute of Science, Rehovot 76100, Israel and

[2]The Department of Neurology; Chaim Sheba Medical Center, Tel-Hashomer, Israel

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11:30 AM
Necessary and Sufficient Global Computations in Texture Segmentation

Texture segmentation plays an important role in separating objects from background. In some cases figure/ground segregation is accomplished in parallel across the visual field. Previous attempts to characterize these cases, concentrating either on global statistical analysis or on local feature analysis, failed to account for the range of phenomena involved. We present a model for texture segmentation, having a minimal global component: An image is convolved with a set of Gabor filters. Local energy differences are detected in each filtered image to indicate possible texture boundaries. Finally, a global threshold is used to distinguish real boundaries from false ones. Analysis of model performance yields excellent agreement with psychophysical data.

Dov Sagi and Barton S. Rubenstein
Department of Applied Mathematics and Computer Science, The Weizmann Institute of Science, Rehovot 76100, Israel

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12:00 PM
Data Structures and Algorithms for Volumetric Brain Imaging

Computer-based three-dimensional (3D) reconstruction of the brain from serial sections is a powerful tool capable of revealing structural and functional relationships not readily available in 2D views. Once reconstructed, computer graphics operations permit generation of cross sections in planes other than those of the original plane of section, shading to reveal 3D shape and coloring for the display of functional maps. From a quantitative perspective the reconstructed brain models prove to be useful for the correlation and analysis of spatially distributed functional maps derived from multiple imaging modalities (e.g. PET,MRI), but which are independent of discrete, anatomical boundaries. A major problem of this technique is the substantial computation and storage demand for reconstruction, manipulation, display and analysis, due to the extremely large numbers of data elements which comprise a brain model of even modest complexity. We present data structures and algorithms for fast, efficient reconstruction, manipulation and display of volumetric data, for serial architecture workstations and for two types of parallel architectures.

Scott B. Berger, Robert D. Leggiero, Jason J. Orefice and Gregory F. March. Cornell University Medical College, Division of Neurobiology, 411 E. 69th Street, New York, NY 10021.

MONDAY, MAY 7 - 10:30 AM-12:30 PM
Room: Oleander B
Contributed Presentations 1
Fractal Sets
Chair: Hans Othmer

10:30 AM
Classification of Strange Attractors by Integers

We show how to characterize a strange attractor by a set of integers. The integers are extracted from the chaotic time series data by first reconstructing the low period orbits and then determining the template, or knot-holders, which supports these orbits, all other periodic orbits embedded in the strange attractor, and the strange attractor itself. The template is indentified by a set of integers which therefore characterize the strange attractor. This indentification is explicitly demonstrated for a dissipative and a Hamiltonian system a relatively small data set (5000 points).

Gabriel B. Mindlin,(1) Xin-Jun Hou,(1) Hernan G. Solari,(1) R. Gilmore(1) and N.B. Tufillaro(2)

(1) Department of Physics and Atmospheric Science Drexel University, Philadelphia, PA 19104-9984

(2) Department of Physics, Bryn Mawr College, Bryn Mawr, PA 19010-2899

10:50 AM
Dependence of Hausdorff and Fractal Dimensions on a Metric of a Phase Space

Here is a problem connected to obtaining estimates for dimensions of attractors of dynamical systems with infinitely many degrees of freedom. Two counter examples showing that one and the same compact set can have finite Hausdorff or fractal dimension with respect to some norm and infinite dimension with respect to a stronger norm will be described. These examples show that an estimate of the dimension of the attractor in some norm does not imply an estimate in a stronger norm. Possible consequences of the fact that the dimension of the attractor in hydrodynamics is finite with respect to an infinite scale of Sobolev norms will be discussed.

Victor I. Shubov
Department of Mathematics
Texas Tech University
Box 4319
Lubbock, TX 79409-1042

11:10 AM
Box-Counting with Base b^n Numerals

Conventional box-counting methods for characterizing the spatial structure of an attractor involve constructing uniform partitions of a set containing the attractor and counting the number of elements of a partition that intersect the attractor. Following a method first described by Georg Cantor in 1877, one may construct from the representation of a point as an n-tuple of base b numerals a single base b^n numeral that approximates the point as a sequence of nested n-dimensional cubes. For attractors represented as ordered lists of such numerals, box-counting is a task of linear complexity.

Stuart C. Bingham
Department of Mathematics
University of Tennessee
Knoxville, TN 37996-1300

11:30 AM
Fingerprints for Strange Sets.

I explore topological characterization of strange sets that can arise from experiments. The topological invariants are the Relative Rotation Rates recently proposed by Solari and Gilmore (Phys. Rev. A38, 1566 (1988)). We show how these topological invariants can be extracted from data and used to 'fingerprint' a strange set. Our method yields a estimate of the topological entropy, as well as the linking numbers of all periodic orbits embededded in a strange set.

Nicholas B. Tufillaro &
Department of Physics
Bryn Mawr College
Bryn Mawr, Pennsylvania
19010-2899 USA
Bitnet: nbt@brynmawr

Hernan G. Solari &
R. Gilmore
Drexel University
Philadelphia, PA
19104

MONDAY, MAY 7 - 4:30 - 6:30 PM
Room: Tangerine A
Minisymposium 6
Modeling and Forecasting Time Series
Chair: Martin Casdagli

4:30 PM
Using Prediction Algorithms to Improve Dimension Estimation

With conventional algorithms, it is difficult to obtain RELIABLE and PRECISE estimates of dimension directly from a time series. Two approaches will be discussed for using predictor algorithms to improve the situation.

The first recognizes that dimension must be small if short-term predictions are even a possibility. Thus, predictability can be used as a more RELIABLE criterion for low-dimensional behavior.

The second approach is to use long-term extrapolation to generate artificial data sets much larger than the original data. From these extended data, conventional algorithms can provide more PRECISE estimates of dimension.

James Theiler
MIT Lincoln Lab
L-244
P.O. Box 73
Lexington, MA 02173

5:10 PM
Analysis of Nonlinear and Chaotic Models in Vibrating Systems

Nonlinear behavior is often encountered in the analysis and experimental identification of vibrating systems. These systems may be driven by deterministic or random inputs. In either case chaotic motion may lead to a loss of predictibility in the system response.

Frequency domain (Volterra in Weiner series), time domain (delay coordinate models), and state space models have been applied to the analysis of nonlinear and chaotic systems. In this paper we briefly review these techniques. Data for our test cases is generated numerically derived from analog computer models, and obtained from experimental models of chaotic vibrating systems.

Norman Hunter
Los Alamos National Laboratory
MS-C931
P.O. Box 1663
Los Alamos, NM 87545

5:50 PM
Noise Amplification and Takens Embedding Theorem

Takens embedding theorem shows how to reconstruct a state space from an observed scalar time series, which is suitable for nonlinear model building. No analysis is given of noise in the observations. In this presentation I will quantify how a takens embedding amplifies small levels of observational noise. I will also remark on how this result may be used to derive fundamental limits on short term predictability in terms of dimension. Liapunov exponents and noise level.

Martin Casdagli
Santa Fe Institute
1120 Canyon Road
Santa Fe, NM 87501

MONDAY, MAY 7 - 4:30 - 6:30 PM
Room: Tangerine B
Minisymposium 7
Understanding Biological Dynamics
Chair: Michael C. Mackey

4:30 PM
Nonlinear Dynamics of Endocrine Regulation

Recent clinical measurements in both patients and healthy persons reveal that on a fine time scale (in the order of 10 minutes) hormone concentrations may undergo dramatic variations which often have the character of very irregular oscillations. We address here the problem of the origin of this apparently chaotic pulsatile activity in the endocrine system from the perspective of the theory of nonlinear dynamical systems. Our current analysis suggests that each gland (e.g. hypothalamic, pituitary, suprarenal) on the one hand is in itself a complicated regulatory unit with own dynamics and, on the other hand, is coupled through various kinds of feedback to other glands, and also to neuronal activity. A mathematical model is proposed which, on the basis of metabolic and enzyme kinetically induced nonlinearities, time delay, and nonlinear superposition of a circadian oscillator explains a variety of the normal and pathological behavior in the endocrine system.

Uwe an der Heiden
Institute for Mathematics
University of Witten/Herdecke
Stockumer Strasse 10
D-5810 Witten
Fed. Rep. Germany

5:00 PM
The Effect of Noise on Oscillation Onset in the Pupil Light Reflex.

The human pupil light reflex (PLR) is a neural control system which exhibits equilibrium and periodic motion as well as aperiodic fluctuations in pupil area. The dynamics of the PLR can be modified using external electronic feedback, and oscillations induced by increasing the feedback gain. A model for the PLR, framed in terms of a nonlinear delay-differential equation (DDE), is proposed which attributes the onset of oscillation to a supercritical Hopf bifurcation. The behaviour of the mean oscillation amplitude and period is explained in the hypothesis that specific physiological parameters are fluctuating. Simulations reveal that the Hopf bifurcation is postponed by both additive and multiplicative colored noise. Theoretical insight into the origin of this effect is given.

André Longtin
Theoretical Division B213
Los Alamos National Laboratory
Los Alamos, NM 87545

5:30 PM
Delayed Mixed Feedback and the Complexity of Neural Dynamics

The mechanisms responsible for generating the complexity of neural dynamics have not yet been identified. Recurrent inhibitory loops (RIL) occur widely in the nervous system and are examples of mixed feedback mechanisms, i.e., both negative and positive feedback. A delay-differential equation for hippocampal RIL produces spike trains whose statistics are consistent with observation. Complex dynamics are also observed in experiments in which the pupil light reflex is "clamped" with external mixed feedback. These observations indicate that very simple neural mechanisms with delayed mixed feedback can generate very complex dynamics with properties similar to those seen experimentally.

John Milton, M.D.
Assistant Professor,
Department of Neurology
University of Chicago
5841 South Maryland Avenue
Chicago, Illinois 60637

6:00 PM
R. M. Westervelt
No abstract submitted.

MONDAY, MAY 7 - 4:30 - 6:30 PM
Room: Oleander A
Minisymposium 8
Graphics, Imaging and Vision 2
Chair: Marc A. Berger

4:30 PM
Cyclic Particle Systems and Cyclic Cellular Automata

A cyclic particle system is a multitype continuous-time Markov process evolving on the d-dimensional integer lattice which is related to the Belousov-Zhabotinsky rotating chemical reaction. A cyclic cellular automaton is the analogous discrete-time deterministic process which generalizes a model of Greenberg and Hastings. In each case, a cyclic structure is imposed on the type-space; this structure induces a stable dynamic as time evolves. The investigation into these processes is an outgrowth of the study of other interacting particle systems, such as the voter model. Empirical information is gathered using a Cellular Automata Machine, which generates "movies" of these processes providing indispensible intuition. Theorems about the one- and two-dimensional versions will be presented, and pictures of the two-dimensional models illustrating conjectured behavior of these processes will be shown.

Robert Fisch
Department of Mathematics
University of North Carolina at Charlotte
Charlotte, NC 28223

4:55 PM
Some computations on parameters of random polygons by simulation

A Poisson line process is simulated in an analog environment and in a digital environment in order to obtain better approximation for parameters of the convex polygons generated by these lines. The first three moments and the distribution of the following parameters are examined. The area, the perimeter and the number of sides. Also, the correlation between them are calculated.

S. Bercovich and E. Merzbach
Department of Mathematics and Computer Science
Bar-Ilan University
Ramat Gan 52100 ISRAEL

5:20 PM
Graphics and Visualization at the Pittsburgh Supercomputing Center

The PSC provides supercomputing time and support to a national community of researchers in a tremendous variety of fields. This user community is distributed across the United States; almost none of the researchers work at our headquaters. We have evolved a graphics and visualization environment based on a standard two-dimensional metafile (CGM) which provides remote users with a good level of functionality and a simple mechanism for animating their results. We are now attempting to extend this paradigm to three dimensions with a lisp-based metafile format called P3D.

Dr. Joel Welling
Pittsburgh Supercomputing Center
Mellon Institute
4400 Fifth Avenue
Pittsburgh, PA 15213

5:45 PM
Image Generation via Iterated Function Systems and the Propagation of Rounding Errors

A novel method for digitized image generation is based on the identification of a given image with the stationary distribution of an ergodic Markov chain which has the Euclidean plane as its state space. The probability structure of the chain is given in terms of an Iterated Function System with Probabilities (a finite number of contractive transformations of the plane into itself and associated weights). We introduce a Markov chain with discrete state space, that serves as an approximate model of the propagation of rounding errors caused by the implementation of the image generation algorithm based on the original chain, and investigate its properties.

Mario Peruggia
Department of Statistics
Carnegie Mellon University
Pittsburgh, PA 15213

6:10 PM
Multi-scale Algorithm for an Image Segmentation Problem

The image segmentation problem here is a Mumford-Shah problem, which is to minimize $\mu^2 \int_D (u-f)^2 + \sum \int_{D_i} |\nabla u^2| + \nu^2 \, \mathrm{length}(\Gamma)$, where f is given and Γ consists of some curves which divides D into $\{\Omega_i\}$. By changing the last term in the M-S problem to the "complexity" of Γ such as the number of connected components in $\mu \to 0$ case one can show that Γ must consist of level curves of f. Thus, a tree structure for the set of level curves is established and a multi-scale algorithm is designed to minimize the energy function.

Yang Wang
Georgia Institute of Technology
School of Mathematics
Atlanta, GA 30332

MONDAY, MAY 7 - 4:30 - 6:30 PM
Room: Oleander B
Minisymposium 9
The Computation of Dynamical Systems 1
Chair: Mitchell Luskin

4:30 PM
Symmetry Creation in Nonlinear Systems

We describe ways in which the existence of symmetry affects the geometric structure of attractors obtained through iteration of discrete dynamical systems. The stimulus for this work is the existence of patterned turbulent states in closed fluid systems such as the Taylor-Couette system, though no direct connection can as yet be made.

In this talk we will present both the mathematics behind symmetry increasing bifurcations and slides showing the variety of attractors that have been observed.

Professor Mike Field
Department of Pure Mathematics
University of Sydney
Sydney, NSW 2006
AUSTRALIA

Martin Golubitsky
Department of Mathematics
University of Houston
Houston, TX 77204-3476

4:55 PM
The Dynamics of Coupled Pendula

Numerical and analytical results on the dynamics of coupled current-biased Josephson junctions are presented. This device is known as a SQUID (Superconducting Quantum Interference Device) and functions as a very sensitive field detector. The mathematical model of two coupled nonlinear ordinary differential equations can also be interpreted in terms of coupled rotating pendula. We discuss the global solution structure of these equations, in particular the fixed points and the rotations of phase gain $2k\pi$ per period. A large variety of homoclinic and heteroclinic orbits exists when the coupling strength is small. A computer animation will be shown to illustrate these motions.

D. G. Aronson, School of Mathematics,
University of Minnesota, Minneapolis MN 55455, USA,
E. J. Doedel, Computer Science Department,
Concordia University, Montreal, H3G 1M8, Canada,
H. G. Othmer, Department of Mathematics,
University of Utah, Salt Lake City UT 84112, USA.

5:20 PM
Computation of Invariant Manifolds

We consider an autonomous system of differential equations that depends on a parameter λ. Suppose we know an invariant torus for $\lambda = 0$. We consider the computational problem to follow the deforming invariant tori numerically as the parameter λ is changed. Under-rather strong-assumptions the tori can be parametrized by variables which are also dependent variables of the given dynamical system. If this is the case, then the tori can be obtained by solving p.d.e.s. We investigate various aspects of this approach.

Jens Lorenz
Dept. of Mathematics and Statistics
The University of New Mexico
Albuquerque, NM 87131

5:45 PM
Computer Algebra and Elliptic Functions

The method of averaging is used to perturb off of systems of differential equations which have Jacobian elliptic functions in their general solution for $\epsilon = 0$. The computer algebra system MACSYMA is used to derive the averaged equations, valid for small ϵ. Examples are

taken from dynamics problems involving mechanical systems.

Richard H. Rand
Dept. of Theoretical and Applied Mechanics
Cornell University
Ithaca, New York 14853

6:10 PM
Numerical explorations of a simple model for cardiac echo

Numerical solutions to differential equations can often shed light on the geometric structure of the underlying dynamics of the system. With the use of the interactive ODE solver PHASEPLANE that can find bifurcation points, invariant manifolds and graph the curves, we study the behavior of a simple geometric model for "echo waves". Echo waves are observed in cardiac and neuro-physiological systems and represent reflected waves in excitable media. We consider a simple model for these based on a pair of differential equations of the torus:

$$\theta_1' = 1 - \alpha\cos(\theta_1) + \beta_2\sin(\theta_2-\theta_1),$$
$$\theta_2' = 1 - \alpha\cos(\theta_2) + \beta_1\sin(\theta_1-\theta_2)$$

We explore the emergence of an unstable closed orbit on the torus. We then find open sets of initial conditions that give complicated patterns of firing (such as echo and propogation failure) before ultimately returning to rest.

G.B. Ermentrout
Dept. of Mathematics & Statistics
University of Pittsburgh
Pittsburgh, PA 15260

MONDAY, MAY 7 - 4:30 - 6:30 PM
Room: Magnolia
Minisymposium 10
Application of Dynamical Systems to the Understanding of Earthquakes
Chairs: Donald Turcotte and John Rundle

4:30 PM
Failure of Hierarchical Distributions of Fiber Bundles: Statics and Dynamics.

We consider by computational and analytic means the failure properties of hierarchically organized bundles of fibers with equal load sharing, a problem that may be treated exactly by renormalization methods. We show, *independent* of the specific failure properties of an individual fiber, that the stress and time thresholds for failure of fiber bundles obey universal albeit different scaling laws with respect to the size of the bundles. The application of these results to fracture processes in earthquake events helps to provide insight into some of the observed scaling laws.

William I. Newman
Departments of Earth and Space Sciences, Astronomy, and Mathematics
University of California
Los Angeles, CA 90024

Andrei M. Gabrielov
Institute of Physics of the Earth, USSR Academy of Sciences
10 Bolshaya Gruzinskaya
Moscow, USSR

S. Leigh Phoenix
Department of Theoretical and Applied Mechanics
Cornell University
Ithaca, NY 14853

Donald L. Turcotte
Department of Geological Sciences
Cornell University
Ithaca, NY 14853

4:50 PM
A Demonstration that Seismicity is an Example of Deterministic Chaos

Crustal deformation is a complex problem involving elastic and plastic deformation, creep processes, fracturing, and frictional interactions on preexisting faults. Many observations such as the frequency-size statistics of earthquakes and faults are fractal. The processes are generally scale invarient over a wide range of scales. A low-order analog dynamical system consists of two sliding blocks coupled to each other and to a constant velocity driver by elastic springs. Over a wide range of conditions this system exhibits chaotic behavior.

D.L. Turcotte and J. Huang, Department of Geological Sciences, Cornell University, Ithaca, NY 14853

5:10 PM
Self-organization, and Scaling in Earthquakes and Automata Models

It has recently been recognized that earthquakes may have self-organizing and scaling properties similar to those observed in percolation, nucleation and critical phenomena. In this talk, dynamical automata models for earthquake faults will be discussed which possess many of the properties of real fault systems. The simplest of these models is the Burridge-Knopoff (BK) model, in which a chain of masses and springs is dragged along a frictional surface. The BK model is obtained as the lowest order expansion of more general continuum models. All of these automata display clustering and scaling properties similar to those observed in nature.

John B. Rundle, Division 6231
Sandia National Laboratories
Albuquerque, NM 87185

5:30 PM
Nonlinear Convection in the Earth's Mantle

There are many routes to chaos in a 2-dimensional fluid with infinite Prandtl number. We take 12, 24 and 40 modes of Saltzman's Fourier model of the Boussinesq equations. The physical limit of infinite Prandtl number eliminates the inertial nonlinearity, to isolate the heat advection nonlinearity. We calculate some trajectories and bifurcations of these systems, and find numerous pitchfork bifurcations, subcritical Hopf bifurcations which give rise to some preturbulent behavior, and become stable periodic orbits at higher Rayleigh number. The 40-mode truncation approaches the spatial resolution of the finite-difference calculations of Lennie et al., who identified a sequence of period-doubling bifurcations of these stable periodic orbits. Therefore, the Lorenz picture of the route to chaos is qualitatively accurate in the limit of infinite Prandtl number, *particularly* when higher-order expansions are taken. This contrasts with the conventional view, based on finite Prandtl number calculations, that higher-order expansions suppress dynamic interactions among low-order modes of thermal convection.

Cheryl A. Stewart, Department of Geological Sciences, Snee Hall, Cornell University, Ithaca, NY 14853

5:50 PM

Fractals in Nucleation in Magnetic Systems and Crystals

The classical theory of nucleation assumes that the metastable state decays due to the occurence of a compact critical droplet with a well-defined surface with a fairly large surface tension, and bulk properties similar to those of the stable phase. Computer simulations and experiments have shown that the classical theory is correct under certain circumstances but fails in others. In fact there is a great deal of experimental data that the classical theory cannot account for.

We have proposed a second kind of nucleation process which is dominant in systems undergoing deep quenches. Based on the idea that deep quenches bring the system into the proximity of a spinodal line, we propose that the critical point-like spinodal line decreases the surface tension to the extent that critical droplets are no longer compact, but are fractal. In this presentation I will discuss the theoretical arguments as well as the simulation evidence that this theory is indeed correct.

William Klein
Dept. of Physics
Boston Univ.
Boston, MA 02215

6:10 PM

Earthquakes As A Self-Organized Critical Phenomenon

The Gutenberg-Richter law for earthquakes can be interpreted as a manifestation of a self-organized critical state. Results of simulations on a deterministic, continuously driven model are presented. It is conjectured that the crust of the earth is at the "border of chaos".
*Work supported by Division of Materials Sciences, USDOE, under contract DE-AC02-76CH00016.

Per Bak, Department of Physics, Brookhaven National Laboratory*, Upton, New York 11973

MONDAY, MAY 7 - 4:30 - 6:30 PM
Room: Lemon-Lime
Minisymposium: 11
Fractal Basin Boundaries
Chair: Kathleen Alligood

4:30 PM

Changes in Accessible Orbits at Crises and Metamorphoses

For invertible, area-contracting maps of the plane, the accessible orbits on basin boundaries have a unique rotation number which describes their motion around the basin. At a metamorphosis (i.e., a sudden jump in the basin boundary as a parameter is varied), this rotation number has a jump discontinuity. Chaotic attractors are similarly observed to have accessible rotation numbers. Like basin boundaries, chaotic attractors undergo discontinuous changes in size and shape, called crises. There are, however, striking differences between these two types of global bifurcations which are linked to changes in accessible orbits.

Kathleen Alligood
Department of Mathematical Sciences
George Mason University
Fairfax, VA 22030

5:10 PM

Basic Sets: Sets That Determine The Dimension of Basin Boundaries

In this talk I will consider the question of how many possible dimensions a basin boundary can have. We conjecture[1] that the number of possible dimension values is at most the number of some well defined asymptotic sets (called basic sets) on the basin boundary. It should be noticed that the dimension of a basic set also has a dynamical meaning. The conjecture was proved for a class of Axiom A systems (namely two dimensional diffeomorphisms and one dimensional chaotic maps). In addition, we will give numerical evidence for a physical example.

1. C. Grebogi, H. E. Nusse, E. Ott, and J. A. Yorke, Lecture Notes in Mathematics, Vol. 1342, p. 220, Ed. J. C. Alexander (Springer-Verlag, 1988).

Celso Grebogi
Laboratory for Plasma Research
University of Maryland
College Park, MD 20742-3511

5:50 PM

Experimental Observation of Crisis-induced Intermittency and Its Critical Exponent

Critical behavior associated with intermittent temporal bursting accompanying the sudden widening of a chaotic attractor was investigated experimentally in a parametrically driven magnetoelastic ribbon. As the driving frequency, f, was decreased through the critical value, f_c, we observed that the mean time between bursts scaled as $|f_c-f|^{-\gamma}$. This behavior is expected for an interior crisis and we have observed an unstable orbit thought to be mediating the crisis. Finally, we have measured the scaling structure of the attractor near one of the points in the unstable orbit and found the scaling exponent γ' to be consistent with the exponent γ.

S. Rauseo(1), W.L. Ditto(1), R. Cawley(1), C. Grebogi(1,2), G.-H. Hsu(1), E. Kostelich(2), E. Ott(1,2) H.T. Savage(1), R. Segnan(1,3), M.L. Spano(1) and J.A.Yorke(1,2)

(1)Naval Surface Warfare Center, Silver Spring, MD 20903-5000
(2)University of Maryland, College Park, MD 20742
(3)The American University, Washington, D.C. 20016-8058

TUESDAY, MAY 8 - 10:00 AM-12:00 Noon
Room: Lemon-Lime
Minisymposium: 12
Control of Chaos 2
Chair: Alfred Hubler

10:00 AM
Aperiodic Perturbations for Optimal Bond Breaking

The concept of aperiodic perturbations and chaotic control has been applied successfully to nonlinear dynamical systems with finite dissipation, for which a given dynamical system is entrained to a desired goal dynamics. In applications like bond-breaking of molecules the systems are conservative and therefore the concept of entrainment is not applicable. We present computational results for classical Morse oscillators and present results for their excitation depending on phase relations and model detuning. We compare the results with periodic perturbation and discuss the concept of nonlinear resonance spectroscopy. Quantum calculations for the same systems will be discussed in another presentation at this meeting.

Gottfried Mayer-Kress
Department of Mathematics
University of California at Santa Cruz

10:40 AM
Control of the Dynamics of Shock Waves and Complicated Flows by Aperiodic Perturbations

The method of Hubler's nonlinear control theory for maps and ordinary differential equations is extended to partial differential equations. We show, given a desired goal dynamics, a suitable driving force can be calculated that gives the appropriate behavior. The main emphasis of this paper is that control can be effected using dynamical, rather than state information, alleviating the necessity of feedback used in traditional control methods. Sensitivity of the control to model inaccuracies, boundary errors and noise are investigated through numerical simulations of Burger's equation.

Russel Shermer
Center for Complex Systems Research
University of Illinois
405 North Mathews Avenue
Urbana, Illinois 61801

11:20 AM
Description of the Dynamics of Kârmân Vortex Streets by Low Dimensional Differential Equations

Differential equations are constructed from special flow vector fields obtained from experimental time series of Kârmân vortex streets. It will be shown that the velocity signal measured in the regular range (50<Re<150) of a vortex street can be modeled by a 2nd order differential equation (ODE) with 10 parameters. The parameters are nearly independent of the probe position and of the Reynolds number. Discontinuities in the Strouhal-Reynolds number dependance (e.g. the Tritton discontinuity) are also reflected in the coefficients. With the knowledge of the ODE the response of the vortex street on perturbations can be predicted.

E. Roesch, F. Ohle, H. Eckelmann
Institut f. Angewandte Mechanik und Strömungsphysik der Universität Göttingen
Bunsenstr. 10
D 3400 Göttingen
A. Hübler
CCSR, University of Illinois
USA-Urbana, Ill 61801

TUESDAY, MAY 8 - 10:00 AM-12:00 Noon
Room: Tangerine A
Minisymposium 13
Applications to Population Biology 2
Chair: Paul Waltman

10:00 AM
A Dynamical Systems Analysis of a Model of Learning in Population Genetics.

A model by Stephens shows environmental predictability and unpredictability are necessary for the evolution of animal learning. The model involves the frequency of three behavioral phenotypes. The evolution of the frequencies is governed by difference equations whose parameters depend on environmental change within generations and between generations. Simulations suggest that learning does not evolve when within-generation and between-generation environmental predictability is highest, but this nonlearning evolution is sensitive to the amount of predictability. I present a dynamical systems analysis of the equations which justifies the results of the simulations and provides analytic results on the sensitivity to environmental predictability.

Steven R. Dunbar
Department of Mathematics and Statistics
University of Nebraska-Lincoln
Lincoln, NE 68588-0323

10:30 AM

A Heterosexual Model for the AIDS Epidemic with Biased Social Mixing

Mathematical models can provide a framework to better understand how the AIDS epidemic is spreading and which intervention strategies might be most effective. We have developed a heterosexual model for the spread of AIDS where the population is distributed according to partner acquisition rates and the duration of infection. The duration of infection allows us to account for variations of the infectivity with infection stage and variable progression rates from infection to AIDS. The mixing between groups with different risk behavior is determined by partner availability and acceptability as specified by an acceptance function. We observe that the growth rate of the model epidemic is determined largely by the social mixing patterns. When individuals only select partners with behavior similar to their own, after an initial transient during which the highest risk individuals are rapidly infected, the epidemic grows much slower than when people are less discriminating about who their partners are.

James M. Hyman and E. Ann Stanley
Theoretical Division, B284
Los Alamos National Laboratory
Los Alamos, NM 87545

11:00 AM

Pioneer-Climax Models of Difference and Differential Equations

Difference equation and differential equation models for population interactions of pioneer and climax species are presented. An effort is made to separate a species response to density from the effects of competition. The dynamical behavior of these models is analyzed both numerically and analytically. Stable periodic or almost periodic oscillations are established for both models via Hopf bifurcation and the possibility of strange attractors is discussed.

James F. Selgrade
Mathematics Department
Gene Namkoong
U.S. Forest Service and
Departments of Genetics and Forestry
North Carolina State University
Raleigh, NC 27695

11:30 AM

A Model of Tumor Growth with Application to Chemotherapy Scheduling

A model of tumor cell population growth will be analyzed. The model divides the tumor cell population into proliferating and quiescent classes. The transition rates between the two classes are nonlinear functions of the total population size. The solution curves exhibit a typical Gompertzian shape, which results from the increasing tendency of proliferating cells to become quiescent as total cell population becomes large. Various chemotherapy simulation studies will be demonstrated and optimal treatment scheduling strategy will be discussed.

G.F. Webb
Department of Mathematics
Vanderbilt University
Nashville, TN. 37235

TUESDAY, MAY 8 - 10:00 AM-12:30 PM
Room: Tangerine B
Minisymposium: 14
Aerospace Design 1
Chair: Helena S. Wisniewski

10:00 AM

Aircraft Design: A Conceptual Approach

This presentation will give an overview of the current practice of aircraft conceptual design in industry. The overall objectives, methods, and practical aspects of creating a new aircraft concept will be discussed. The analytical techniques whereby that concept is refined and optimized will also be outlined. The appropriate usage of advanced computational techniques (CFD, FEM, numerical optimization, etc...) will be highlighted, as will the use of CAD in conceptual design. (The presentation will largely be drawn from Mr. Raymer's textbook of the same title, published by AIAA.)

Daniel Paul Raymer
Lockheed Aeronautical Systems Company
2555 North Hollywood Way
(Mailing Address: P.O. Box 551)
Dept. 69-05, Bldg. 63-3, Fac. A-1
Burbank, CA 91520

10:25 AM

S. A. Orszag

No abstract submitted.

10:50 AM

ADVANCED LARGE EDDY SIMULATION ON HIGHLY PARALLEL COMPUTERS

Large Eddy Simulation technology for practical solution of time-dependent fluid dynamics on highly parallel computers requires uniform compressible subgrid models which are well matched at the grid scale to computationally efficient, high-resolution CFD algorithms. Explicit linear filtering in tradition LES models can damage unnecessarily the intermediate wavelengths, which good CFD algorithms are quite capable of resolving, and represents an additional computational expense. A framework will be described for minimal integrated LES models that is currently in production on a TMC Connection Machine. Calibration of the effective subgrid model is underway. The inclusive of stochastic backscatter effects and practical issues such as performance, realistic boundary conditions, and compressibility aspects of the intrinsic subgrid model will be discussed. The weighted harmonic mean law (i.e. "Amdahl's law"), usually quoted as limiting the practical use of highly parallel computers for CFD, has major loopholes which can be exploited.

Dr. Jay Boris, Chief Scientist and Director
Laboratory for Computational Physics & Fluid Dynamics
Code 4400, U.S. Naval Research Laboratory
Overlook Ave., Washington DC, 20375

11:15 AM
M. Salas
No abstract submitted.

11:40 AM
T. Jameson
No abstract submitted.

12:05 PM
Overview of Adaptive Techniques - Using Unstructured Grids

We will review automatic self-adaptive techniques for the optimization of unstructured grids. The aim of these techniques is to optimize the ratio of the accuracy of the numerical solution vs. the number of degrees of freedom employed. All three traditional approaches used in aerodynamics: mesh movement, h-refinement and mesh regeneration have their advantages and disadvantages. Grid regeneration is best suited for steady-state problems, or when body motion is present. However, for strongly unsteady flows, which require a newly adapted mesh every 5-10 timesteps, h-refinement seems to outperform all other techniques. Numerous examples, taken from daily production runs, will be presented as evidence for the conclusions drawn.

Rainald Löhner
CMEE, SEAS, The George Washington Univ.
Washington, D.C. 20052

TUESDAY, MAY 8 - 10:00 AM-12:00 Noon
Room: Oleander A
Minisymposium 15
Statistical Methods in Image Processing
Chair: Basilis Gidas

10:00 AM
Image Restoration with Implicit and Explicit Representation of Discontinuities.

The non-linear restoration problem is to recover an ideal two-dimensional brightness distribution X from the actual recorded, an usually corrupted values Y. We study a Bayesian stochastic method which involves minimizing a non-convex functional of the form E(X) = Prior(X) + Data(X,Y). We examine models with Prior(X) = Q(L(X)) where L is the norm of an n-th order derivative and Q is an even and increasing function with finite limit at infinity. We show that these models encode disconinuities implicitly and are naturally associated with "dual" models which encode the discontinuities explicitly. We also examine a method for optimizing E by an algorithm which is hierarchical in the order of the derivative. Restorations of real and synthetic images degraded by both blur and noise will be shown.

Don Geman and George Reynolds
Department of Mathematics
Univ. of Mass.
Amherst, Ma. 01003

10:30 AM
A Comprehensive Statistical Model for Medical Emission Tomography

In medical emission tomography, projection data are used to reconstruct an isotope concentration map. In this talk, the physics of the emission process -including attenuation, scatter, and the poisson nature of decay-are modelled in a probabilistic framework, and a physical phantom is used in experiments designed to measure the magnitude of these effects. The iterated conditional expectation (ICE) algorithm is presented as an effective method of achieving useful reconstructions. Isotope concentrations are reconstructed for both patient data and physical phantom data.

Stuart Geman, Donald E. McClure and Kevin Manbeck
Division of Applied Mathematics
Brown University
Providence, RI 02912

11:00 AM

Data and Model Driven Multiresoltion

A homogeneous approach to recognition of 3D objects is presented. Layered and parallel parameter transforms compute feature and object hypotheses on the basis the input and lower-level feature hypotheses. Constraint satisfaction networks collect and fuse evidence from various sources and ensure a globally consistent scene interpretation.
We introduce a new approach to multiresolution, which elegantly fits into this framework. Iteratively, the input is processed at a coarse resolution and at a selected high-resolution "spot." Both images are used simultaneously to form hypotheses about the scene content.
We conclude with drawing some parallels between constraint satisfaction networks and Markov random fields.

Ruud M. Bolle, Andrea Califano, and Rick Kjeldsen
Thomas J. Watson Research Center
Exploratory Computer Vision Group
P.O. Box 704
Yorktown Heights, NY 10598

11:30 AM

Computational and Estimation Algorithms in Computer Vision

We will present multiresolution-multilevel algorithms for image processing tasks. The basic procedure involves a combination of Annealing, Renormalization Group ideas , and Multi-grid techniques. We will also outline a new method for estimating the parameters of Markov Random Fields. The method is computationally more efficient than and as accurate as, the Maximum Pseudolikelihoood and EM algorithms.

Basilis Gidas
Division of Applied Mathematics
Brown University
Providence, RI 02912

TUESDAY, MAY 8 - 10:00 AM-12:00 Noon
Room: Oleander B
Minisymposium 16
Magnetic Dynamos 2
Chair: Ittai Kan

10:00 AM

Magnetic Field Generation by the Motion of a Highly Conducting Fluid.

Using an asymptotic expansion of the Green's function for the problem of magnetic field generation by the 3D steady flow of a highly conducting fluid a general antidynamo theorem is proved in the case of no exponential stretching of liquid particles. Explicit formulae connecting the spectrum of the magnetic modes with the geometry of the Lagrangian trajectories are obtained. The existence of fast dynamo action for special flows with exponential stretching is proved under the condition of smoothness of the fields of stretching and non-stretching directions.

M.M. Vishik
Institute of Physics of the Earth
National Academy of Sciences of USSR
10 Bolshaya Gruzinskaya
Moscow, 123810, USSR

Department of Mathematics, Statistics, and Computer Science
University of Illinois at Chicago
Chicago, IL 60680

10:40 AM

Stable and Unstable Manifolds in Chaotic Fast Dynamos

Fast dynamos require exponential growth of magnetic field in a fluid flow at large magnetic Reynolds number. Such a requirement suggests the use of chaotic flows. However, the folding characteristics of such flows result in magnetic field **cancellation.** The geometry of stable and unstable manifolds in stretch-fold-shear (SFS) chaotic fast dynamo mechanisms will be addressed in order to understand how phase reinforcement reduces magnetic field **cancellation.**

Isaac Klapper
Courant Institute,
New York University
New York, NY 10012

11:20 AM

Fast Dynamo Action in Chaotic Webs

We study the numerical computation of fast dynamo action within the region of Lagrangian chaos of a steady 3-dimensional flow field. An approximate model of a chaotic web is introduced, and the structure and growth of magnetic field transported through the web is studied.

S. Childress
Courant Institute
New York University
New York, NY 10012

U. Frisch
Observatoire de Nice
BP 139, 06003 Nice Cedex
France

A. Gilbert
DAMTP
Silver ST., Cambridge
CB3 9EW
U.K.

TUESDAY, MAY 8 - 10:00 AM-12:00 Noon
Room: Hybiscus
Minisymposium 17
Nonlinearities in the Atmospheric Sciences
Chair: Thomas Warn

10:00 AM

Chaos and Predictability in Atmospheric flows with Two Scales of Motion

This study considers the effect of nonlinear interactions between different scales of motion on the predictability of atmospheric flows. Chaotic solutions of a coupled model with two Lorenz models of different scales have been studied. The Lyapunov exponents and the growth of small random errors are found to depend on the strength of the coupling. In some cases, the errors grow rapidly and saturate at the smaller scale and the overall growth depends on the Lyapunov exponent of the larger scale. The implication of similar error growth in a simple coupled atmosphere–ocean climate model on the predictability of El Niño is discussed.

V. Krishnamurthy
Center for Ocean–Land–Atmosphere Interactions
Department of Meteorology
University of Maryland
College Park, MD 20742

10:30 AM

Applying Chaos Theory to Weather and Climate

Chaos theory has found numerous applications in weahter and climate. This only natural since chaotic dynamical systems imply intrinsically unpredicatable systems.

In this report we outline the areas of atmospheric research where chaos has found a place. Specifically we will discuss the search for attractors in weather (shorttime scales) and climate (longtime scales). Trying to reconstruct underlying the weather and/or climate attractors has proven to be a difficult task but to date there are many indications that low-dimensional attractors may exist.

The implications of such findings in understanding and exploring the limits of predictability will also be discussed.

Anastasios A. Tsonis
Department of Geosciences
University of Wisconsin-Milwaukee
3413 N. Downer Avenue
Milwaukee, WI 53201

11:00 AM

An Attractor-Preserving Algorithm for Truncating Pre-Chaotic Hydrodynamic Systems

Many atmospheric dynamical models exhibit transitions to chaos involving hierarchies of simple bifurcations. Because some chaotic attractors disappear as model size increases, having an algorithm for specifying truncations preserving the simple attractors in these hierarchies is a crucial step toward proper representation of the associated chaotic flows. An important type of bifurcation hierarchy includes toral solutions, which may arise via double Hopf bifurcations from steady states. In this paper the power series method is extended to produce appropriate truncation levels for dynamical models representing these bifurcating tori, and this technique is applied to a rotating convective system.

Hampton N. Shirer
Department of Meteorology
Robert Wells
Department of Mathematics
The Pennsylvania State University
University Park, PA 16802

11:30 AM

1-D Models of 2- and 3-D Turbulence with Many Scales

Severe D-1 directional Fourier truncation of the equations for D-dimensional (D=2,3) incompressible flow leads to a set of coupled PDE's retaining the original inviscid quadratic invariants. Numerically generated equilibria for the reduced inviscid truncated systems agree with statistical mechanical equipartition spectra. High Reynolds number calculations are consistent with inverse energy and direct enstrophy cascades (D=2), but show less convincing agreement with Kolmogorov phenomenology (D=3).

Although no tendency for coherent vorticity structures is noted, small-scale intermittency is observed in the vorticity gradient (D=2) and vorticity (D=3) fields. The reduced models consequently mimic many of the properties of the full sets.

Peter Bartello, Recherches en prévision numérique
2121, voie de Service Nord
Route Trans-canadienne
Dorval, Québec H9P 1J3

Thomas Warn, Department of Meteorology
McGill University
805 Sherbrooke Street West
Montréal, Québec H3A 2K6
Canada

TUESDAY, MAY 8 - 10:00 AM-12:00 Noon
Room: Azalea
Contributed Presentations 2
Bifurcation Theory
Chair: Martin Golubitsky

10:00 AM

Hopf Bifurcation Coefficients by Power Series Methods

Normal form coefficients for Hopf bifurcation in autonomous ordinary differential systems, can be computed to "arbitrary" order by a program using power series methods. Each component function f1,..,fn in the system must belong to the class of functions defined by starting with constants, variables x1 through xn and the bifurcation

parameter, and applying a finite number of elementary operations taken from a collection (+,-,*,/,log,exp,..). The algorithm uses at most 3-dimensional series operations, allows automatic analysis of all singularities of Z2-codimension < 4 and allows construction of accurate local bifurcation diagrams. The techniques generalize easily to singularities of higher Z2-codimension.

Brian Hassard and Hao Zhou
Department of Mathematics
State University of New York at Buffalo
Buffalo, NY 14214

10:20 AM

A Perturbed Hopf Bifurcation with Reflection Symmetry

We study the effects of a small symmetry breaking perturbation on a Hopf bifurcation with O(2) symmetry, where the perturbation breaks the continuous rotation symmetry, but retains a discrete reflection symmetry. In applications to convection in fluids, the O(2) symmetry arises from the assumption that the fluid occupies an infinite layer and satisfies periodic boundary conditions, while the perturbation adds the effects of distant sidewalls in a finite layer.

Wayne Nagata
Department of Mathematics
University of British Columbia
Vancouver, B.C., Canada
V6T 1Y4

10:40 AM

Degenerated Hopf Bifurcation of A Stochastically Disturbed System

Reults of a study on the degenerated Hopf bifurcation of a stochastically excited single degree of freedom oscillator is presented in this paper. The approach is based on the perturbation method, the limit theorem of Khasminskii which is in essence similar to the stochastic averaging of Stratonovich but is relatively more simple to use for second order approximations, some results from the singularity theory and group theory. Our main result is that with negative unfolding parameter the randomly excited system can have bifurcation in contrast to the unperturbed system in which no bifurcation is possible.

C.W.S. To and D.M. Li
Department of Mechanical Engineering
The University of Western Ontario
London, Ontario, Canada N6A 5B9

11:00 AM

Global Bifurcations in the Disturbed Hamiltonian Vector Field Approaching 3:1 Resonant Poincaré Map (I)

By using the qualitative method, we study global and local bifurcations in the disturbed Hamiltonian vector field approaching 3:1 resonant Poincaré map. We give explicit calculation formulas to determine bifurcation parameters and draw various bifurcations of phase portraits in the phase plane, e.g., introduction, analysis of the unperturbed system, detection functions, detection curves and phase portraits.

Li Jibin
Kunming Institute of Technology
Kunming Yunnan 650093
P.R. of China

11:20 AM

Bifurcation Into Sphere

Consider the following generalized normal form equations

$$\dot{x} = (\mu I + \Omega_c)x - \rho^2 x, \quad \in \mathbb{R}^n \tag{1}$$

where $\Omega_c = -\Omega_c^T$ is any skew-symmetric matrix and ρ is the Euclidean norm, i.e.,

$$\rho^2 = \sum_{i=1}^{n} x_i^2. \tag{2}$$

Focusing on the ρ-dynamics, we see that when μ exceeds zero, in addition to the now repelling origin, a new invariant orbit $\rho = \sqrt{\mu}$ appears. In the context of bifurcation theories, (1) exhibits a local, *primary* bifurcation into the $(n-1)$-sphere $\mathcal{S}^{n-1}$. It is interesting to compare this result to the more well known *secondary* bifurcations into tori from topological viewpoint, and to the phase space of the Euler's equations of motion for a free rigid body.

Jyun-Horng Fu, Applied Mathematics Program,
Department of Mathematics and Statistics,
Wright State University, Dayton, Ohio 45435

11:40 AM

Monotone and Antimonotone Behavior in the Cubic Map

The bifurcation diagram of a cubic family is analyzed, obtaining regions of monotone increasing, monotone decreasing and antimonotone behavior. This provides an example of a unidimensional map which is not piecewise monotone. Cubic maps appear connected to different physical problems. They also serve to analyze the antimonotonicity of the Henon family. Bubbles in this case are related to the existence of an underlying cubic map. Different criteria are developed in order to decide what kind of behavior should be expected for different cubic families. This analysis may help to understand the low number of antimonotone windows in the Henon map.

Silvina Ponce Dawson
Celso Grebogi
Laboratory for Plasma Research
University of Maryland
College Park, MD 20742

James A. Yorke
Institute for Physical Science and Technology
University of Maryland
College Park, MD 20742

TUESDAY, MAY 8 - 1:30 - 3:30 PM
Room: Tangerine A
Minisymposium 18
Stochastic Chaos-State Space Modeling
Chair: Wallace Larimore

2:00 PM
State Space Reconstruction in the Presence of Noise

State space reconstruction is an important technique for identifying determinism in dynamical systems because it helps find structures which are highly nonlocal in time and makes estimation of extremely nonlinear functions tractable. There are several different approaches to reconstruction, for example principal value decomposition and delay embeddings, each with its own criterion for optimal parameter estimation. For the noise-free case, Taken's theorem assures us that delay embeddings are sufficient, but there is no similarly obvious choice for noisy time series. We shall describe a criterion based on minimizing noise amplification which allows direct comparison of different reconstruction.

Stephen Eubank
Los Alamos National Laboratory
MS-B213
P.O. Box 1663
Los Alamos, NM 87545

2:30 PM
Canonical Variate Analysis of Stochastic Chaos

Accurate empirical modeling of nonlinear dynamical systems requires an adequate state space embedding. For deterministic nonlinear systems, Takens theorem guarantees an optimal embedding that is finite dimensional and linear. When noise is present, there is usually no finite dimensional embedding, and efficient solution of the problem fundamentally involves approximate embedding that requires nonlinear functions of the past observations. The canonical variate analysis (CVA) approach determines an optimal selection of the state for a given state dimension. The theory of CVA for nonlinear systems is discussed in a Hilbert space setting that is required for the nonlinear case. Computational algorithms are discussed for determining the canonical states and nonlinear state dynamics. The method is demonstrated on simulated data from a stochastic version of the Lorenz chaotic attractor.

Wallace E. Larimore
Computational Engineering, Inc.
36 Commerce Way, Suite 410
Woburn, MA 01801

3:00 PM
Approximating Noisy Functions in High Dimensions

A new algorithm (multivariate adaptive regression splines) is presented for approximating a function of several to many variables given only the values of the function, possibly contaminated with noise, at various points in the argument space. The method makes no specific assumptions concerning the nature of the function, requiring only that its dominant trends be relatively smooth. It can often provide useful approximations with relatively small data sets. Several examples illustrating the technique are also presented.

Jerome H. Friedman
Department of Statistics
Stanford University
Stanford, CA 94305

TUESDAY, MAY 8 - 1:30 - 3:30 PM
Room: Oleander B
Minisymposium 19
Nonlinear Models in Image Processing
Chair: Jayant Shah

1:30 PM
Feature Oriented Image Enhancement using Nonlinear Partial Differential Equations

The concepts and techniques developed in the numerical solution of conservation laws and the numerical analysis of moving front problems have been found to be relevant to feature oriented image processing. These subjects all deal with the discrete representation of discontinuous functions. Ideas such as characteristic speed, TVD or ENO approximations, the need for nonlinear approximations to linear problems, compressive methods, etc., when suitably modified, are very useful for image enhancement.

We will discuss the analytic justification for applying these techniques to image processing and present examples of enhanced images.

This is joint work with Leonid Rudin and Emad Fatemi.

Professor Stanley Osher
Mathematics Department
UCLA
Los Angeles, CA 90024

and

Cognitech, Inc.
2020 Broadway, Suite 201
Santa Monica, CA 90404

2:00 PM
A Nonlinear Filter that Enhances Edges

We describe a nonlinear filter algorithm that smooths relatively flat parts of an image, and enhances strong edges. It uses a variable Gaussian smoothing, with a kernel elongated along edges, and then displaced away from strong edges to enhance them. At each point in the domain of an image, both the shape and the displacement of the kernel are computed by the gradient of the input image in a neighborhood of the point, so that the algorithm is parallelizable. We derive a heat-equation interpretation for the filter via a continuous limit, analyze the behavior of the filter at edges, corners and triple points, and give examples of the filter applied to real and synthetic images.

Mark Nitzberg and Takahiro Shiota
Department of Mathematics
Harvard University
Cambride, Massachusetts 02138

2:30 PM
Image Reconstruction and Recognition through Deformable Templates

Prior knowledge on the space of poosible images is given in the form of a function ar template in some domain.The set of all possible images is assumed to be formed by composition of that function with continuous mappings of the domain into itself. A prior Gaussian distribution is given on the set of continuous mappings.The observed image is assumed to have been degraded by additive noise. Given the observed image, a posterior distribution is obtained and has the form of a non-linear perturbation of the Gaussian measure on the space of mappings. We will present simulations of the posterior distribution which lead to reconstructions of the true image and enable comparing landmarks and characteristic features of the original template and the true image. Moreover we will show that reconstruction is relatively successful when the images are degraded by noise which is not necessarily additive. New ideas concerning the application of this approach to object recognition and data compression will be addressed.

Professor Yali Amit
Division of Applied Mathematics
Brown University
Providence, Rhode Island 02912

3:00 PM
Hierarchical Image Segmentation by Variational Methods

Variational methods that include an explicit representation of boundaries have been introduced for image segmentation by Mumford and Shah, and by Blake and Zisserman. We develop a paradigm that improves on these methods to allow segmentation on different scales while retaining the accuracy usually attained only for the finest scale. The paradigm leads to several algorithms requiring scheduling of the parameters of the variational formulation and feedback from the approximating image into the data. The feedback rates and the schedule are governed by several limit theorems which have been attained for the variational model. An efficient computational scheme is built on a sequence of approximating problems converging to the variational problem in the sense of epi-convergence. Connections with many other methods can be drawn.

Dr. Thomas Richardson
Center for Intelligent Control Systems
Department of Electrical Engineering and Computer Science
M.I.T.
Cambridge, Mass. 02139

TUESDAY, MAY 8 - 1:30 - 3:30 PM
Room: Hybiscus
Minisymposium 20
Applications of Dynamical Systems in Combustion Theory
Chair: Stephen B. Margolis

1:30 PM
Applications of Nonlinear Stability Theory in Premixed Combustion Systems

Problems in premixed combustion, such as the burning of gas-phase mixtures of fuel and oxidizer, the deflagration of solid and liquid propellants, and the combustion synthesis of refractory materials from metal powders, are described by dynamical systems of PDE's in which temperature and concentration are strongly coupled through Arrhenius (exponential) reaction-rate expressions. These systems generally admit a basic solution characterized by a steadily-propagating, planar reaction front, or flame, that converts unburned reactants into burned products. This basic solution is, however, susceptible to both steady (cellular) and pulsating (Hopf) instabilities when system parameters are varied. We consider the nonlinear stability of solutions in the neighborhood of both types of neutral stability boundaries and employ perturbation methods to describe the local bifurcation structure. Particular attention is paid to the types of nonsteady, nonplanar combustion waves that arise as secondary and higher-order bifurcations near multiple eigenvalues.

Dr. Stephen B. Margolis
Combustion Research Facility
Division 8363
Sandia National Laboratories
Livermore, CA 94551-0969

2:00 PM
Patterns in Time-Periodic Laminar Premixed Flames

Recent experiments of El-Hamdi and Gorman on laminar premixed flames have shown periodic modes of propagation with different spatial and temporal characteristics. We will show how techniques from bifurcation theory with symmetry can help to classify both the kinds of states and the transition between states that are observed in these experiments. In this talk we present both a videotape of the experiments and the background from generic Hopf bifurcation in the presence of circular and square symmetry that is needed to make this connection.

Martin Golubitsky
Department of Mathematics
University of Houston
Houston, TX 77204-3476

Michael Gorman
Department of Physics
University of Houston
Houston, TX 77204-5504

2:30 PM
Bifurcation, Pattern Formation and Chaos in Combustion

In gaseous combustion we construct solutions which bifurcate from a stationary cylindrical flame front solution, and which exhibit spatial and temporal patterns which become more complex with distance from the bifurcation point. They describe cylindrical flames which oscillate about the stationary cylindrical flame front, stationary cellular flames, and oscillatory cellular flames with traveling and standing waves on the front.
In gasless, solid combustion we describe various modes of propagation through a cylindrical sample, as bifurcations from a uniformly propagating planar front. These include oscillatory combustion (planar front propagates with oscillatory velocity), spin combustion (hot spots move in a helical path along the sample), multiple point combustion (hot spots appear, disappear, and reappear repeatedly), and intermittent and chaotic combustion.

Bernard J. Matkowsky
Department of Engineering Sciences and Applied Mathematics
Northwestern University
Evanston, IL 60208

3:00 PM
Bifurcations in a Burner-stabilized Flame

We consider a diffusional-thermal model of a premixed burner-stabilized flame. The model is described by a system of nonlinear partial differential equations.

We find an explicit solution corresponding to a stationary planar flame. We then show that as the Lewis number is decreased past a critical value, this solution loses stability to stationary polyhedral flames (multifaceted flames anchored on a Busen buruner) which bifurcate from the basic solution. We find conditions for tertiary bifurcation to rotating polyhedral flames.

D. O. Olagunju
Department of Mathematical Sciences
University of Delaware
Newark, DE 19716

B. J. Matkowsky
Department of Engineering Science & Appl. Math.
The Technological Institute
Northwestern University
Evanston, IL 60201

TUESDAY, MAY 8 - 1:30 - 3:30 PM
Room: Tangerine B
Contributed Presentations 3
Population Biology
Chair: Hal Smith

1:30 PM
Invariant Manifolds in a Predator-Prey Model

A predator-pray model with the prey growing logistically in a periodically fluctuating environment is studied. In the neighborhood of a Hopf oscillation, the fluctuating carrying capacity generates an integral manifold. The behavior of the solutions on this manifold, in particular, the existence of periodic solutions with the same period as the fluctuation, is investigated.

Alfredo Somolinos and Alfonso Casal
Mercy College — Madrid University
Dobbs Ferry NY — Madrid. Spain.

1:50 PM
Intermittency and Quasiperiodicity in Age-Structured Population Models with Constrained Total Biomass

Chaotic population dynamics can occur when a total biomass limit is added to conventional difference equations applicable to multispecies fisheries. We find that the transition to chaos exhibits type-I intermittency in models that retain realistic age structure. Our simulations of lower-dimensional maps, tracking only two age-classes, yield very different dynamics, with long periodic cycles (> 100 years) over a wide range of control parameter. Chaos with similar features could occur in other multicomponent physical, chemical and biological systems in which each component has its own dynamics, and the components are linked by a system-wide constraint.

Rebecca S. Sample and Susan R. McKay
Department of Physics and Astronomy
Bennett Hall
University of Maine
Orono, Maine 04469

2:10 PM
Diffusive Instabilities in a One-Dimensional Model System for Mite Interaction on Fruit Trees

Cancelled

A weakly nonlinear analysis relevant to the formation of one-dimensional spatial patter[illegible] rated by diffusive instabilities is pe[illegible] ar-ticular interaction-diffus[illegible] era-ture-dependent predat[illegible] it trees. This bif[illegible] state is of ture-[illegible] [illegible] iting [illegible] occurrence o[illegible] by the preda-to[illegible] spersal advantage when its [illegible] ng tendency toward preytac-tic [illegible] es in some critical range may help [illegible] the inhomogeneous ecological patterns exhib[illegible]ed by phytophagous arthropods found on uniformly distributed plans or on plants grown in monocultures.

David J. Wollkind and John B. Collings
Department of Pure and Applied Mathematics
Washington State University
Pullman, WA 99164-2930 U.S.A.
Maria Concepcion Briones Barba
Department of Mathematics
University of the Philippines
Cebu City, Cebu 6401 PHILIPPINES

2:10 PM

Global Stability and Uniform Persistence of Diffusive Food Chains

One of the most important questions concerning interacting species is whether all the species coexist in the long term, which, to some extent, equivalent to the uniform persistence analysis of the related mathematical model. Such question for systems of reaction-diffusion equations modelling various food chains are studied here. By combining theory of Liapunov functionals for repellers and dynamical system analysis of invariant sets, criteria for global stability and uniform persistence of these models are obtained. Some of these results can be extended to diffusive delay food chains.

Yang Kuang
Department of Mathematics
Arizona State University
Tempe, AZ 85287

2:30 PM

A Solution Semiflow with a Nondiscrete Rest Point Set

We describe the asymptotic behavior of the solution semiflow of

$$\partial u/\partial t - \Delta u = d_1 u\,[1 - u - v] \quad \text{on } \Omega \times (0,\infty)$$
$$\partial v/\partial t - \Delta v = d_2 v\,[1 - u - v] \quad \text{on } \Omega \times (0,\infty)$$
$$\partial u/\partial \nu = 0 = \partial v/\partial \nu \quad \text{on } \partial\Omega \times (0,\infty)$$

where Ω is a bounded domain in $\mathbf{R}^n$, $d_1, d_2 \in (0,\infty)$ and ν denotes the outer unit normal field on $\partial\Omega$.
Our interest is for the role of the ω-limit set in applying the Hale-Massatt theorem or results from the theory of strongly order-preserving semiflows.
We comment on some related questions.

Georg Hetzer
Division of Mathematics,
Foundations, Analysis, Topology
Auburn Univ., AL 36849-5310

2:50 PM

Coexistence of two types on a single resource in discrete time

In theoretical ecology, the principle of competitive exclusion shows that two species cannot stably coexist on a single resource. In parallel with results in continuous time, I show that a deterministic model of two asexual types competing for a single resource generically produces either oscillatory coexistence or bistability if one of the types displays periodic or chaotic behavior in isolation. The conditions for coexistence are derived and coincide with invasibility criteria.

Frederick R. Adler
Center for Applied Mathematics
Cornell University
Ithaca, NY 14853

TUESDAY, MAY 8 - 1:30 - 3:30 PM
Room: Oleander A
Contributed Presentations 4
Forced Systems
Chair: P. R. Sethna

1:30 PM

Coplanar and nonplanar forcing of a damped pendulum

A forced, damped pendulum is probably the simplest dynamical system to exhibit a bifurcation structure for periodic motion leading to breakdown into chaotic motion. Analytical and numerical methods are used to investigate properties of the periodic solutions of the differential equations governing coplanar and nonplanar pendulum motion. The stable solutions describe motion which is symmetric or asymmetric, downward or inverted, at integer multiples of the forcing period, or doubly-periodic in limit cycles. Period-doubling sequences are found to terminate in nearly-periodic motion in the neighbourhood of the periodic motion, distinct from fully chaotic motion.

Peter J. Bryant
Mathematics Department
University of Canterbury
Christchurch, New Zealand

1:50 PM

A Model of a Damped Spherical Pendulum Horizontally Forced Near Resonance

This model, which was derived by John Miles, is a set of four averaged differential equations describing the slowly-varying small amplitude motion of a damped spherical pendulum horizontally forced near resonance. Miles has found parameter regions for which the motion is apparently chaotic. My work has involved describing the attractors which appear in this model. I have generalized the problem to one with higher codimension in order to fully describe a particular class of symmetry breaking perturbations from an O(2) symmetric four-dimensional vector field.

Bradford D. Bond
Cornell University
Center for Applied Mathematics
422 Sage Hall
Ithaca, New York 14850

2:10 PM

Large Amplitude Quasi Periodic Motions for Certain Forced Nonlinear Dynamical Systems

Consider large amplitude quasi periodic forcing h(t) for the Duffing equation without dissipation. A long outstanding question related to "Hamiltonian Chaos" is, "Does this problem have a quasi periodic solution whose frequencies are exactly those of the forcing term h(t)?" In this talk I am able to give an affirmative answer to this question, in certain cases, by putting certain sign restrictions of the coefficients of the Duffing equation. This result is achieved by passing to almost periodic motions and then obtaining an a priori estimate for the desired solution x(t) in terms of h(t). This estimate enables the frequencies of x(t) to be determined in terms of those of h(t). Related dynamical problems are also discussed.

Melvyn S. Berger
Department of Mathematics & Statistics
University of Massachusetts
Amherst, MA 01003

2:30 PM

Homoclinic Chaos in Systems Perturbed by Weak Langevin and Multiplicative Noise

By means of the Melnikov function generalized to ensembles the effect of noise on the onset of homoclinic crossing and thus homoclinic chaos is examined for periodically driven non-linear systems. It is shown that multiplicative noise may suppress as well as induce homoclinic chaos where it does not otherwise exist. A criteria is given for the average induced crossing. The driven Duffing oscillator and R.F. S.Q.U.I.D. may be considered as examples. In addition, for multiplicative noise it is argued that the stochastic Melnikov function is Gaussian distributed.

William C. Schieve
Center for Statistical Mechanics
The University of Texas at Austin
Austin, Texas 78712
and
A.R. Bulsara
Research Branch
Naval Ocean Systems Center
San Diego, California 92152

2:50 PM

Synchronization in Chaotic Systems

Certain subsystems of nonlinear, chaotic systems can be made to synchronize by linking them with a common signal. The criteria for this are the signs of the sub-Lyapunov exponents. We derive this criteria and apply it to synchronizing systems built from Lorenz, Rossler, and other nonlinear systems. We also present results from a circuit, part of which synchronizes in real time with the chaotic voltages and currents of another circuit. We will also present some results on the basins of synchronization for driven nonlinear systems.

Louis M. Pecora
Thomas L. Carroll
Code 6341
Naval Research Laboratory
Washington, D.C. 20375-5000

3:10 PM

Response of self-oscillating flows to time-harmonic forcing

The response of the complex Landau equati time-harmonic forcing is investigated ana and numerically. The condition for the e of stable phase-locked solutions is deriv represented by a surface in the parameter Outside this surface, strongly quasi-peri solutions exist. The results compare fav with experiments and direct numerical sim of the Navier-Stokes equations.

Work supported by ONR Contracts N-00014-8 and N00014-88-J1218

George S. Triantafyllou
Room 5-426A
Department of Ocean Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139

TUESDAY, MAY 8 - 1:30 - 3:30 PM
Room: Azalea
Contributed Presentations 5
General Theory & Software
Chair: Brian Hassard

1:30 PM

A Graph Method to Solve Partial Different Equations The M-Tree Algorithm

Given a system of PDE in one unknown func will give a constructive procedure to sol system, provided proper initial data has given. This method will also define exac are "proper initial data". The discussio based only on examples and algorithms. Th consists of building a tree that I called Tree". By tracing the tree, we will disc proper procedure to solve our system. Ea is analogous to the classic Cauchy-Kowalev slightly generalized. For this reason I c algorithm the M-tree algorithm.

Yves de Montaudouin
IBM Watson Research Center
Department of Computer Science
P.O. Box 704
Yorktown Heights, N.Y. 10598

1:50 PM

Decomposition Solution of Nonlinear Bounda Problems

A further adaptation of the (Adomian) deco method [1,2] allows a convenient accurate method for rapidly convergent series solut linear, nonlinear, ordinary and partial di tial equations.

1) Nonlinear Stochastic Operator Equation Academic Press

2) Nonlinear Stochastic Systems Theory an Applications to Physics, Kluwer, 1988

G. Adomian
Center for Applied Mathematics
University of Georgia
Athens, GA 30602

2:10 PM

Universal Algebras For Discrete Event Dynamic Systems

Several papers have been written on the use of dioids in discrete event systems. Here, a class of Petri nets, called event graphs, have been represented as a linear time invarient finite dimensional system using dioids.

The present paper illustrates the utility of pointed sets over the reals as dioid algebras. Additionally, by inducement techniques universal algebras are created whereby important descriptors, such as daters and counters, are obtained using parallel algorithms.

Charles R. Giardina
City University of New York
34 Elizabeth Lane
Mahwah, N.J. 07430

2:30 PM

On the Geometry of a Class of Dynamical Systems and Differential Automata

Dynamical systems with discontinuities in derivatives, systems with time or state dependent delays, or systems defined over discontinuous vector fields, can be successfully modeled using the concept of differential automata. It appears that there is a fundamental relation between their state space geometry and the underlying automata. The presentation will provide a closer look at that relation and demonstrate its usefulness through examples with variable structure control systems and systems containing hysteretic elements.

Mladen Luksic
Digital Equipment Corporation
301 Rockrimmon Blvd., CXO1-1/Q13
Colorado Springs, CO 80919

2:50 PM

Mathematical Software for Dynamical Systems with Delays

A software package that solves differential equations with state-dependent delays is discussed. It may be used to handle automatically several of the common problems associated with dynamical systems. A novel feature of the software is its ability to locate automatically points of derivative discontinuity in the system. In addition, it locates roots of user-defined event functions, a feature useful in the generation of Poincare sections. The software is based on continuously imbedded Runge-Kutta methods of Sarafyan which allow an attractive form of error control. The user interface will be discussed. Use of the software will be illustrated with examples from the recent literature.

Skip Thompson
Department of Mathematics and Statistics
Radford University
Radford, Virginia 24142

3:10 PM

Towards The Dynamic Systems of Essap

Many rendezvous spacecraft algorithms are mainly based on Pontryagin's maximum principal, Bellman dynamic programming, and Raleigh Ritz type procedures.

The mathematical techniques in this paper are adapted to ESSAP, Expert System Solving Aerospace Problems.

The given approach has applications in Aerospace tracking, Telecommunication systems, and the Collision Avoidance's Problems.

Dr. Moustafa El-Arabaty
53, El-Montaza Street, Heliopolis
Cairo, Egypt

TUESDAY, MAY 8 - 1:30 - 3:30 PM
Room: Lemon-Lime
Contributed Presentations 6
Applications 1
Chair: Ben Wilcox

1:30 PM

Steady States and Dynamics of the Moving Bed Catalytic Reactor: A Geometric Analysis

Paper presents the mathematical model of a moving bed catalytic reactor under assumption that adsorption equilibrium between the fluid-phase reactant and the catalytic surface is attained instantaneously. Dynamic behavior of such system is modelled by a system of first-order hyperbolic differential equations. Steady states are described by a system of constrained ordinary differential equations with boundary conditions. Solutions of such systems are generally discontinuous. Paper presents the complete geometric classification of discontinuous steady states. Method of characteristics is then used to describe the development of these steady states from initial conditions by constructing a sequence of profiles.

Dmitry A. Altshuller
McDonnell Aircraft Company
P.O. Box 516
Mailcode 2761380
St. Louis, MO 63166-0156

1:50 PM

Hopf Bifurcations in Power Systems

When a complex pair of eigenvalues of a linearized system crosses into the unstable right half plane, the resultant oscillations of the corresponding mode will increase up to a limit amplitude determined by the non-linearity of the system. In power systems such periodic steady state conditions - examples of Hopf Bifurcation - may be observed and simulated in the case of line oscillations, torsional dynamics, and ferroresonance.

A. Semlyen and M.R. Iravani
University of Toronto
Toronto, Canada

2:10 PM
Nonlinear Near-Steady Dynamics of an Aerospace Plane

The classical theory of small vibrations about an equilibrium has been effectively employed since the early part of this century to analyze the near-steady motion of aircraft. The longitudinal motion under the flat earth assumption is a superposition of two complex modes - the phugoid mode and angle of attack mode. Future transportation vehicles, collectively known as the aerospace plane, may possess near-steady dynamics which cannot be adequately characterized using the theory of small vibrations. Hypersonic velocities and nonlinear thrust laws corresponding to multi-mode propulsion systems hold the potential for more complex motion. An exploratory study of the near-steady motion has been conducted using a combination of analytical and computational techniques. The results of this study will be discussed.

Kenneth D. Mease
Hwa-Jin Chang
Mechanical and Aerospace Engineering Department
PRINCETON UNIVERSITY
Princeton, NJ 08544-5263

2:30 PM
A Mathematical Model of the Dynamical Processes in an End-Pumped Solid State Laser System

Solid state lasers are being developed which have the potential for meeting performance and longievity requirements for space and air based remote sensing of the atmosphere. In response to the need for understanding the transient development of the dynamical processes in the laser and the effects of design modifications, we have developed a general rate equation model of an end-pumped solid state laser system. The model describes the four-level operation of a solid state laser and is applicable to both three and four level systems. General qualitative characteristics of the solutions and numerical results which are specific to a Titanium-doped sapphire laser system will be presented.

Lila F. Roberts
Department of Mathematics and Computer Science
Georgia Southern College
Statesboro, Georgia 30460-8093

A. Martin Buoncristiani
Department of Physics and Computer Science
Christopher Newport College
Newport News, Virginia 23606-2988

John J. Swetits
Department of Mathematical Sciences
Old Dominion University
Norfolk, Virginia 23529

2:50 PM
A Moving Boundary Problem in Plasma Physics.

In modelling electrodynamic properties of capacitive radio frequency discharges, a principal role is played by space-charge sheaths. Different models have been developed to describe the sheath characteristics, but none of them accounts for the nonlinear sheath dynamics. Also in order to solve these models, various assumptions and modifications were made which led to inconsistencies. We propose a model which accounts for all the nonlinear processes in the sheaths. This model is described by a moving boundary problem that we are able to solve. The obtained sheath characteristics are then compared with the experimental results.

Valery Godyak
GTE Laboratories
Waltham, MA

Natalia Sternberg
Department of Mathematics
Clark University
Worcester, MA 01610

3:10 PM
Using fractals to detect partial gas saturation of sand/shale sequences.

This report is a feasibility study for using the fractal dimension of seismic data as a hydrocarbon detector. Fractals have been used to explain the spectral properties of sonic compressional wave reflection coefficients. Frequency attenuation of seismic signal is different for gas filled sandstone beds than water filled. What is being reported is how the fractal dimension of the underlying reflection coefficient sequences can be estimated from seismic data, and how confidently this measurement may be used to detect hydrocarbons. Model derived sandstone/shale reflectivity sequences are used with varying degrees of gas saturation and added ambient noise.

David H. Carlson
B P Exploration
12206 Chartwell Drive
Houston, Texas 77031

MONDAY, May 7 - 3:30 - 4:30 PM &
TUESDAY, MAY 8 - 3:30 - 4:00 PM
Room: Orange Room - POSTER SESSION

Mon: 3:30-4:30 Tues: 3:30-4:00

Control of the AIDS Epidemic

We present a mathematical model for the spread of the AIDS epidemic and examine the possible control of the epidemic by the systematic modification of sexual activity levels. Employing both time-dependent and feedback effects on the behavioral parameters we investigate the temporal and asymtotic behavior of the model epidemic. The model indicates that behavioral parameters must decrease sharply if modification of sexual behavior is to be an effective means of controlling the epidemic and that current efforts, while they may prove useful in the short term, may not be optimally effective in the long run.

Jeffrey S. Palmer and Michael E. Moody
Department of Pure and Applied Mathematics
Washington State University
Pullman, WA 99164-2930 U.S.A.

Mon: 3:30-4:30 Tues: 3:30-4:00

Laser with injected signal: perturbation of an invariant circle.

Laser systems present a characteristic U (1) symmetry associated with the phase of the light emitted. Injection of an external field introduces a reference for the phase which breaks the symmetry. We study the dynamics resulting from the perturbation of the circle of fixed points that represents the unperturbed laser in its normal operating regime. The dynamics is dominated by a Hopf+saddle-node codimension two bifurcation, and a reinjection mechanism (phase-drift). The nonlinear unfolding of the bifurcation depends on other characteristics of the laser signaling the accesibility of more complex bifurcations.

HERNAN G. Solari (1) and GIAN-LUCA OPPO (2)

(1) Department of Physics and Atmospheric Science, Drexel University,
32nd and Chestnut Sts, Philadelphia PA 19104

(2) Department of Physics and Applied Physics, University of Strathclyde,
John Anderson Bldg., 107 Rottenrow, G4 ONG, Scotland, U.K.

Mon: 3:30-4:30 Tues: 3:30-4:00

Large time behavior of viscoelastodynamics in many dimensions

We discuss multidimensional viscoelasticity. The elastic energy is allowed to be non-elliptic, and the viscous term is of Kelvin-Voigt type. The main tool of our investigation is a multidimensional generalization of the change of variables introduced by Andrews and exploited by Andrews-Ball and Pego in one space dimension. Our main rigorous result is the dynamical stability in the sense of Liapunov of weak local minimizers of the stored energy functional. We also obtain formally an equation describing the long-time behavior of the strain for arbitrary initial data.

Piotr Rybka
Courant Institute
New York University
251 Mercer St.
New York, NY 10012

Mon: 3:30-4:30 Tues: 3:30-4:00

An Application of the Phase-Variable Canonical Form of Time-Invariant Linear Dynamic Systems

Consider a time invariant system E (dx/dt) = Ax+Bu, in recent literature such systems are usually called "descriptor systems." The problem is this: Find a constant matrix K for which the "state feedback law" u=Kx yields a system E(dx/dt) = (A+BK)x having solutions of the form x = exp(rt)v where v is some prescribed constant scalar and v is some constant vector. This problem has been considered by several authors (e.g. see, Al-Nasr et al., Int. J. Systems Sci., 14, 59, 1983). The novelty of this papers approach is in the use of the notion of the phase-variable canonical form (introduced by Asseo in I.E.E.E. Trans. Autom. Control, 13, 129, 1968) to obtain a non-singular transformation x = Tz leading to an equivalent descriptor system in which the multipliers of (dz/dt) and u are of the respective forms

$$\begin{bmatrix} 0 & I \\ P & \end{bmatrix} \text{ and } \begin{bmatrix} 0 \\ I \end{bmatrix}.$$

Dr. Ala Al-Humadi
Math and Physical Science Department
Embry-Riddle Aeronautical University
Daytona Beach, FL 32114

Mon: 3:30-4:30 Tues: 3:30-4:00

Measuring dynamical complexity of chaotic signals

Cancelled

We apply to low-dimensional chaotic signals a recently introduced approach to the chara[illegible] sation of complex behaviour, based [illegible] fication of the system's symbo[illegible] of the rules governing i[illegible] structed which rep[illegible] mation of the [illegible] [illegible]ons based on i[illegible] [illegible]ons, and discr[illegible] [illegible]metric and topolo[illegible] [illegible]mplexity.

The [illegible]amics is reconstructed by identifyin[illegible] unstable periodic orbits up to a certain order and by selecting a partition which assigns to them different itineraries.

MONDAY, 3:30 PM/TUESDAY 3:30 PM

Giorgio Broggi
Physik-Institut der Universität
CH-8057 Zürich

Remo Badii and Marco Finardi
Paul Scherrer Institut - LUS
CH-5232 Villigen-PSI

Mon: 3:30-4:30 Tues: 3:30-4:00

The Effect of Hysteresis on Bifurcation Phenomena in Ferroresonant Circuit

Nonlinear phenomena in ferroresonant circuit driven externally are studied. The nonlinear inductance has hysteresis. Coupled equations for current i(t) and voltage v(t) are solved numerically and the trajectory in (i(t),v(t)) space is investigated. If the B-H curve is approximated by the normal magnetization curve (no hysteresis case), v(t) is known to satisfy the Duffing equation. In this report the effect of hysteresis on the bifurcation of the solution is stadied.

Nozomi Morioka
Kokushikan University
Faculty of Engineering
Department of Electrical Engineering
4-28-1 Setagaya, Setagaya-Ku
Tokyo 154
Japan

Mon: 3:30-4:30 Tues: 3:30-4:00

Relaxation and Bifurcation in Brownian Motion Driven by a Chaotic Force

Brownian motion driven by a chaotic sequence of iterates of a map F(x), which may depend on a bifurcation parameter, is discussed: $\dot{v} = -\gamma v + f(t)$ where $f(t)=Ky_{n+1}$ for $n\tau<t\leq(n+1)\tau$ $(n=0,1,2,\ldots)$ and $y_{n+1}=F(y_n)$. The time evolution equation for the density function of v is derived. The relation between the stationary density of v and the invariant density of F(x) is discussed. The dependence of relaxation processes on the bifurcation parameter is also investigated. The fluctuation-dissipation theorem is discussed. The theoretical results are shown to be in a good agreement with numerical ones, which have been done for the tent map and the logistic map.

Toshihiro Shimizu
Division of Physics, Faculty of Engineering,
Kokushikan University
Setagaya 4-28-1, Setagaya-Ku,
Tokyo 154, Japan

Mon: 3:30-4:30 Tues: 3:30-4:00

The Invertebrate Heart as a Chaotic Oscillator

The circulatory system of crustaceans shows complex dynamics. Beat to beat heart rate variability exists. The system responds to variables such as environmental temperature and oxygen concentration. The ganglion controlling the heart may be the smallest semi-autonomous nervous system capable of spontaneous impulse generation; a complete model of the system seems feasible. We have used a noninvasive technique to collect a continuous time series of heart rate. The power spectrum of the instantaneous heart rate has an approximate 1/f distribution. The phase portrait shows an attractor qualitatively similiar to the Rossler Attractor.

Andrew D. Arsenault
Physics Department

T.E. Keliher
Physics Department

M. Edwin DeMont
Biology Department
St. Francis Xavier University
Antigonish, Nova Scotia
Canada B2G 1C0

Mon: 3:30-4:30 Tues: 3:30-4:00

Loss of Chaos in Quasiperiodically Forced Nonlinear Oscillator

It has been shown that random noise approximated by quasi-periodic perturbation stabilizes a period-doubling bifurcation point. This stabilization can lead to the loss of chaos in the chaotic systems with this type of perturbation. The mean Poincare maps have been introduced to describe this phenemenon. First based on approximate analysis of nonlinear deterministic system an analytical condition for chaotic behaviour has been introduced. Next an existance condition for the loss of chaos based on Feigenbaum universal properties of period doubling has been developed. This approach has been used in investigations of several nonlinear oscillators with practical applications.

Tomasz Kapitaniak
Department of Applied Mathematics and
Centre for Nonlinear Studies,
University of Leeds
Leeds LS2 9JT, U.K.

Mon: 3:30-4:30 Tues: 3:30-4:00

Dynamic Theory of Multimass Systems Vibrating with Impacts

Multimass systems vibrating with impacts are much used in engineering. But in the past, the studies were always limited to some individual objects with single or double mass, because the motion of the systems are very complicated. In this paper, a system that is composed of any number of masses connected in series and collides with many free bodies is dealt with. A dynamic theory for determining any complex periodic motion and its stability conditions of the system is proposed. In addition, variform functions of the system are discussed.

Shu Zhongzhou
Department of Engineering Mechanics
Southwestern Jiaotong University
Emei, Sichuan, 614202
The People's Republic of China

Mon: 3:30-4:30 Tues: 3:30-4:00

Nonlinearity, Perturbation Techniques, and Equations of the Atmospheric Sciences

We consider a boundary-value problem for a class of quasi-linear equations similar to those arising in the atmospheric sciences. Our approach is based on perturbation of the equation by a special source function, which then can be found as a solution of some non-linear operator equation. Solution of the unperturbed original problem is found in "explicit" form. Existence, uniqueness, and stability of the method are discussed.

Igor G. Malyshev
Department of Mathematics and Computer Science
San Jose State University
One Washington Square, San Jose, CA 95192

Mon. 3:30-4:30 PM; Tue. 3:30-4:00 PM

Fourier Analysis on the Fractal Sets

Let E be a self-similar fractal of Hausdorff dimension s and such that its Hausdorff measure H^s is finite and positive. We consider a differentiation basis on E which differentiates $L^1(E,H^s)$, and an orthonormal system of functions in the Hilbert space $L^2(E,H^s)$.

Using the differentiation properties, we study the convergence almost everywhere of the Fourier series, respect to the orthonormal system of functions, of every function of the space $L^1(E,H^s)$.

Dr. Miguel Reyes
Dpto. de Matematica Aplicada
Facultad de Informatica
Campus de Montegancedo s/n
Boadilla del Monte
28660 Madrid
Spain

Mon. 3:30-4:30 PM; Tue. 3:30-4:00 PM

Centre of Mass and Moment of Inertia of Random Fractals and Fractal Attractors

We consider fractal attractors generated by a system of functions in a deterministic or random way. We define the centre of mass and the moment of inertia for them, and we find formulas to compute the earlier elements in both cases.

Miguel-Angel Martin
Univ. Politecnica de Madrid
Matematica Aplicada
E.T.S.I. Agronomos Ciudad Universitaria
28040 Madrid Spain
91-2444807

3:30 PM Monday and Tuesday

Numerical Orbits of Chaotic Magnetic Field Lines in Tokamaks

The resonant field created by helical windings brokes the symmetry of the tokamak plasma field which then can be described by an almost integrable system. Considering the helical current as a control parameter, the line equations have been numerically integrated to investigate the trajectories of the magnetic lines. Specific maps and spectra have been obtained to characterize the transition from quasi-periodical to chaotic orbits.

Maria Vittoria A.P. Heller
Ibere Luiz Caldas
Instituto de Fisica
Universidade de Sao Paolo
C.P. 20.516, 01498 Sao Paolo - SP Brazil

3:30 PM Monday and Tuesday

A Possible Tool to Generate Fractal Boundary Structures

The role of perturbations destroying analyticity on the qualitative behavior of discrete dynamical systems is investigated. We present an example of a 2-D real non-analytic map the dynamics of which behaves equivalently to that of the well-known complex analytic logistic map. For the case of linear non-conformal transformations, an explicit criterion can be derived which allows one to check whether a map is conjugate to a complex holomorphic dynamics. Taking into account that analyticity does not provide a necessary condition to get Mandelbrot-set-like boundaries in parameter space (as well as Julia-set-like boundaries in phase space), the central point of this contribution concerns the general mechanism possibly underlying the creation of fractal structures in discrete (or, even more interestingly, in continuous) dynamical systems.

Jürgen Parisi and Joachim Peinke
Physical Institute, University of Tübingen, D-7400 Tübingen, Fed. Rep. Germany

Michael Klein and Otto E. Rössler
Institute for Physical and Theoretical Chemistry, University of Tübingen, D-7400 Tübingen, Fed. Rep. Germany

Claus Kahlert
Electronics Research Laboratory, University of California, Berkeley, CA 94720, U.S.A.

TUESDAY, MAY 8 - 4:00 - 6:00 PM
Room: Tangerine A
Minisymposium 21
Noise Reduction and Models of Dynamical Systems
Chair: Eric Kostelich

4:00 PM

Noise Reduction in Chaotic Experimental Data

A novel method is described for reducing noise in experimental time series whose dynamics can be described as low dimensional chaos. An attractor is reconstructed from the time series using the time delay embedding method. We show how the motion of points along the trajectories can be used to identify and correct errors resulting from noise. The objective is to find a new, slightly altered time series whose dynamics are more consistent with those on the reconstructed phase space attractor. The method seems to reduce noise levels by a factor of 10 or more in some laboratory data sets.

Eric Kostelich
Dept. of Mathematics
Arizona State University
Tempe, AZ 85287

4:20 PM
A Noise Reduction Method for Chaotic Systems

In the analysis of a data set generated by a chaotic process, accuracy in the measurement of dynamical parameters depends upon a low noise level. A method is presented which can reduce the noise of a chaotic orbit on an attractor by more than ten orders of magnitude. This method is simple and fast: it's performance is analyzed for several two-dimensional systems at moderate noise levels, including the Ikeda map. The method works well with coupled with a simple map-learning scheme, such as local linear maps using a least-squares fit.

Stephen M. Hammel
R-41 Naval Surface Warfare Center
10901 New Hampshire Ave.
Silver Spring, MD 20903

4:40 PM
Signal Processing on Strange Attractors

Signal processing, familiar in linear systems, involves the classification of the system by invariants of the orbits, the identification of the space in which to do the classification, and prediction of future behavior of the system from observed time series. In chaotic systems where the Fourier spectra of the time series are broadband (and thus would 'normally' be classified as noise), the identification of the space requires, in time domain, a reconstruction of the dynamical phase space. We discuss how that reconstruction can be carried out. Further we discuss how to determine, from measured time series, the invariants of motion on the strange attractor producing the chaotic orbit. These invariants are the nonlinear generalization of spectral frequencies in the linear case. Finally, we show how one can use the phase space structure to construct nonlinear models which allow prediction of future evolution on the orbit consistent with the maximum allowed by the instabilities of nonlinear systems. The ideas will be illustrated with time series data from laboratory, geophysical, and computer generated data.

Henry D.I. Abarbanel
Dept. of Physics and Scripps Inst. of Oceanography
University of California/San Diego
San Diego, CA 92093

5:00 PM
Optimal Shadowing and Noise Reduction

We present a solution to the shadowing problem which provides an effective and convenient method for noise reduction for data generated by a dynamical system. We perform a least-mean-squares fit to the noisy data, subject to the constraint that the solution be deterministic with respect to the system dynamics. When the dynamics are known exactly the resulting noise reduction is limited by machine precision; if the dynamics must be learned from the data the noise reduction is limited by the accuracy of the learning algorithm. We demonstrate our numerical methods on several model systems, and compare our techniques to other algorithms which have been proposed for reducing noise in chaotic time series.

John J. "Sid" Sidorowich
Center for Nonlinear Studies
Los Alamos National Laboratory
Los Alamos, NM 87545

5:20 PM
Inferring Statistical Complexity

In what sense can a turbulent fluid or a noisy transistor be said to perform a computation? An answer comes from using information theory and techniques from stochastic grammatical inference to reconstruct minimal computational models of deterministic chaotic behavior. As a function of a control parameter, many nonlinear systems undergo a transition from regular predictable behavior (a solid phase) to chaos (a vapor phase). It turns out that formal language theory gives a much more refined description of such transitions to complex behavior than currently used in statistical mechanics. Additionally, the approach leads to a new measure of physical complexity that suggests significant computation is localized to processes at or near phase transitions. Computers are, in this sense, physical systems designed to be in a 'critical' state. They are constructed to support arbitrarily long time correlations within certain macroscopic 'computational' degrees of freedom by decoupling these from error-producing heat bath degrees of freedom.

James P. Crutchfield
Dept. of Physics
Univ. of California/Berkeley
Berkeley, CA

5:40 PM
Symbolic Models for Chaotic Dynamics

It is known that uniformly hyperbolic sets can be modelled by the space of paths on a finite graph (subshifts of finite type). Hofbauer proved that, after the exclusion of a small set, a piecewise monotone map of the interval with positive topological entropy, can be modelled by the space of paths on a countable graph. Extensions of this result to smooth two dimensionsal diffeomorphisms will be described. Also, relations between these symbolic models and measures of maximal entropy will be discussed. In particular, conditions which insure that the set of measures of maximal entropy is a finite dimensionsal simplex will be presented.

Sheldon Newhouse
Dept. of Mathematics
Univ. of North Carolina
Chapel Hill, NC 27599

TUESDAY, MAY 8 - 4:00 - 6:00 PM
Room: Tangerine B
Minisymposium 22
Understanding Biological Dynamics: The Nonlinear Perspective 2
Chair: Michael C. Mackey

4:00 PM

A Differential Equation with Two Time Delays to Model the Platelet Regulatory System

The mammalian platelet regulatory system is modeled as a two-compartment system, taking into account both the platelets and their precursors, the megakaryocytes. The maturation time of the latter and the senescence of the former are explicitly incorporated in the nonlinear delay-differential equation obtained. A local stability analysis of the stationary solutions is performed, and Hopf bifurcations are analysed. Numerical computations are used to compare the predictions of this model with clinically observed pathologies. The possible explicit dependence of the maturation time on the platelet level, yielding a state-dependent delay, is also discussed.

Jacques Bélair
Département de mathématiques et de statistique
and
Centre de recherches mathématiques
Université de Montréal
C.P. 6128-A, Montréal, Québec
H3C 3J7
AND
Centre for Nonlinear Dynamics in Physiology and Medicine
McGill University, Montréal, Québec, Canada
H3G 1Y6

4:30 PM

Oscillations in Tubuloglomerular Feedback

Tubuloglomerular feedback regulates the fluid and solute load in each individual nephron of the mammalian kidney. Recent experiments by physiologists show that oscillations may be induced in tubular fluid pressure and concentration, owing to time delays in the feedback system. We have developed a mathematical model for this system and examined it numerically and analytically. The model system behaves as a low-pass filter, with high-frequency perturbations causing only small deviations from steady-state solutions, while low-frequency perturbations or step perturbations of sufficient amplitude may set up sustained, large-amplitude oscillations.

Harold Layton
Department of Mathematics
Duke University
Durham, NC 27706-2586

E. Bruce Pitman
Department of Mathematics
State University of New York at Buffalo
Buffalo, NY 14214-3093

5:00 PM

Models for synchrony in populations of fireflies

Several different mathematical problems are suggested by the phenomenon of "firefly trees" - large numbers of synchronously flashing fireflies. Certain species can alter their intrinsic frequencies in order to synchronize with zero phase lag to a range of periodic stimuli. We will explore models for single and large populations of fireflies. Numerical and analytical techniques are applied. A cellular automaton is also described.

G.B. Ermentrout
Department of Mathematics & Statistics
University of Pittsburgh
Pittsburgh, PA 15260

5:30 PM

Cellular Control Models with Diffusion and Delays.

Biochemical control by repression is important in several cellular metabolic pathways. Two models are considered which include time delays and spatial dependence. In collaboration with Stavros Busenberg, a model of repression for an internally controlled metabolite is developed. A second model examines the effects of an external controlling element on a growing cell. Both models include time delays for transcription and translation and diffusion for the movement of biochemical species in the cytoplasm. A technique is shown for taking the reaction-diffusion equations with delays to a system of delay differential and Volterra equations which no longer depends on space. With certain symmetry assumptions this system can be analyzed in detail. Bifurcations in behavior of the cell occur as the cell increases in size. A possible triggering mechanism for cell division is suggested in the first model, while the second model shows how cell size and external concentration of some substance could be important in morphogenesis.

Joseph M. Mahaffy
Department of Mathematical Sciences
San Diego State University
San Diego, CA 92182-0314

TUESDAY, MAY 8 - 4:00 - 6:00 PM
Room: Oleander A
Minisymposium 23
Metastable Dynamics in Physical Systems 1
Chair: Peter W. Bates

4:00 PM

Phase Transitions and Singular Perturbations

In the modeling of phase transitions by partial differential equations, one often encounters very slow movement of the transition layers. A phenomena often referred to as metastability. The speaker will give an explanation of this fact from elementary concepts in dynamical systems using specific equations as illustrations. Theoretical and numerical aspects of phase transitions will be discussed.

Jack K. Hale
Center for Dynamical Systems and Nonlinear Studies
Georgia Institute of Technology
Atlanta, Georgia 30332-0190

4:40 PM

Motion by Mean Curvature as the Singular Limit of Certain Reaction-Diffusion Equations

The singular limit of certain reaction-diffusion equations is studied in a bounded domain in $\mathbb{R}^N$. The solutions u^ε of these reaction-diffusion equations develop a "transition layer structure" and it is found that, in the radial case, the transition surface moves with normal velocity equal to the sum of its principal curvatures as ε tends to 0.

Lia Bronsard
Institute for Advanced Study
Princeton, NJ 08540

5:20 PM

Manifolds of Metastable States for the Cahn-Hilliard Equation

The Cahn-Hilliard equation has been introduced as a model for the solidification of a binary alloy. The equation itself is a singularly perturbed nonlinear forward/backward heat equation, the perturbation being a small multiple of a bilaplacian term which regularizes the equation. As a dynamical system the Cahn-Hilliard equation is dissipative, possessing a global attractor composed of the equilibria and their unstable manifolds. In the case of one space dimension we construct the unstable manifold of the equilibrium which has two interior layers. We also compute the flow on this manifold, showing that it is exponentially slow.

Peter W. Bates
Dept. of Mathematics
342 TMCB
Brigham Young Univ.
Provo, UT 84602

Nicholas Alikakos
Dept. of Math.
Univ. of Tennessee
Knoxville, TN 37996

Giorgio Fusco
Dept. of Math.
Univ. of Rome II
Rome, Italy

TUESDAY, MAY 8 - 4:00 - 6:00 PM
Room: Oleander B
Minisymposium 24
The Computation of Dynamical Systems 2
Chair: Mitchell Luskin

4:00 PM

Determining nodes, Finite Difference Method and Inertial Manifolds

The theory of Inertial Manifolds (IM's) and Approximate IM's have emerged as a new technique to fully describe and simulate the long time bahavior of certain dissipative evolution equations that appear in mathematical physics and fluid dynamics. So far, the applications and studies of this theory have been restricted to the spectral Galerkin type approximations. Using the Kuramoto-Sivashinski equation (KSE) as an illustrative example, we implement the theory of IM's to show that the dynamics of the nodal values of the exact solutions is equivalent to that of the solutions themselves. Consequently, one can think of the finite difference scheme, which is the most natural way to approximate the evolution of the nodal values, as an Approximate Inertial Form. It is remarkable that the number of determining nodes, in KSE case, is proportional to the dimension of the Inertial Manifold.

Ciprian Foias, Department of Mathematics, Indiana University, Bloomington, IN 47405.

Roger Temam, Department of Mathematics, Indiana University, Bloomington, IN 47405, and Laboratoire d'Analyse Numerique, CNRS et Universite Paris-Sud, Bat. 425, 91405 Orsay, France

Edriss S. Titi, Department of Mathematics, University of California, Irvine, CA 92717.

4:25 PM

Preserving Dissipation in Approximate Inertial Forms

It has been observed that the use of certain explicit approximate inertial forms can give rise to numerical artifacts such as spurious turning points and inaccurate solution branches. These shortcomings were attributed to a lack of dissipation in the forms used. We show analytically and verify numerically that with an appropriate adjustment we can eliminate these numerical artifacts. The motivation for this adjustment is to enforce dissipation, while maintaining the same order of approximation. We demonstrate with computations that the most natural remedy, namely preparation of the equation, can be highly sensitive to assumptions on the size of the absorbing ball. As an illustrative example we use here the Kuramoto-Sivashinsky equation.

Michael S. Jolly:

Institute for Mathematics and its Applications, University of Minnesota, Minneapolis, Minnesota 55455, on leave from Indiana University, Department of Mathematics, Bloomington, IN 47405

Ioannis G. Kevrekidis:

Department of Chemical Engineering, Princeton University, Princeton, NJ 08544

Edriss S. Titi:

Department of Mathematics, University of California, Irvine, CA 92717

4:50 PM

Common Dynamic Features of Coupled Chemical Reactors

We analyze computationally the dynamic behavior of several models of coupled chemical reactors. We systematically vary two parameters: the strength of the coupling between the two reactors, and the difference between the "natural" states of the systems when uncoupled. The entire structure of the resonance regions as well as the breaking of the quasiperiodic solutions existing for low coupling strengths is studied. We verify the results of previous one-parameter studies and normal form analyses, including the existence of a stable steady state solution at finite coupling amplitudes, and further complete the details beyond the normal form picture by numerically constructing two-parameter diagrams and approximating global bifurcations.

I. G. Kevrekidis and M. A. Taylor
Department of Chemical Engineering
Princeton University
Princeton, NJ 08544

5:15 PM

A Kinematic Theory of Spiral Waves in Excitable Media

Despite an enormous amount of analysis in the past decade, there is at present no adequate theory to predict the dynamics of the core of spiral waves in excitable media. We shall review some of this theoretical work, present computational results that indicate where it fails, and present a phenomenological kinematic theory that predicts the core size and rotation frequency in two-dimensional media. We shall also discuss some of the difficulties inherent in connecting the kenematic theory with the governing partial differential equations.

Hans G. Othmer
Department of Mathematics
University of Utah
Salt Lake City UT 84112

5:40 PM

A STUDY OF SPURIOUS STEADY-STATE NUMERICAL SOLUTIONS OF NONLINEAR ORDINARY DIFFERENTIAL EQUATIONS

The sensitivity of numerical solutions to initial data and the strong dependence of solutions of the discretized parameters (i.e., time step, and numerical dissipation coefficients) are absent from linear analysis and yet present quite often in nonlinear analysis. The subject area on spurious equilibria of numerical methods by the nonlinear dynamic approach will have a dramatic impact on better understanding of numerical analysis for nonlinear ordinary differential equations (ODEs) such as nonlinear stability. It will also provide insight on how well a numerical solution can mimic the true physics of the problem. The main objective of this work is to investigate what types of new phenomena arise from the numerical methods but not from the original ODEs.

H.C. Yee
Computational Fluid Dynamics Branch
NASA Ames Research Center, Moffett Field, California 94035 USA

P.K. Sweby
Department of Mathematics
University of Reading, Whiteknights, Reading RG6 2AX, England

D.F. Griffiths
Department of Mathematical Sciences
University of Dundee, Dundee, DDI 4HN, Scotland

TUESDAY, MAY 8 - 4:00 - 6:00 PM
Room: Hybiscus
Minisymposium 25
Nonlinear Dynamics of Rotating Fluid Flows
Chair: J. Brindley

4:00 PM

Finite Dimensional Dynamics in Taylor-Couette Flow

We present the results of an experimental and theoretical study of the appearance of chaos in a novel variant of the Taylor-Couette system. The onset of time-dependence is shown to occur through the interaction of steady flows via multiple bifurcation points. Here, direct comparison can be made between experiment and numerical calculations. Chaos is shown to arise through the routes of homoclinicity, frequency locking and torus doubling. The interpretation of these latter phenomena can be made in terms of finite dimensional models deduced from the numerical solutions.

Dr. T. Mullin, Dept. of Physics, University of Oxford, Clarendon Laboratory, Oxford, OX1 3PU, U.K.

4:30 PM

The Transition to Chaos Near to a Homoclinic Orbit in Rotational Taylor-Couette Flow

At gap height to width ratios of order one, the bifurcation diagram of rotational Taylor-Couette flow is well known by experimental and numerical investigation and shows a rich variety of behaviour. Extending these studies to higher Reynolds numbers we investigate the dynamical behaviour of a one vortex state as a function of Reynolds number and aspect ratio. We find Hopf bifurcations, homoclinic orbits, intermittency and finally chaotic behaviour. The experimentally obtained results are analyzed by estimating Lyapunov spectra and fractal dimensions using a proper reconstructed phase space.

Prof. Gerd Pfister, Institut für Angewandte Physik, Universität Kiel, F.R.G.

5:00 PM

Chaotic Regimes and Transitions in a Thermally-Driven, Rotating, Stratified Fluid

Analysis of high-precision time series of measurements of temperature and total heat transport in a rotating, cylindrical fluid annulus indicate two main regions of parameter space in which a transition from quasi-periodic to chaotic behaviour occurs. In the first a transition occurs to a lower azimuthal wavenumber, in which a quasi-periodic, amplitude-modulated travelling wave (2-torus) gives way to a low-dimensional ($D \sim 3$) chaotically-modulated vacillation at very low frequency. The second transition to low-dimensional ($D \sim 3?$) chaotic behaviour is associated with a weak temporal modulation of azimuthal (and radial?) harmonics of the dominant wave ('structural vacillation'). Some efforts to model these transitions using a low-order quasi-geostrophic numerical model will be discussed.

Dr. P. L. Read, Meteorological Office Unit, Robert Hooke Institute, Clarendon Laboratory, Parks Road, Oxford, OX1 3PU, U.K.

5:30 PM

Nonlinear Mode Competition and Co-existence and the Approach to Turbulence in Closed Rotating Flows

Time dependent flows in Taylor-Couette systems, or in rotating annulus experiments, frequently resemble a nonlinear superposition of two (or more) simple modes, each having a different spatial structure itself compatible with the boundary constraints. Experiments in which data is collected simultaneously from many points have illuminated the spatial structure of each mode, and hence suggested the physical mechanism driving it. Simple theoretical models for annulus flows, where modes are driven by baroclinic instabilities, show modal co-existence, stationary or oscillatory, for some parameter ranges. Though no adequate deductive model yet exists for the Taylor-Couette configuration, mechanistic models with appropriate behavior are helpful.

Prof. J. Brindley, Dept. of Applied Maths and Centre for Nonlinear Studies, University of Leeds, Leeds, LS2 9JT, U.K.

TUESDAY, MAY 8 - 4:00-6:00 PM
Room: Lemon-Lime
Minisymposium 26
Fractals and Their Dimensions
Chair: Jeffrey Geronimo

4:00 PM

X. Viennot

No abstract submitted.

4:25 PM

Analogues of the Lebesque density theorem for fractal sets of reals and integers.

By applying a second order averaging technique, the order-two density of Hausdorff measure is defined. For various examples including the middle third set and the zero set of Brownian motion we show that the order-two density exists and is almost surely constant. Various generalizations and applications are discussed. This work is joint research with A. Fisher.

Dr. Tim Bedford
Department of Mathematics
Delft University of Technology
PO Box 356
2600 AJ Delft
The Netherlands
Tel. 31-15-783259

4:50 PM

Universal Cantor Sets and Iterated Function Systems

Cantor set attractors for unimodal functions are discussed from an iterated function system (IFS) perspective. For instance, if C is the attracting Cantor set for $g(x) = 1-(1.527...)x^2+...$, the quadratic solution to the Feigenbaum-Cvitanovic functional equation, then it is well known that C is also the attractor for the IFS consisting of the maps $u(x) = (-.3995...)\ x$ and $v(x) = g_+^{-1}(x)$. It is shown that each unimodal function f with a Cantor set attractor may be associated with a unique IFS (u_f, v_f) and the action of the Feigenbaum renormalization operator T is then described in terms of an operator on IFS's. Sufficient conditions for the convergence of $T^n(f)$ in terms of (u_f, v_f) are given.

Douglas P. Hardin
Department of Mathematics
Vanderbilt University
Nashville, TN 37235

5:15 PM

Non-Linear Dynamics and Propagation of Round-Off Error

We describe an investigation of methods for limiting growth of computational round-off error in performing calculations in non-linear dynamics, based on combining symbolic dynamics of non-linear maps with Monte Carlo methods. Exact symbolic answers can be obtained by purely combinatorial methods. The computation is carried out by sampling from among exact symbolic orbits, and then performing high-precision floating-point computations for only the selected orbits. In a sense, we have exchanged the unacceptable, unstable error propagation due to iterative arithmetic operations for the controllable error due to random sampling.

Isabel Beichl
Francis Sullivan
National Institute of Standards and Technology
Center for Computing and Applied Mathematics
Gaithersburg, Maryland 20899

5:40 PM
On the inverse fractal problem

The problem we will consider is the following: Given a compact fractal set, can one find a finite set of contractive affine maps such that the attracting set associated with these maps will approximate in some metric the original set of interest? We will restrict our attention to the case when the sets of interest lie in R or R^2. We will discuss some methods which may be useful in finding the affined maps mentioned above.

Jeffrey S. Geronimo
School of Mathematics
Georgia Institute of Technology
Atlanta, GA 30332

TUESDAY, MAY 8 - 4:00-6:00 PM
Room: Azalea
Contributed Presentations 7
Applications 2
Chair: Ann Castelfranco

4:00 PM
Dynamics of an Operator Semigroup Model of G1-Threshold Regulation of Cell Cycle

The model formalizes concepts of supramitotic cell cycle regulation, introduced by Sennerstam and Strömberg (*J Theor Biol (1988)* **131**: *151-162*), for transformed embryonic cells. Two cell types (large and small) are present. Type 1 may switch to type 2 and conversely. Other probabilistic elements are distributed G1 size threshold and unequal division. Model equation, of delay-integral type, generates a strongly continuous semigroup of positive bounded linear operators, cf. Arino and Kimmel (*SIAM Appl Math (1987)* **47**: *128-145*). It is eventually compact with spectrum containing a strictly dominating simple real eigenvalue. From this, asymptotic behavior is inferred. Properties including pedigree corellations are discussed.

Marek Kimmel
Ovide Arino
Investigative Cytology Lab
Memorial Sloan-Kettering
1275 York Ave., New York, NY 10021
Department of Mathematics
University of Pau
Av. de l'Université, 64000 Pau, France

4:20 PM
Perturbation and Approximation Techniques for Models of Bursting Electrical Activity in Pancreatic β-Cells

The Sherman-Rinzel-Keizer model of bursting electrical activity in β-cells has an active phase whose leading-order problem is a Lienard differential equation which depends on a parameter with slow dynamics. The problem can be treated as a strongly nonlinear oscillator and by approximating the functions which describe the channel dynamics, explicit invariants for the system can be found using a "direct" method. The relation between these invariants and the active phase duration will be discussed and approximation formulas for the duration presented.

Mark Pernarowski
Department of Applied Mathematics, FS-20
University of Washington
Seattle, WA 98195

Robert M. Miura
Department of Mathematics
University of British Columbia
Vancouver, B.C., Canada V6T 1Y4

J. Kevorkian
Department of Applied Mathematics, FS-20
University of Washington
Seattle, WA 98195

4:40 PM
Phase Entrainment in Biological Oscillators

Numerical and analytical studies of the rotation number of Poincaré and Denjoy have been used to investigate both chaotic and non-chaotic behavior of a variety of two-dimensional non-linear oscillator models. Here the rotation number is used to study n:m phase entrainment in a pair of biological oscillators. If the coupling is unidirectional then the physiological system reduces to an oscillator subject to periodic input and it is found from both mathematical theory and biological experiment that there are distinct frequency regimes in which the oscillator fires at some rational multiple of the input frequency. A phase-interaction model is used to discuss the transitions between frequency regimes and also to study what effect the amplitude of the input current has on the stability of these regimes. The extension to n-dimensional systems of coupled oscillators and an application to learning in neural networks are also considered.

Diana E. Woodward
Department of Mathematics
208 Clements Hall
Southern Methodist University
Dallas, TX 75275

(214) 692-2515 (office)
(214) 692-2506 (dept.)

5:00 PM
Low Frequency Dispersive Waves in Neural Networks

The higher frequencies observed in the EEG are explained as the contribution of nondispersive brain waves in the global "standing wave" theory. The low frequencies for which there is no theoretical explanation as yet, indicate the presence of dispersive waves due to imaginary proper masses. The presence of such waves would be consistent with the fact that information is generated and carried in neural networks collectively and nonlocally.

Dr. S. Vishnumhatla
BELLCORE
PYA2J312
3 Corporate Place
Piscataway, NJ 08854

5:20 PM
Neural Networks for Constrained Scheduling Optimization in a Time Window

Formalisms for applications of Neural Networks to Constrained Scheduling Optimization in a time window are investigated. We consider the assignment of N interdependent jobs with resource and deadline constraints to M heterogeneous processors within a window of L time steps. A variety of networks are shown to be suitable for this problem. Simulation results are presented for a three dimensional LMN-net and a data inversion net. The latter is an approach where the constraints are treated as measurements on a physical system and the scheduling problem is cast in terms of a data inversion algorithm.

Jurn-Sun Leung & Yel-Chiang Wu
General Purpose Machines Laboratory, Inc.
16 Dickens Court, Irvine, CA 92715-4029

5:40 PM
A Dynamical Systems Perspective For Mathematical Programming

This presentation will describe how mathematical programming can be considered as an extension of nonlinear dynamical systems theory. The basic theme will be to show that using concepts from the qualitative theory of dynamical systems, interior point methods to solve mathematical programs, including Karmarkar's algorithm, arise "naturally" as a consequence of this perspective. In the pursuit of developing more efficient algorithms to solve mathematical programs, we demonstrate the need to closely follow a "unique" path from the initial point to the optimal solution. The dynamical systems representation of this trajectory leads to an algorithm that offers certain advantages over the standard gradient-related algorithms in the mathematical programming literature.

Terry L. Friesz
G. Anandalingam
Nihal J. Mehta
Dept. of Systems
Univ. of Pennsylvania
Phila. PA 19104

Roger L. Tobin
GTE Laboratories
40 Sylvan Road
Waltham, MA 02254

WEDNESDAY, MAY 9 - 10:30 AM-12:30 PM
Room: Lemon-Lime
Minisymposium 27
Control of Chaos 3
Chair: Alfred Hubler

10:30 AM
M. Welge
No abstract submitted.

11:10 AM
DYNAMICS OF ADAPTIVE SYSTEMS

We introduce a simple adaptive control mechanism into nonlinear systems which are capable of complicated oscillatory states and chaotic dynamics. We show that besides providing efficient regulation, it displays novel behavior. We also demonstrate how sudden perturbations in the system's parameters can degenerate into chaotic bursts with no precursors. When such bursts occur, the system first reverberates wildly and then recovers in times that are inversely proportional to the stiffness of the control mechanism. We exhibit a general control principle which provides a quantitative relation between the maximum amplitude of a perturbation from which a system can recover, and the speed at which it does so.

B. A. Huberman and E. Lumer

Xerox Palo Alto Research Center, Palo Alto, CA. 94304
and
Department of Applied Physics, Stanford University
Stanford, CA. 94305

11:50 AM
Optimal Control of Catastrophes

A new method based on anharmonic driving forces is used to alter the limiting behavior of nonlinear systems in order to avoid catastrophes. The method requires some feedback from the experimental system for the modelling of the dynamics of the system. But, once the model is known, or can be predicted from previous feedback, no additional feedback is necessary to calculate appropriate driving forces. The control can be optimized so that the outside influence of the system is kept at a minimum.

Kodogeorgiou Athanasios
Department of Physics
University of Illinois at Urbana-Champaign
1110 West Green Street
Urbana, Illinois 61801

WEDNESDAY, MAY 9 - 10:30 AM-12:30 PM
Room: Tangerine A
Minisymposium 28
Mathematical Epidemiology 1
Chair: Herbert Hethcote

10:30 AM

Epidemiological Models with Varying Population Size

Disease transmission models are formulated under assumptions that the size of the population varies and the force of infection is of the proportionate mixing type. Analysis of the models shows an intricate coupling between the demographics of the population and the dynamics of the disease.

P. van den Driessche
Department of Mathematics and Statistics
University of Victoria
P.O. Box 1700
Victoria, B.C. V8W 2Y2
Canada

11:00 AM

Oscillations in Age-Structured Epidemic Models

Epidemic models with globally stable endemic equilibria can show undamped oscillations if individuals are allowed to have their infectivity (ability to infect others) depend on their age. This holds if age is understood as time since birth as well if it means time since infection. Specifically, undamped oscillations can occur in a life-age-structured $S \to I \to R$ model with constant population size and in an infection-age-structured epidemic model with disease fatalities and population-size-dependent contact rate. Dynamical system methods are used to show disease persistence and the loss of stability of the endemic equilibrium.

Horst R. Thieme
Department of Mathematics
Arizona State University
Tempe, AZ 85287-1801

11:30 AM

"A Gonorrhea Model with Sensitive and Resistant Strains"

In recent years gonorrhea infection with antibiotic-resistant strains, especially PPNG, has become a significant public health problem. Drawing on the gonorrhea model of Lajmanovich and Yorke, a multigroup model that embraces both resistant and sensitive strains of the organism is introduced. It is shown that, like the Lajmanovich and Yorke (single-strain) model, in the general case the sensitive-resistant model has a unique globally asymptotic equilibrium. As a function of the interplay between contact rates, cure rates, and reversion rates, the equilibrium can lead to endemic infection with sensitive infection only, resistant infection only, or both, or to elimination of sensitive and resistant infection.

Paul Pinsky and R. Shonkwiler
School of Mathematics
Georgia Institute of Technology
Atlanta, GA 30332

12:00 PM

Mathematical Models for Dengue

Mathematical models for dengue will be formulated. Analysis of steady states and their stability, and of dependence of the basic reproductive number on parameters, will be outlined. Comparisons with available data will be addressed.

K.L. Cooke, Department of Mathematics, Pomona College, Claremont, CA 91711
C.Castillo-Chavez, Biometrics Unit, 337 Warren Hall, Cornell University, Ithaca, NY 14853-7801
C. Vargas, CINVESTAV, Dpto de Matemáticas, A.P. 14-740, Mexico D.F. 07000

WEDNESDAY, MAY 9 - 10:30 AM - 1:00 PM
Room: Tangerine B
Minisymposium 29
Aerospace Design 2
Chair: Helena S. Wisniewski

10:30 AM

Developing CFD Tools for Design of Commercial Airplanes

Computational Fluid Dynamics (CFD) has become an indispensable tool in aerodynamic design of commercial airplanes. A discussion of the role and the pay-off of CFD in aerodynamic technology leads to some discussions of establishing an environment for efficient introduction of new CFD tools to engineering. Examples of applications of CFD tools in aerodynamic analysis and design will be given. Through these examples, the applicability and the weaknesses of the current technology can be established and illustrated. The discussions of the weaknesses lead to the identification of the new challenges in turbulence, separated flows and design optimization. The new challenges require applied mathematics to play a major role in development of new knowledge and new CFD tools.

Dr. Wen-Huei Jou,
Manager, CFD Development
Boeing Commercial Airplanes
P.O. Box 3707 M/S 7K-06
Seattle, WA 98124-2207

11:00 AM
Computational Fluid Dynamics on the Massively Parallel Connection Machine

Efficient computational fluid dynamics codes can be developed by utilizing the recent developments in computer architectures. Three-dimensional Euler/Navier-Stokes codes have been developed on the massively parallel Connection Machine for both the structured hexahedral grids and the unstructured tetrahedral grids. Both the codes use an explicit, finite-volume multi-stage Runge-Kutta time-stepping algorithm. For steady flows various convergence acceleration schemes, such as local time-stepping and explicit residual smoothing are investigated. The structured-grid code utilizes the nearest neighbor communications which is 5-20 times faster than the general purpose router. An algebraic RNG-based turbulence model has been incorporated in the structured-grid Navier-Stokes code. The performance of the codes has been evaluated by computing a number of test cases and comparing the solution with the available experimental data and with the TEAM code results on the Cray-XMP.

Dr. Mohammad M. S. Khan
Research Scientist
Lockheed Aeronautical Systems Co.
Dept 70-11, Unit 50B, Plant 2
P. O. Box 551
Burbank, CA 91520
(805)-295-4732

11:30 AM
D. Dwoyer
No abstract submitted.

12:00 PM
Some Problems in the Transition from Laminar to Turbulent Flow

The importance of the location, extent and nature of transition to lifting reentry vehicle technology and aircraft configurations using laminar flow control are well known. Discoveries of large-scale coherent structures in both free and wall-bounded turbulent shear flows indicate that such structures are very much in common with those in transitional shear flows. We present thorough studies of "the" prototype structure: longitudinal vorticity elements in a boundary layer that originated from initial Gortler vortices. Mechanisms leading to the development of secondary instabilties and fine-scale turbulence generation are elucidated. Theoretical considerations and approximations lead to reduction of computational time in bringing out the essential physics. Simplified eddy models are useful in selective eddy-control studies and may well lead to practical CFD implementation where "complete" numerical simulation is neither practicable nor necessary in flight vehicle design.

Joseph T. C. Liu
Division of Engineering
Brown University
Providence, Rhode Island 02912

12:30 PM
CFD for Aircraft Design: Present Capabilities and Future Requirements

Computational fluid dynamics (CFD) is rapidly evolving as a critical technology for flight-vehicle development. CFD allows simulation of flow phenomena by solving the fluid dynamic equations on a digital computer. Using computational simulations to complement wind-tunnel testing offers the most effective approach to reducing time and cost associated with evaluation of numerous geometric modifications in a design process. CFD codes vary in the complexity of mathematical model employed and in their ability to model the flow physics. At one end of the spectrum are codes based on the nonlinear Reynolds-averaged Navier-Stokes equations and at the other end are the panel codes based on linearized potential-flow equations. Codes based on Euler and nonlinear potential-flow equations fill the gap between the two ends. In this paper, capabilities and limitations of CFD codes will be examined from an aircraft design perspective, and critical requirements for making CFD fully effective will be discussed.

Dr. Pradeep Raj
Lockheed Aeronautical Systems Company
D/75-51, B/63, P/A-1
Burbank, CA 91520-7551

WEDNESDAY, MAY 9 - 10:30 AM-12:30 PM
Room: Oleander A
Minisymposium 30
Dynamical Systems in Crystalline Structures
Chair: John A. Simmons

10:30 AM
Extension of the Cahn-Hilliard Equation to Ordered Systems with Multiple Length Scales

This lecture will introduce several physical problems in materials science that involve diffusional transport in crystalline solids, over length scales that include and range upward from atomic dimensions. The aim will be to provide physical insight for processes which require rearrangements on the atomic scale, such as the formation of ordered superlattices, as well as on a significantly larger scale, e.g. phase separation. Relevant alloy microstructures will be shown and discussed. An overview of some of the mathematical framework for describing the evolution will be given, with emphasis on problems that are poorly understood.

Samuel M. Allen
Department of Materials Science and Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139

11:10 AM

Evaluation Equation for Ordered Systems Using the Path Probability Method

The microscopic structure of a crystalline ordered system is described using configurations of a local cluster, e.g., a pair or a tetrahedron. The probability of finding a configuration of the cluster is called the state of the system. The time evaluation of the system is described by a set of simultaneous differential equations for all of the independent state variables. The recipe of deriving the differential equations is given by the Path Probability Method, which is based on the principle that the evaluation occurs toward the direction of the largest probability of the change.

Ryoichi Kikuchi
Department of Materials Science and Engineering
University of California, Los Angeles
Los Angeles, CA 90024

11:50 AM

Morphological Dynamics of Crystal Surfaces

At low temperature, most crystals exhibit sharp, well-defined facets. If one imposes an artificial corrugation on this surface, the morphology consists of broad terraces separated by monoatomic steps. This talk concerns how the surface returns to its facetted ground state under the action of surface diffusion. The kinetics of morphological equilibration turn out to be highly non-linear. Remarkably, the actual evolution of the steps and terraces (obtained by numerical solution of the equations of motion) conform to the prediction obtained by the separated variable solution of the non-linear PDE. Thus, flattening of the surface proceeds by way of a shape-preserving solution independent of the initial conditions. A perturbation analysis suggests that this solution is an attractor of the equations of motion. A continuum version of this theory yields a different non-linear PDE whose separated variable solution does not conform to the numerical solution. Many open questions of mathematics and physics remain.

Andrew Zangwill
School of Physics
Georgia Institute of Technology
Atlanta, GA 30332

WEDNESDAY, MAY 9 - 10:30 AM-12:30 PM
Room: Hybiscus
Minisymposium 31
Metastable Dynamics in Physical Systems 2
Chair: Peter W. Bates

10:30 AM

Invariant Manifolds for Metastable Patterns in the Bistable Reaction-Diffusion Equation

When a bistable reaction-diffusion equation has traveling waves with zero speed and a small diffusion coefficient, solutions with patterns of thin transition layers evolve extremely slowly. Neu (unpublished) formally argued that layer velocities are exponentially small and are approximated by nearest-neighbor attractive forces. Fusco & Hale (J. Dyn. Diff. Eqn. 1989) suggested the viewpoint of geometric singular perturbation theory, conjecturing that these "metastable" patterns are associated with the global unstable manifolds of certain steady states. We have proved this, obtaining a precise description of the global unstable manifolds of equilibria having a fixed finite number of transitions in the limit of small diffusion. We also introduce and analyze a statistical model for the distribution of layers in the coarsening process which is driven by the annihilation of pairs of layers as closest neighbors come together.

Jack Carr
Dept. of Math.
Heriot-Watt Univ.
Edinburgh EH14 4AS
UK

Robert Pego
Dept. of Math.
Univ. of Michigan
Ann Arbor, MI 48109-1003

11:10 AM

Optimal High Order in Time Approximations for the Cahn-Hilliard Equation

We present a new approach for computing the order of convergence of fully discrete approximations to solutions of the Cahn-Hilliard equation. These approximations are generated by (arbitrarily) high order Implicit Runge-Kutta methods for the time-stepping and a Galerkin Finite Element process for the spatial discretization. In particular, we show that the well-known order reduction phenomenon afflicting IRK methods does not occur. Numerical results utilizing these high order methods to demonstrate the existence of a slow-motion manifold for the Cahn-Hillard equation in one space dimension are also presented.

William R. McKinney
Departmentof Mathematics
North Carolina State University
Box 8205
Raleigh, NC 27695-8205
(919) 737-3265

Ohannes Karakashian
Department of Mathematics
University of Tennessee
Knoxville, TN 37996-1300
(615) 974-4272

11:50 AM

Computations on the Cahn-Hilliard Model of Solidification

Numerical studies of interface migration in the two-dimensional Cahn-Hilliard equation will be discussed. Our results add evidence to support the connection between this equation and the well-known quasi-static model of solidification. Finite elements coupled with a second order time discretization scheme were used for the computations. The nonlinear systems of equations that arise on each time step are solved by fixed point iteration while the linear systems are solved by preconditioned conjugate gradients.

Donald A. French
Department of Mathematics
Carnegie Mellon University
Pittsburgh, PA 15213-3890

WEDNESDAY, MAY 9 - 10:30 AM-12:30 PM
Room: Oleander B
Minisymposium 38
Nonlinear Mechanical Systems
Chair: Steven M. Shaw

10:30 AM

Global Bifurcation and Chaos in Parametrically Forced Systems with One-One Resonance

Global bifurcations of a fourth order Hamiltonian system with $Z_2 \oplus Z_2$ symmetry are studied. The system represents normal form equations that arise in a variety of problems which have one-one internal resonance and which are forced sinusoidally at the natural frequencies. Four qualitatively different types of global behaviors are shown to occur. Using a generalization of the Melnikov method, three different heteroclinic cycles are shown to break generating Smale horseshoes resulting in chaotic phenomena. The theoretical results are verified by numerical simulations. The main conclusion of the analysis is that chaotic phenomena are very common in this class of systems and they are expected to occur even in systems with dissipation, if the latter is of sufficiently high order.

Z. C. Feng

and

P. R. Sethna

Department of Aerospace Engineering and Mechanics
University of Minnesota
Minneapolis, MN 55455
U.S.A.

11:00 AM

Lyapunov Exponents for Stochastic Mechanical Systems

In practice, it is generally most desirable to examine the almost-sure sample stability and the results thus obtained hold true with probability one. In this work, almost-sure stability for coupled mechanical systems under a combination of harmonic and stochastic parametric excitations is examined using the well developed concept of Lyapunov exponents. As a first step in the analysis, a set of approximate Ito equations are derived using both deterministic and extended stochastic averaging methods. The maximal Lyapunov exponent, λ, is calculated for the Ito equation using the approach given by Khasminskii. The mechanical system is said to be almost-sure stable if $\lambda < 1$.

N. Sri Namachchivaya
Department of Aeronautical & Astronautical Engr.
University of Illinois
101 Transportation Building
104 South Mathews Avenue
Urbana, IL 61801

11:30 AM

Nonlinear Dynamics of a Parametrically Excited Inextensional Elastic Beam

The nonlinear dynamics of a clamped-clamped/sliding inextensional elastic beam subject to a harmonic axial load is investigated. The Galerkin method is used on the coupled bending-bending-torsional nonlinear equations with inertial and geometric nonlinearities and the resulting two ordinary differential equations are studied by the method of multiple time scales and by direct numerical integration. The amplitude equations are analyzed for steady and Hopf bifurcations. Depending on the amplitude of excitation and the damping, various qualitatively distinct frequency response diagrams are uncovered and limit cycles and chaotic motions are found. In the truncated two-degree-of-freedom system the transition from periodic to chaotic amplitude modulated motions is via the process of torus-doubling.

Jim M. Restuccio
Department of Applied Mechanics
California Institute of Technology
Pasadena, CA 91125

Charles M. Krousgrill, Anil K. Bajaj
School of Mechanical Engineering
Purdue University
West Lafayette, IN 47907

12:00 PM

Center Manifold Approach to Post-Hopf Behavior

The usual center manifold approach to a Hopf bifurcation involves reducing a system of n ode's to a system of 2 ode's. This reduction is accomplished by obtaining an approximate expression for the 2 dimensional center manifold, and then projecting the flow onto it, thereby discarding n-2 dimensions. In this work we use the center manifold approach to investigate the stability of the limit cycle born during the Hopf bifurcation. This is done by substituting the approximate expression for the limit cycle solution into the n-2 equations previously discarded, which govern the nature of the flow transverse to the center manifold. This results in an n-2 dimensional Floquet theory problem. In the case that n=3, closed form stability criteria are obtained. Examples show that the instability may correspond to period-doubling.

Richard H. Rand
Dept. of Theoretical and Applied Mechanics
Cornell University
Ithaca, New York 14853

WEDNESDAY, MAY 9 - 10:30 AM-12:30 PM
Room: Azalea
Contributed Presentations 9
Applied Fluid Modeling
Chair: Francis Sullivan

10:30 AM

Quasi-recurrent Motions with the Two-Dimensional Nonlinear Schrodinger Equation for Deep-water Modulated Gravity Wavetrains

We purport to give a simple analytic explanation of the numerical results of Martin and Yuen[1] on the long-term evolution of spatially periodic solutions of the two-dimensional nonlinear, deep-water, modulated gravity wavetrain. We show that this nonlinear system can be described as effectively possessing an arbitrarily high number of degrees of freedom so that the overall motion can at best be only quasi-recurrent. This result is also supported by an investigation of the long-time evolution of the unstable modulation near the threshold for linear stability of the two-dimensional nonlinear Schrodinger equation indicating that the modulation does not quite non-linearly develop into pure periodic state.

1. D.V. Martin and H.C. Yuen: Phys.Fluids 23, 881, (1980).

Bhimsen K. Shivamoggi
Department of Mathematics
University of Central Florida
Orlando, FL 32816

This is now in Minisymp. 12 pg.A11

Description of the Dynamics of Karman Vortex Streets by Low Dimensional Differential Equations

Differential equations are constructed from special flow vector fields obtained from experimental time series of Karman vortex streets. It will be shown that the velocity signal measured in the regular range ($50<Re<150$) of a vortex street can be modeled by a 2nd order differential equation (ODE) with 10 parameters. The parameters are nearly independent of the probe position and of the Reynolds number. Discontinuities in the Strouhal-Reynolds number dependance (e.g. the Tritton discontinuity) are also reflected in the coefficients. With the knowledge of the ODE the response of the vortex street on pertubations can be predicted.

Erika Roesch, F. Ohle, P. Lehman, H. Eckelmann
Institut fuer Angewandte
Mechanik u. Stroemungsforschung
der Universitaet Goettingen
Bunsenstr. 10
D-3400 Goettingen, W. Germany

A. Hubler
CSSR, University of Illinois
Urbana, IL 61801

10:50 AM

Chaos and Acoustic Remote Sensing in the Straits of Florida

There is interest in using acoustic remote sensing to monitor the heat transported by the Florida Current through the Straits of Florida because knowledge of its temporal variability is thought to be important for predicting global climate. We have calculated acoustic ray paths in the Straits using a bathymetric model for which the small-scale bottom structure, i.e., bottom roughness, is superimposed on a representation of the large-scale average bathymetry. The calculation suggests acoustic remote sensing has limited application because bottom roughness introduces "blurring" or uncertainty into the effective ray path associated with a given pulse-arrival-time interval. We have shown this uncertainty is the result of classical chaos.

D. R. Palmer
Office of the Director
AOML/NOAA
4301 Rickenbacker Causeway
Miami, FL 33149

L. M. Lawson
Department of Mathematics
East Tennessee State University
Johnson City, TN 37614-0002

T. M. Georges and R. M. Jones
WPL/NOAA
325 Broadway
Boulder, CO 80303

11:10 AM

Dynamical Systems for Inverse Ocean Modelling

In recent years, steady-state box models of the world's oceans based on chemical tracer data have been developed in an attempt to deduce large-scale mean oceanic circulation patterns. This contrasts with dynamical methods which attempt to make use of relatively plentiful temperature and salinity data to determine the geostrophic component of the water velocities.

This paper discusses mathematical modelling for a theoretical "ocean" in which the fields of water velocity and turbulence and tracer concentration are all known and together satisfy a steady-state advective-diffusive equation "perfectly".

This paper studies the sensitivity to data errors of box models formulated as overdetermined systems. Future directions of the research are discussed.

Richard S. Segall and Arthur H. Copeland
Mathematics Department
University of New Hampshire
Durham, NH 03824-3591

Chris D. Ringo and Berrien Moore, III
Institute for the Study of Earth, Oceans and Space

University of New Hampshire
Durham, NH 03824-3525

11:30 AM
Dynamics of Flows in Complex Geometries

We obtain basic eigenfunctions for two flows in complex geometries through the proper orthogonal decomposition procedure: flow through a grooved channel and flow past a cylinder. We consider parameter regimes where the temporal structure is simple, in particular oscillatory (limit cycle). The decomposition then identifies the spatial modes responsible for the oscillatory behavior. In both flows more than 98% of the energy of the motion is in the first two spatial modes. Other, less energetic modes are also obtained, which elucidate details of the flow previously inferred by other means (e.g. wall modes). We form and study dynamical systems of varying orders, by suitable projection of the Navier-Stokes equations onto the eigenspace of these modes.

Anil E. Deane, George E. Karniadakis and Ioannis G. Kevrekidis
Program in Applied and Computational Mathematics and Departments of Chemical and Mechanical Engineering
Princeton University
Princeton, NJ 08544

THURSDAY, MAY 10 - 10:30 AM-12:30 PM
Room: Lemon-Lime
Minisymposium 32
Control of Chaos 4
Chair: Alfred Hubler

10:30 AM
Stimulation of Quantum Systems

We discuss methods for the optimal control of driven quantum systems, such as an atom or molecule in the field of a laser, and the comparison between classical and quantum predictions when the classical dynamics are chaotic. Applications include the tailoring of a laser pulse to achieve maximal ionization or dissociation, or to selectively excite a particular state or mode of an atom or molecule.

Peter W. Milonni and Bala Sundaram
Theoretical Division, Mail Stop B-268
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

11:00 AM
Resonances of Nonlinear Systems

The maximum energy exchange of two harmonically coupled nonlinear oscillators is investigated. We calculate the maximum energy exchange close to resonance and show that the corresponding resonance curves have a universal shape and become broader and smaller when the amplitude-frequency coupling becomes large. Since there is a large variety of nonlinear oscillators where the trajectories are nearly homothetic curves in a phase space representation, we furthermore investigate the special situation where the oscillators are homothetic. We argue that in this case there is a scaling of the maximum energy exchange at resonance. Numerical investigations show that these relations remain valid if the oscillators are slightly damped or perturbed by random noise.

T. Eisenhammer
Sektion Physik,
Ludwig-Maximilians Universitaet,
D-8000 Muenchen 2, FRG

11:30 AM
Nonlinear Resonance Spectroscopy

Nonlinear resonance spectroscopy can be used to characterize a chaotic system actively. We introduce a constant amplitude driving force, which is used without feedback from the system, to make the method practical at the molecular level. This driving force is similar to one that is shown to minimize the required amplitude, and the disturbance to nearby systems. Finally, we discuss the effects of noise and temperature, showing the method can still be used.

Daniel Bensen
Department of Physics
University of Illinois
1110 West Green
Urbana, Illinois 61801

12:00 PM
Generalized Resonance Spectroscopy

Using ideas from nonlinear resonance spectroscopy, we introduce a more general definition of resonance which is applicable in systems without well-defined energies. We derive formulas for the shape of these "resonance" curves and show that they have a similar shape for a wide range of continuous and discrete dynamics. Application to the modelling and control of nonlinear systems will also be discussed

Kenneth H. Chang
Center for Complex Systems Research
University of Illinois
405 North Mathews Avenue
Urbana, Illinois 61801

THURSDAY, MAY 19 - 10:30 AM-12:30 PM
Room: Tangerine A
Minisymposium 33
Mathematical Epidemiology 2
Chair: Herbert W. Hethcote

10:30 AM
Epidemic Models with Distributed Delays

We examine some simple models for the spread of a communicable disease in a population with density-dependent births and deaths. For a disease from which all victims recover with immunity against re-infection, the endemic equilibrium (if it exists) is always asymptotically stable. For a disease which is universably fatal, the endemic equilibrium may be unstable; this depends on the population dynamics and on the distribution of infective periods. What happens if a fraction of the victims recovers with immunity?

Fred Brauer
Department of Mathematics
University of Wisconsin
Madison, WI 53706

11:00 AM

Nonlinear Dynamical Features of Seasonally Driven Epidemics

Seasonally driven epidemics, such as measles, mumps, and rubella, have been observed to exhibit a wide variety of dynamical behavior. In large populations, recurrent epidemic behavior is seen for a wide range of periods, as well as small and large amplitudes. Chaos has also been observed for diseases such as measles. This talk will discuss the mechanisms for the onset of both periodic and chaotic behavior in a simple nonlinear epidemic model for a single population. New results coupling small and large populations will also be presented.

Ira B. Schwartz
US Naval Research Laboratory
Code 6520
Washington, DC 20375-5000

and

Math and Business Consultants
6805 Greyswood Road
Bethesda , MD 20817

11:30 AM

Epidemic Cycles in Africa

The SEIR epidemic model with vital dynamics and seasonal variation in transmission has been used to analyze the behavior of diseases which are transmitted from person to person and generate lifelong immunity after infection. However, models calibrated for industralized populations cannot be directly applied to African populations for 3 reasons: (1) African populations have higher birth rates, death rates and growth rates; (2) schools are not as important in creating seasonal variation since most children are infected at very young ages; and (3) the duration of infectivity may be prolonged. It is shown that assumptions appropriate for African populations change the expected period of epidemic cycles. Measles in Africa is discussed.

Joan L. Aron
Department of Population Dynamics
Johns Hopkins School of Hygiene and Public Health
615 N. Wolfe St.
Baltimore, MD 21205

12:00 PM

Chaos in Childhood Diseases

Childhood disease--chickenpox, measles, mumps, and rubella typically exhibit recurrent oscillations in incidence. The fluctuations range from yearly outbreaks of roughly constant amplitude (chickenpox) to apparently chaotic motions (measles, mumps, and rubella). We discuss the evidence for chaos in the latter cases analyzing both the real world data and the output of differential equations and Monte Carlo simulations. We conclude that in the case of measles, the data are best explained by positing chaotic fluctuations in the presence of the sampling error that results from finite population size.

William M. Schaffer
Department of Ecology
& Evolutionary Biology
University of Arizona
Tucson, Arizona 85721

THURSDAY, MAY 10 - 10:30 AM-12:30 PM
Room: Tangerine B
Minisymposium 34
Hyperbolicity in Dynamical Systems 1
Chair: Kenneth Palmer

10:30 AM

STRANGE ATTRACTORS OF HOMEOMORPHISM HAVING NONCOMPACT DOMAINS

Consideration is given to homeomrphisms having noncompact domains which arise naturally as Poincare maps of orbits homoclinic to invariant set. The concepts of attractors and topological conjugacy between attractors are generalized to such maps. The method of blowup and the idea of homoclinicly symbolic system of block shift operator are introduced to describe the attractors associated with transverse homoclinic points of diffeomorphisms, the Shilnikov's saddle-focus homoclinic orbit and the Lorenz equations.

Bo Deng
Department of Mathematics & Statistics
University of Nebraska-Lincoln
Lincoln, NE 68588-0323

11:00 AM

Numerical Analysis and Effiecient Computation of Heteroclinic Orbits

We present a direct numerical method for the computation of heteroclinic orbits that connect two hyperbolic fixed points of a vector field in R^n. Basically, we truncate a boundary value problem on the real line to a finite interval. We also show how the method can be extended to the case of center manifolds. The emphasis is on systematic computation of heteroclinic orbits by using continuation. The method is incorporated in the software package AUTO. As applications, we consider the computation of traveling wave solutions to reaction diffusion problems and a saddle-node bifurcation. Using the fact that the linearized operator of our problem is

Fredholm in appropriate weighted Banach spaces, we employ the general theory of approximation of nonlinear problems to show that the errors in the approximate solution decay exponentially with the length of the approximating interval. The presentation is based on joint research of the author with Doedel, Lin and Schecter.

Mark Friedman
Department of Mathematics
University of Alabama in Huntsville
Huntsville, AL 35899

11:30 AM
Breakdown of stability and bifurcating invariant sets

We consider breakdown of stability of a two-dimensional torus in a non-linear dynamical system. Assuming that the torus continues to exist after stability is lost, we give a general discussion of the nature of bifurcating invariant sets.

Russell Johnson, Institute for Mathematics and Applications, University of Minnesota, Minneapolis, Minnesota 55455 and Department of Mathematics, University of Southern California, Los Angeles, California 90089.

12:00 AM
Generalization of Shadowing Lemmas and Chaos Near Homoclinic Orbits

We generalize the shadowing lemma to the cases where the linearized flow does not have exponential dichotomies or the unstable and the stable manifolds of successive pseudo orbits do not intersect transversely. The results are used to study various periodic or aperiodic solutions near a homoclinic solution asymptotic to a hyperbolic or nonhyperbolic equilibrium. The equation can be autonomous or perturbed by almost periodic functions.

Xiao-Biao Lin
Mathematics Department
North Carolina State University
Box 8205
Raleigh, NC 27695-8205

THURSDAY, MAY 10 - 10:30 AM-12:30 PM
Room: Jasmine
Minisymposium 35
Geometric Theory and Dynamics of Model Systems
Chair: Robert Cawley

10:30 AM
Smooth Dynamics on Weierstrass Nowhere Differentiable Curves

We consider a family of smooth maps on an infinite cylinder which have invariant curves which are nowhere smooth. Most points on such a curve are buried deep within its spiked structure, and the outer-most exposed points of the curve constitute an invariant subset which we call the "facade" of the curve. We find that for suprisingly many of the maps in the family, all points in the facades of their invariant curves are eventually periodic.

Brian R. Hunt
Naval Surface Warfare Center, Code R41
Silver Spring, MD 20903-5000

and

James A. Yorke
Institute for Physical Science and Technology
University of Maryland
College Park, MD 20742

11:00 AM
Invariant Attracting Continua in Cylinder Maps

Let g be the period one tent map given by g(x) is twice the distance from x to the set of integers. Let T map the cylinder $S^1 x R$ into itself by $T(e^{2\pi ix}, y) = (e^{2\pi iax}, b(y-g(x))$, where a is an integer ≥ 2 and $0<b$. If $b>1$, there is an invariant universally repelling curve which is the graph of a Hardy-Weirstrass function. If $b<1$ there is an invariant continuum M which is universally attracting. Various properties of M will be discussed including the facts that M is not the graph of a function and T is chaotic on M.

Patricia Carter
Naval Surface Warfare Center
Code R41
White Oak, Silver Spring, MD 20903-5000

R. Daniel Mauldin
Mathematics Department
University of North Texas
Denton, Texas 76203-5116

11:30 AM
Dynamics of an Impulsively Driven Morse Oscillator

We study the dynamics of a Morse oscillator subjected to periodic impulsive forcing. The system is governed by an area-preserving map that is factored explicitly into the product of two orientation-reversing involutions. The symmetry lines of these involutions are determined analytically. We classify the periodic and homoclinic orbits by the symmetry lines that they visit.

We also examine the boundary in parameter space that separates bounded and unbounded orbits. Numerical calculations reveal this boundary to have a highly intertwined fractal structure.

James Heagy
R41
Naval Surface Warfare Center
10901 New Hampshire Ave.
Silver Spring, MD 20903-5000

12:00 PM
A New Multifractal Theory for Moran Fractals

We present a rigorous construction and generalization of the multifractal decomposition for Moran fractals induced by infinite product measure. The generalization is specified by a system of nonnegative weights in the partition sum. All the usual (smooth) properties of the $f(\alpha)$ theory are recovered for the case that the weights are equal to unity. The generalized spectrum, $f(\alpha,w)$, is invariant to a group of gauge transformations of the weights, and, in addition, need no longer be concave. In the pairwise disjoint and map specified case, α is the pointwise dimension of the measure. We discuss properties of some examples.

Robert Cawley
Naval Surface Warfare Center
Code R44
White Oak, Silver Spring, MD 20903-5000

R. Daniel Mauldin
Mathematics Department
University of North Texas
Denton, Texas 76203-5116

THURSDAY, MAY 10 - 10:30 AM-1:00 PM
Room: Oleander B
Minisymposium 36
The Dynamics of Neural Networks and Their Applications
Chair: Helena S. Wisniewski

10:30 AM
B. Yoon
No abstract submitted

10:55
H. Szu
No abstract submitted

11:20
J. Barhen
No abstract submitted

11:45 AM
Dynamical Behavior of Feedback Networks Implemented in Analog Hardware

For neural networks to achieve their true potential they must be implemented in analog hardware. This is particularly true for feedback networks whose rich dynamic behavior provides a means of producing enormous gains in computation and decision speeds. Lessons learned from the implementation of feedback networks in hardware will be presented. In particular, a formalism has been identified which results in a system for which correct final states of the network are independent of prior initial conditions. This behavior is related to the analog nature of the components and indicates the importance of studying dynamics on real hardware.

William A. Fisher
Lockheed Palo Alto Research Laboratory
Org. 91-10, Bldg. 256
3251 Hanover Street
Palo Alto, CA 94304

12:10 PM
Neural Networks for Invariant Image Recognition

Neural networks offer a potential for technology innovation to provide a next-generation on-board processing capability in space-based systems for strategic defense and surveillance as well as other non-military space applications such as remote sensing of the environment. We describe a 1-D shape function method for coding of scale and rotationally invariant shape information. This method reduces image shape information to a periodic waveform suitable for coding as an input vector to a neural network associative memory. The shape function method is suitable for near term applications on conventional computing architectures equipped with VLSI FFT chips to provide a rapid image search and recognition capability.

THURSDAY, 10:30 AM

Sheldon Gardner
Naval Center for Space Technology
Naval Research Laboratory
Washington, D.C. 20375

12:35 PM

AN AUTOMATA NETWORK FOR VISUAL COGNITION: WHY DYNAMICS IS IMPORTANT

We have recently described a fully parallel automata network that attempts to synthesize model-based and data-driven approaches to visual cognition. The former method is exemplified by traditional "rule-based" schemes, and the latter by many neural net methods that learn directly from examples, and which are justified by an energy landscape picture whose minima ideally form stable attractors. To effect the synthesis, implications as well as correlations must be incorporated. This leads to a different picture than the energy landscape, and the behavior of the network is characterized by first passage and sojourn times in the neighborhood of desired configurations. Learning and processing in such networks can be developed in a unified way. This talk will present our findings on these issues, examples from image recognition, and will conclude with our view of the chief difficulties facing effective learning.

Dr. Raghu Raghavan, Lockheed R&DD, D-9740/B-202, 3251 Hanover Street, Palo Alto, CA 94304.

THURSDAY, MAY 10 - 10:30 AM-12:30 PM
Room: Azalea
Contributed Presentations 10
Control and Optimization
Chair: J. U. Kim

10:30 AM

Discrete Approximations for Nonlinear Optimal Control Systems

We consider optimal control problems for dynamical systems governed by ordinary differential equations with state constraints. In computer calculations such systems are usually replaced by finite difference control systems with discrete time. We regard discrete approximations as a process with decreasing time quantization period and study stability: convergence problems without any convexity assumptions. Constructive methods are proved for the perturbations of the state constraints so that value stability results and necessary optimality conditions in the form of the approximate maximum principle are fulfilled. The results obtained are used for the analysis of qualitative and numerical aspects of optimal control.

Boris S. Mordukhovich
Department of Mathematics
Wayne State University
Detroit, MI 48202

10:50 AM

Global Optimization with a Lattice Dynamical System

We describe a method for global optimization which uses a network of coupled discrete maps. The model used is "FRACTAL CHAOS" described in the book "DE Nouvelles Voies vers l' Intelligence Artificielle" by JC. Perez (Masson, Paris 1988). Each individual map can adapt itself to oscillate periodically or chaotically while the whole lattice can self-organize via the local adaptation and communication rules. These rules determine the global properties of the system such as its response to external perturbations. We discuss applications to the task assignment and traveling salesman optimization problems where the system is induced to dynamically explore the solution space. The simulations show that good solutions can be found quickly, reliably, and robustly.

Jean-Claude Perez IBM Montpellier
Jean-Michel Bertille CRIM Montpellier University
IBM France
European Competency Center in Artificial Intelligence.
Dept. 1510 B.P. 1021
34006 Montpellier Cedex
France

Jerry Magnan
Dept. of Mathematics and Supercomputer
Computations Research Center
Florida State University
Tallahassee, FL 32306
U.S.A.

11:10 AM

Robust Output Feedback and Observer Based Controller for Decentralized Interconnected Systems

A decentralized interconnected system is considered. It is assumed that a number of local subsystems are interconnected to a main system. The main system has an uncertain parameter and no direct control input. It is also assumed that the states of the local subsystems are not accessible. Two types of controllers, output feedback and observer based, are considered and in each case the control laws determined to give a less sensitive system response.

Rajab Challoo, Ph.D., P.E.
EE&CS Department
Campus Box 192
Texas A & I University
Kingsville, Texas 78363
Tel. (512) 595-2004
Edwin Sawan, Ph.D., P.E.
EE Department
Campus Box 44
The Wichita State University
Wichita, Kansas 67208
Tel. (316) 689-3415

11:30 AM
The Optimal Control of Pricing Problem

The formulation of an optimal control requires: A mathematical model of the process to be controlled, the system's constraints, and specification of a performance criteria. By considering the dynamic system and defining the hamiltonian, the necessary conditions for the optimization problem are given.

The singular control necessary conditions are expressed according to the Weierstrasse Erdmann conditions.

We present the control of linear system by two competitive controllers applied to the optimal control of Pricing Problem.

Dr. Moustafa El-Arabaty
53, El-Montaza Street, Heliopolis
Cairo, Egypt

11:50 AM
Innovative Control Design Methodologies: A Smart Structures/Neurocontroller Approach

Current interest in deploying large flexible space structures has focused attention on active control techniques to achieve advances in vibration suppression, pointing accuracy, and shape control. The extreme sophistication of these space structures, lack of accurate finite-element structural models, and more stringent requirements on performance, presents complex control and structural design challenges. The new and innovative controls and structures technologies that are presented in this paper can meet these challenges by capturing the fundamental tradeoffs that arise in control and structural design applications. Specifically, we present a methodology that integrates optimal fixed-structure and optimal neurocontroller approaches, with smart structure controller design using multisensor fusion (MSF) techniques, thus merging advanced controls-structures synergism. The key feature of this formulation is that multiple system (controller-structure) design goals, such as performance, robustness, and complexity are addressed within a common framework that effectively permits simultaneous treatment in terms of systematic tradeoffs. The systematic design procedure presented here results in high-performance, minimally complex, robust controller synthesis by utilizing a smart structure approach with innovative controller design methodologies.

Frederic M. Ham, Wassim M. Haddad and Samuel P. Kozaitis
Florida Institute of Technology
Department of Electrical and Computer Eng.
150 West University Boulevard
Melbourne, FL 32901-6988

THURSDAY, MAY 10 - 10:30 AM-12:30 PM
Room: Hybiscus
Contributed Presentations 11
Chaos and Turbulence
Chair: John Lavery

10:30 AM
Chaotic vortex-body interaction

It is shown, by using the Poincaré-Melnikov-Arnold method, that the motion of a linear vortex in the flow past a cylindrical body is chaotic. More general problems of vortex-body interaction are discussed qualitatively. Possible applications of the theory are indicated.

E. A. Novikov
Institute for Nonlinear Science, R-002
University of California, San Diego
La Jolla, California 92093

10:50 AM
An Experimental Study of Stability and Transition to Turbulence of Flow between Two Rotating Disks

The stability and transition to turbulence are investigated for a flow between two rotating disks with a small gap. Concentric and spiral cells are observed as a result of steady state bifurcations, depending critically on the Rossby number and weakly on the Reynolds number based on the gap width as the length scale and the relative wall speed as the velocity scale. The critical radii separating laminar, unstable and turbulent are found to be scaling function of the Reynolds number which takes into account the effects of gap-radius ratio and the disk speed ratio. The wavelength of these cells is equal to the gap width when only one disk is rotating or both disks are rotating, and a value of 2.5 the gap width when the disks are counterrotating. The secondary instabilities of the concentric cells are manifested by the cell waviness and the local cell splitting. For the spiral cells, cell bifurcations and localized size increased are observed prior to turbulence.

Prof. Anuvat Sirivat
Department of Mechanical Engineering
University of Pittsburgh
Pittsburgh, PA 15261

11:10 AM
Couette Flow of Granular Materials Spatio-Temporal Coherence and $1/f$ Noise

The Couette flow of granular material between parallel rough walls is studied numerically. When the gap is moderate the stresses are similar to the granular kinetic theory of Lun, et al. for a shear flow of infinite extent. For small gaps and high concentrations, stresses are found to be significantly smaller, but the ratio of shear to normal stress at the walls is only slightly reduced. At lower concentrations the power spectra of the stress fluctuations have the character of white noise. With increasing solids concentration, temporal correlations occur and we find $1/f$ noise frequency spectra. It is possible that this system may have some use as a "toy" turbulence model.

Stuart B. Savage
Department of Civil Engineering &
Applied Mechanics
McGill University
Montreal, Quebec H3A 2K6

11:30 AM
Upper Semicontinuous Global Attractors for Viscous Flow

Two of the profound open problems in the mathematical theory of three dimensional viscous flow are the unique solvability theorem for all time and the existence theorem for the global attractor. We have shown in our earlier studies that certain regularization of the Navier-Stokes equations are uniquely solvable (up to dimension six) and can be characterized by compact global attractors. A natural question then is to investigate the possibility of establishing such results for the conventional Navier-Stokes equations by a limit process. In this talk we will show that in two dimensions the attractor for the regularized system converges to the attractor of the conventional system as regularization parameter goes to zero. A far more restricted result is available for three dimensions.

Yuh-Roung Ou
ICASE
NASA Langley Research Center
Mail Stop 132C
Hampton, VA 23665

and

S. S. Sritharan
Department of Aerospace Engineering
University of Southern California
Los Angeles, CA 90089-1191

11:50 AM
Intermittency Corrections to Spectra of Temperature Fluctuations in Isotropic Turbulence

The purpose of this paper is to describe and compare the dissipative effects on the scaling laws of the Obukhov-Corrsin universal equilibrium theory as intermittency corrections formulated according to the following three models: (i) the log-normal model of Obukhov and Kolmogorov; (ii) the B-model of Frisch, Sulem and Nelkin, and (iii) the gamma model of Andrews, Phillips, and Shivamoggi.

Refs:
1. B.K. Shivamoggi, R.L. Phillips, and L.C. Andrews: J. Phys. A 22, 1253, (1989).
2. L.C. Andrews and B.K. Shivamoggi: Phys. Fluids, In Press, (1990).

Bhimsen K. Shivamoggi
Ronald L. Phillips and Larry C. Andrews
Department of Mathematics
University of Central Florida
Orlando, FL 32816

12:10 PM
Period Doubling Cascade to Chaos in Numerical Hydrodynamic Modelling of Stellar Pulsations

The nonlinear pulsational behavior of state of the art stellar model sequences (Population II Cepheids) undergo well understood period doubling cascades from regular pulsational behavior to chaos. Higher luminosity sequences display a textbook tangent bifurcation to chaos. By means of Floquet analysis it is shown that a half-integer resonance provides the mechanism which gives rise to the chaotic behavior. The occurrence of chaos is found to be very robust to numerical modelling as well as to the inclusion of time dependent convection.

On the basis of our numerical hydrodynamic modelling we conjecture that the observed irregular pulsations of some stellar types have their origin in an underlying deterministic chaotic dynamic.

J. Robert Buchler
Physics Department
University of Florida
Gainesville, FL 32611

THURSDAY, MAY 10 - 2:00-4:00 PM
Room: Tangerine A
Minisymposium 37
Fractal Time Dynamics
Chair: Michael Shlesinger

2:00 PM
PROBABILITY LIMIT DISTRIBUTIONS IN GLASSY DYNAMICS

The nature of relaxation in glassy, disordered materials is investigated via a transport model based on the extremely intermittent motion of defects. Even though the motion of a single defect is highly irregular, it is shown that the behavior of many defects is governed by a probability limit distribution. The overall relaxation is quite regular and follows the stretched exponential law. The divergence of the time scale in this law can be derived by examining the clustering of defects as the temperature is lowered towards the glass transition temperature.

Michael F. Shlesinger, Office of Naval Research Physics Division, 800 N. Quincy St., Arlington VA 22217.

2:30 PM
ON THE UBIQUITY OF 1/f NOISE

A generic mechanism for the ubiquitous phenomena of 1/f noise is reviewed. This mechanism arises in random processes expressible as a product of several randon variables. Under mild conditions this product form leads to a lognormal distribution which we show straightforwardly generates 1/f noise. Thus, 1/f noise is tied directly to a probability limit distribution. A second mechanism involving scaling is introduced to provide a natural crossover from lognormal to inverse power-law behavior and generates 1/f noise instead of pure 1/f noise. Examples are drawn from economics, scientific productivity, bronchial structure and cardiac activity.

Bruce J. West
Department of Physics
University of North Texas
Denton, Texas 76203
817/565-2630

3:00 PM
Avalanche Dynamics in a Droplet Growth Model with Sliding

What is the origin of the long-range spatial and temporal correlations that are commonly observed in open dissipative systems? The existence of a stationary state in a simple model of sand pile has prompted Bak, Tang and Wiesenfeld to propose that the type of scale-invariant avalanches that occur in the sand pile model might be related to the scaling and fractal behavior in other systems. We have investigated a model of droplet deposition, coalescence and avalanche. Our model may mimic processes such as the falling of dew on a cobweb or the flow of rain drops on a window pane. We begin by randomly adding droplets to a system and once a given droplet reaches a critical mass, it falls along a preferred direction in the system and in the process coalesces and removes all the droplets that it comes in contact with. We have used both lattice and off-lattice models and have investigated the basic dynamical features of the system. We find scaling behavior in some of the properties of the system, but no power law decay is observed in the auto-correlation function for mass transport. This suggests interesting differences between self-organized criticality in the sand pile model and the behavior of our model, which will be discussed.

Fereydoon Family, Department of Physics, Emory University, Atlanta, GA 30322

3:30 PM
Self-Organized Criticality: A Status Report

Self-organized criticality is the name given to a new behavior observed in models of spatially extended dynamical systems, wherein one observes spatial and temporal fluctuations of all sizes. Surprisingly, no parameters need be tuned to achieve the critical state; rather, it appears as an attractor of the dynamical rules.

Our present understanding of self-organized criticality is largely descriptive rather than predictive. Most of what we know is based on simulation of cellular automaton rules, which mimic simple (though nonlinear) diffusion processes. The talk will review the known facts, and highlight the unresolved issues that have emerged as fundamental.

Kurt Wiesenfeld
School of Physics
Georgia Institute of Technology
Atlanta, GA 30332

THURSDAY, MAY 10 - 2:00-4:00 PM
Room: Oleander B
Minisymposium 39
Dimensional Estimates and Extractions of Low Dimensional Models
Chair: Katepalli R. Sreenivasan

2:00 PM
Finite Dimensional Attractors, Inertial Manifolds, Weak Turbulence and Strong Turbulence

Recent results on low dimensional descriptions of a damped and driven nonlinear Schrodinger (NLS) equation, i.e., a Complex Ginsburg-Landau (CGL) equation, are presented. Attractor and inertial manifold dimensions are derived, establishing that the CGL equation is, asymptotically in time, a finite dimensional dynamical system. Rigorous estimates on various norms of the solutions show a qualitative difference between the modulationally stable and unstable regimes of the underlying NLS equation. In the unstable regime the NLS equation possesses self-focussing blow-up solutions. The remnants of these blow-up solutions appear to dominate the dynamics of the dissipative CGL equation, leading to the identification of strong turbulent behavior.

Charles R. Doering
Dept. of Physics and Inst. for Nonlinear Studies
Clarkson University
Potsdam, NY 13676

2:40 PM
On the Characterization of Complicated Phenomena by Low Dimensional Systems

The method of empirical eigenfunctions (Karhunen-Loeve procedure, Lumley's POD) may be shown to yield an optimal description of complicated phenomena based on a variety of criteria. For example this representation leads to the minimal representational entropy in the information-theoretic sense. This and other closely related function bases recommend themselves for use in low dimensional approximations to chaotic dynamical systems. Both the Galerkin procedure and its extension to approximate inertial manifolds (methods of slaved variables) then lead to substantially reduced systems. This will be discussed and illustrated within the framework of chaotic fluid flows and related model problem. Comparison of approximate and ideal dimension estimates will also be presented.

Lawrence Sirovich
Brown University
Center for Fluid Mechanics, Turbulence and Computation
37 Manning Street, Box 1966
Providence, RI 02912

3:20 PM
P. Constantin
No abstract submitted

THURSDAY, MAY 10 - 2:00-4:00 PM
Room: Tangerine B
Contributed Presentations 8
Control
Chair: John A. Burns

2:00 PM
Exact Internal Controllability of a One-Dimensional Aeroelastic Plate

In this paper, we show that a one-dimensional elastic plate with self-induced aerodynamic pressure can be controlled exactly with locally distributed control. The model discussed here is well-known in aeroelasticity. However, exact controllability has been proved for the first time in this paper. We employ the energy method combined with compensated compactness, which is a new tool in the theory of partial differential equations.

Jong Uhn Kim
Department of Mathematics
Virginia Polytechnic Institute & State University
Blacksburg, VA 24061

2:20 PM
On the Global Dynamics of Adaptive Control Systems

The standard structure of Adaptive Systems consists in a finite dimentional linear system with parameters continuously adjusted by an algorithm (the adaptation algorithm) which takes into account the signals generated by the system itself and certain overall desired behavior specified by the designer. Current examples of this kind of systems are adaptive control and output error adaptive identification schemes (see for instance Goodwin/Sin 1983).

The inherent non-linear dynamics of these systems with parametric feedback, poses serious theoretical problems that, for the moment (probably due to its intrinsic complexity), have not received enough consideration. However, from a practical point of view, a successful implementation is based on a thorough knowledge of the circumstances under which non-linear oscillations, abrupt transients, or even intermittency may occur.

Martin Espana
Centro Atomico Bariloche
8400 S.C. de Bariloche
Rio Negro, Argentina

2:40 PM
Quantum Mechanical Control Systems

This paper outlines some results recently obtained concerning quantum mechanical control systems. The relationship between classical and quantum control systems are discussed in the framework of the Lagrangian and Hamiltonian formalisms. The problems of constructing variational principles for a given second-order differential equation is considered. Approaches to the solutions of the problems of the general theory of control systems described by the equations of quantum physics are formulated and discussed.

En-Bing Lin
Department of Mathematics
University of Toledo
Toledo, OH 43606

3:00 PM
Morse Decomposition and Maximal Transitive Sets for Bilinear Control Systems

With every bilinear control system of the form

(1) $\dot{x}(t)=u(t)\,x(t)$, $x(0)=x_0 \in R^d$

(2) $u \in \mathcal{U} := \{u: R \to \Omega$, integrable $\}$,

where $\Omega \subset \mathbb{R}^{d\times d}$ is convex and compact, we associate the dynamical system on $R^d \times \mathcal{U}$ given by

$$(t,(x_0,u)) \to (x(t,x_0,u), u(t+\cdot)) \quad , \quad t \in R .$$

where $x(\cdot,x_0,u)$ is the solution of (1) corresponding to $u \in \mathcal{U}$. We prove that the induced dynamical system on $P^{d-1}\times\mathcal{U}$; P^{d-1}=(d-1)-dimensional projective space, possesses a finest Morse decomposition in the sense of C. Conley; under a Lie algebraic condition, also the topologically transitive sets of this dynamical system can be characterized. These decompositions are compared and their control theoretic meaning is clarified. This contribution is based on joint work with Wolfgang Kliemann.

Fritz Colonius
Institut für Mathematik
Universität Augsburg
D-8900 Augsburg
West Germany

3:20 PM
The Lyapunov Spectrum of Bilinear Control Systems

Control systems "are" dynamical systems over the space of admissible control functions with the usual shift. Their linearization, w.r.t. steady states, lead to bi-linear control systems, whose Lyapunov exponents can roughly be characterized using methods from dynamical systems: Oseledec's theorem, dynamical spectrum of Sacker, Sell et al al, Morse decompositions and their spectrum. The fine structure of the Lyapunov spectrum, however, is given through specific control theoretic constructions, which also shines a new light on the above mentioned approaches for dynamical systems. Applications to stabilization problems for nonlinear control systems will be outlined, including examples.

Wolfgang Kliemann
Dept. of Mathematics
Iowa State University
Ames IA 50011

Fritz Colonius
Inst. f. Mathematik
Universitat Augsburg
8900 Augsburg, FRG

3:40 PM

Stability of Large-Scale Discrete Dynamical Systems

Vector Liapunov functions are extensively applied to solve the problems of stability of large-scale dynamical systems. For discrete systems, however, previous work was limited to the applications of linear comparison equations. In this paper, a general approach to aggregate discrete nonlinear comparison equations is presented. Various criteria for discrete nonlinear equations to remain stable or asymptotically stable are developed. Among those, the criteria for (globally) asymptotic stability are not only sufficient, but necessary as well. All the criteria are merely of algebraic forms and can be applied to a great number of noncontinuous dynamical systems.

Shu Huang
Department of Computer Science
Southwestern Jiaotong University
Emei, Sichuan
614202
P.R. China

THURSDAY, MAY 10 - 2:00-4:00 PM
Room: Azalea
Contributed Presentations 12
Biological Oscillators
Chair: Bard Ermentrout

2:00 PM

Isolated Periodic Solutions and Analysis of Degenerate Hopf Bifurcation in the Hodgin-Huxley Model

This work uses the local techniques of degenerate Hopf bifurcation analysis to show the existence of periodic solutions of the Hodgkin-Huxley model, which is central in the theory of nerve conduction. The results confirm the existence of periodic solution branches not locally connected to the stationary branch. The "modal parameter," which determines such branches, is derived through Hopf bifurcation analysis and then shown to be consistent with values geometrically derived from numerically computed bifurcation diagrams. This work also suggests the presence of a higher order degeneracy when the modal parameter is 1. Two numerical techniques were used in following solution branches, locating and analyzing (non)degenerate Hopf bifurcation. Degeneracies are classified by singularity theory.

Lie June Shiau
Department of Mathematics
University of Houston-Clear Lake
Houston, Texas 77058

Brian Hassard
Department of Mathematics
SUNY at Buffalo
Buffalo, New York 14214

2:20 PM

Periodic Solutions in Models of Neuronal Excitability

Two models are developed to examine the contribution made to neuronal excitability by the coupling between ionic processes. The behavior and stability of the solutions of the models are studied with emphasis on understanding the dependence of solutions on the parameters. In both models, there exist parameter values for which Hopf bifurcations of periodic solutions occur. The global bifurcation structure of the models is examined using numerical techniques. For certain parameter values, the global bifurcation structure of one of the models is unexpectedly rich; unstable homoclinic and heteroclinic orbits exist alongside families of stable and unstable periodic solutions.

Ann M. Castelfranco
Dept. of Math. and Stat.
University of Minnesota
Duluth, MN 55812

2:40 PM

Collective Phenomena in Coupled Populations of Nonlinear Oscillators

We study the dynamics of large populations of coupled oscillators. These systems co-
nonlinear oscillators which are ... y
simple, but are coupled to...
exhibit more complex ...
phenomena we ...
phase ... ..., the
e... ...e effects of
ra... ...ms provide simplified
mo... ...l oscillator networks in the
hea... ., etc. and are also useful in
mode...ing charge-density wave systems in solid state physics.

Cancelled

Renato Mirollo
Boston College
Department of Mathematics
Chestnut Hill, MA 02167

Steven Strogatz
M.I.T.
Department of Mathematics
Cambridge, MA 02139

3:00 PM

Collective Dynamics of Oscillator Networks

Large networks of nonlinear oscillators can exhibit remarkable collective phenomena, including mutual entrainment. and phase transitions. " tractable models. ˉ applicationᵉ· ˉworks of biologⁱ˙ ..yed depinning oᶠ ˎ .. Mirollo.)

cancelled

St . Strogatz
De... of Mathematics
MIT
77 Massachusetts Ave.
Cambridge, MA 02139

2:40 PM

Long Distance Coupling in a Chain of Oscillators as a Model of the Lamprey Spinal Generator for Swimming

Previous work which modelled the lamprey spinal generator for swimming as a chain of coupled oscillators (Cohen, Holmes and Rand; Ermentrout and Kopell) is extended by the addition of long distance coupling between oscillators. The system of ordinary differential equations of the model is linearized around a uniform travelling wave solution. This linearization is used to describe deviations from a uniform travelling wave which appear as connections between oscillators are detuned. Qualitative distinctions are made between coupling schemes based on the precision of tuning they require in order to produce an approximately uniform travelling wave of the appropriate wavelength.

Tim Kiemel
Center for Applied Mathematics
Cornell University
Ithaca, NY 14853

3:00 PM

Singular Perturbation Analysis of a Neuron Model

The nonlinear response of the membrane of nerve cells to external excitation is crucial to the production and propagation of electrical impulses. In the process of interneural communication, bursts of oscillations of the potential difference through the membrane codify the information flow. In this talk, I discuss some differential equation models of the Hodgkin a Huxley type capable of producing bursts of signals combinations of averaging and quasi-static stat approximations, as well as numerical computations to understand the mechanisms of bursting phenomena.

Humberto Carrillo
Departamento de Matematicas
Facultad de Ciencias, UNAM
Mexico, D.F., 0410

THURSDAY, MAY 10 - 2:00-4:00 PM
Room: Hybiscus
Contributed Presentations 13
Integrable Systems
Chair: Jacques Belair

2:00 PM

Integrability Aspects of the Lorenz Equations

By using the Painleve condition, Segur[1] and Tabor and Weiss[2] determine certain special values of the parameters of the Lorenz systems for which the latter is integrable. The purpose of this paper is to present a more general formulation on this aspect which contains the results of Segur[1] and Tabor and Weiss[2] as special cases. This is accomplished by looking at the general class of solutions for which $b = 2\sigma$ (here σ is the Prandtl number and b is some physical dimension of the region under consideration).

1. H. Segur: In lectures given at the International School of Physics "Enrico Fermi", Varenna, Italy, (1980).

2. M. Tabor and J. Weiss: Phys. Rev. A 24, 2157, (1981).

Bhimsen K. Shivamoggi and Ram N. Mohapatra
Department of Mathematics
University of Central Florida
Orlando, FL 32816

2:20 PM

Geometric Asymptotics and Hannay-Berry Phases for Dynamical Integrable Systems and their Applications

The Method of Geometric Asymptotics was first introduced in 2- and 3-dimensional case by Keller and Rubinow to explain whispering gallery phenomenon of acoustics and to describe the interior wave conductor.
The present work describes a genera' hod for constructing geometric asymptotiᶜ iamical Integrable Systems as functioᶜ complex variables on the Jacobian ˉ 'ulti-sheeted Riemann surfacᶜ case is obtained from the ᵉ˙ .ns. As a result of a speᶜ .ction billiard sys' , the integrable problems and diffracted modes ..g gallery modes, are obᵗ .sional case. These modes .estigation of the geometric .tion.
.ay-Berry phases are found for the p. .ed families of nonlinear Integrable Sy. .s.

cancelled

Mark S. Alber
Department of Mathematics
University of Pennsylvania
Philadelphia, PA 19104-6395

2:20 PM

Chaotic Numerics from an Integrable Hamiltonian System

We investigate the dynamics of the map E obtained by applying Euler's method with stepsize h to the central force problem. We show that for any positive h, the nonwandering set of E contains a subset on which the dynamics of E are topologically semi-conjugate to a subshift of finite type. The subshift has positive topological entropy, hence so does E. Thus we get chaotic numerics independent of our choice of stepsize. This behavior contrasts sharply with that of the central force problem which is well known to be completely integrable.

Kevin G. Hockett
Department of Mathematics
George Washington University
Washington, DC 20052

3:00 PM
Applications of Integrable Dynamical Systems to Numerical Analysis

Cancelled

There were a lot of attempts to find limit
continuous approximations for integrab' ices.
In particular, the Boussinesq equ' te-
weg-de Vries equation were e' ing
systems for the usual T t-
tice was used as a e
equation of s
associat
sys
imilar
on. This approach
e eper link between
co. e problems. In particular,
hie ontinuous systems associated with
Volt tices, Toda lattices and relativistic
Toda lattices are found as limit continuous
approximations.

Solomon J. Alber
Department of Mathematics
University of Pennsylvania
209 South 33rd Street
Philadelphia, PA 19104-6395

2:40 PM
Chaotic Scattering in Several Dimensions

For chaotic scattering in two-degree-of-freedom ($N = 2$), time-independent, Hamiltonian systems, scattering functions (i.e., plots of the dependence of a phase space variable after scattering versus a phase space variable before scattering) typically display singularities on a fractal set. For $N > 2$, however, scattering functions typically do not have fractal properties (even when the chaotic invariant set is fractal), unless the fractal dimension of the chaotic set is large enough. A numerical investigation of this phenomenon is presented for a scatterer consisting of four reflecting spheres at the vertices of a regular tetrahedron.

Qi Chen, Mingzhou Ding, and Edward Ott
University of Maryland
College Park, MD 20742

Moved to Contributed Session 1, Mon. 10:30 AM
Analytical Models for Phase Transition

We will present several models where the phenomena of phase transition happen. It is known that certain materials present magnetic properties at low temperature. It is also observed that there exists a transition value of the parameter temperature where suddenly the magnetization occurs. Sometimes more than one equilibrium state can coexist in the transition value of temperature. We use thermodynamic formalism, entropy, pressure and spectrum of dimension to analyze the above physical problems.

Complex analysis and ergodic theory are essentially used to derive rigorous and precise results on the critical exponent of transition, as considered in the physics literature by Felderhof, Gaspard and Wang.

Artur O. Lopes
Institute for Physical Science and Technology
University of Maryland
College Park, MD 20742

THURSDAY, MAY 10 - 2:00-4:00 PM
Room: Jasmine
Contributed Presentations 14
Applications 3
Chair: Terry Herdman

2:00 PM
An Iterated Function Systems Approach to LMS Filtering and Noise Reduction

One of the main problems in signal detection is that of modeling an unknown background. Previous models assume knowledge of the statistical properties of the background, such as power spectra, or the existence of a given length scale based upon some correlation. The work presented applies iterated function systems (IFS) to the problem of matched filter design and noise reduction. It will be shown that the techniques implicitly model unknown backgrounds that are either scale invariant, such as fractal backgrounds or smooth backrounds. No statistical information is required apriori.

Ira B. Schwartz
U S Naval Research Laboratory
Code 6522
Washington, DC 20375-5000
and
Laurie Reuter
George Washington University
Dept. EE and CS
Washington, DC 20052

2:20 PM
Preliminary Concepts in the Use of Chaotic Nonlinear Dynamics to Model Random Behavior in Signal Processing Applications

Traditional signal processing techniques normally apply stochastic process theory to account for the inability to predict, control, or reproduce precise results in repeated experiments.

This often requires fairly restrictive assumptions (e.g. linear and Gaussian) regarding the nature of the processes generating the signal source and its contamination. Our purpose is to provide a preliminary analysis of an alternative model to account for this random behavior. The alternative model assumes that the signal and contaminating processes have been generated by dynamical systems exhibiting possibly chaotic behavior. This provides the option to use nonlinear dynamic estimation methods instead of traditional statistical modeling.

William W. Taylor, Ph.D.
The RTA Corporation
5613 Artesian Drive
Rockville, MD 20855
301-590-0949

2:40 PM
Dynamics of Pulses in Birefringent Optical Fibers

Approximate Hamiltonian dynamics are derived for soliton-like pulses propagating in a weakly birefringent nonlinear optical fiber. The approximate dynamics are low-dimensional ODE approximations to the coupled nonlinear Schrödinger equations describing the evolution of the pulse envelopes; note the latter are infinite-dimensional Hamiltonian systems. From the simplified equations, obtained with perturbation and variational methods, we present some of the interesting dynamics of the coupled system, and explain how the nonlinear coupling between the polarization modes affects the propagation of electromagnetic energy along the optical fiber. In addition, to verify the accuracy of the approximations, we give comparisons with numerical simulations of the equations.

David J. Muraki
Tetsuji Ueda
William L. Kath

Department of Engineering Sciences and Applied Mathematics
McCormick School of Engineering
Northwestern University
Evanston, Illinois 60208

3:00 PM
A Model for Radially Symmetric Phase Transitions

One process for the manufacture of superconducting wire involves 3-phase diffusion of material at relatively low temperatures. A model is presented which describes the time behavior of the interface locations and predicts depletion times.

Kenneth A. Heimes
Department of Mathematics
Iowa State University
Ames, IA 50011

3:20 PM
Global Instability and Pattern Formation in Dendritic Solidification of a Dilute Binary Alloy

This work is concerned with the global instability mechanisms of solidification from a dilute binary alloy. The results obtained in the present paper show that the interfacial wave theory previously developed for dendritic solidification from a pure substance can be extended to the binary alloy system in a very similar form; the binary alloy system also permits a discrete set of unstable Global Trapped Wave (GTW) modes, which describe the characteristics of waves trapped in the region between the tip point and a special turning point. We obtained the uniformly valid asymptotic expansions and the quantum conditions of corresponding eigenvalues for these global modes; The self-sustaining GTW-mode in the binary alloy system is calculated, which explains the origin and persistence of the dendritic microstructure in solidification; the Global Neutral Stability (GNS)-condition selects the tip-velocity of dendrite.

Dr. Jian-Jun Xu
Department of Mathematics and Statistics,
McGill University
Montreal, Quebec,
Canada H3A 2K6

3:40 PM
On the Dynamics of Fine Structure in One Dimension

We investigate models which are Euler-Lagrange equations, with additional dissipative terms, and whose underlying potential energy functions possess minimizing sequences with arbitrarily fine structure. The models are of interest as examples of dissipative dynamical systems with infinitely many unstable equilibria that can display sensitive dependence on initial conditions, and as cartoons of the dynamical development of fine structure which is observed in certain phase transformations. Full details are in J.M. Ball, P.J. Holmes, R.D. James, R.L. Pego and P.J. Swart [1990] (in preparation), "On the Dynamics of Fine Structure".

Pieter J. Swart
Center for Applied Mathematics
Sage Hall 305
Cornell University
Ithaca, NY 14853

THURSDAY, MAY 10 - 2:00-4:00 PM
Room: Lemon-Lime
Contributed Presentations 15
Chair: Joseph Mahaffy

2:00 PM
Periodic Structures in A Reaction-Diffusion System with Diffusion Instability

Spatially and temporarily periodic structures in a fourth-order reaction-diffusion system with diffusion instability, where the diffusion is governed by the Cahn-Hillard's law, is studied by bifurcation theory. Techniques of singularity and group theory are applied to analyse the problem. Previous studies on bifurcations of reaction-diffusion systems are mostly based on second-order systems with diffusion instability. Consequently, our results will present a new mechanism forming periodic structures in dissipative systems and reveal the complexity and versatility of reaction-diffusion phenomena.

Q.S. Lu and C.W.S. To
Department of Mechanical Engineering
The University of Western Ontario
London, Ontario, Canada N6A 5B9

2:20 PM

Asymptotic Behavior of Strongly Monotone Time-Periodic Dynamical Processes with Symmetry.

We consider a time-periodic, spatially independent, irreducible cooperative system of n reaction-diffusion equations
$\partial u/\partial t = D(t)\Delta u + F(t,u)$ for $(t,x)\in R^1_+ \times R^N$
with spatially periodic boundary conditions in R^N with an initial distribution u_0 which belongs to the Banach lattice V of all continuous maps $f: R^N \to R^n$ satisfying the boundary conditions. Let $T: V \to V$ denote the corresponding Poincaré (period) map. We prove that the ω-limit set $\omega(u_0)$ of every stable point $u_0 \in V$ consists of spatially constant maps only, and if also n=1 or 2, then $\omega(u_0)$ is a single fixed point of T. The dynamics on $\omega(u_0)$ is given by the system of ODE's
$du/dt = F(t,u)$ for $t\in R^1_+$.

The set of all unstable points $u_0 \in V$ is contained in a union of at most countably many Lipschitz manifolds of codimension one in V. We treat also more general strongly monotone processes with spatial symmetry. No large diffusivity is assumed.

Peter Takáč
Mathematics Department
Vanderbilt University
Nashville, TN 37235

2:40 PM

Omega and Alpha Limit Sets Under Discretisation

The effect of time-discretisation on the ... and alpha limit sets of autonomous d... is studied. The approach ... crete problem as ... by the ti... ti...

Cancelled

... of ... theory is ... numerical methods ... do not possess a particular ... solution is identified.

Andrew Stuart,
School of Mathematical Sciences,
University of Bath,
Bath, BA2 7AY,
U.K.

2:40 PM

Numerical Approximation of Invariant Tori

We consider the problem of computing a smooth invariant manifold for finite dimensional dynamical systems. We assume that the manifold is parametrized over a torus in terms of a subset of the system variables. Our approach then involves solving a PDE system subject to periodic BCs. In this talk we focus on some of the numerical aspects of this approach and briefly compare it to other existing ones.

Luca Dieci, School of Mathematics, Georgia Institute of Technology, Atlanta, GA 30332

3:00 PM

Absorbing Sets and a Global Attractor for a Reaction-Diffusion System from Climate Modeling

We study a weakly coupled system of quasilinear autonomous strongly parabolic equations on the two-sphere which arises from an energy balance climate model.
The system generates a global solution semiflow in the positive cone of some fractional order Sobolev space. We find a family of absorbing order intervals, and establish the existence of a connected global attractor.
Such results provide some insight into the long-term behavior of the terrestrial climate system.

Georg Hetzer & Paul G. Schmidt
Division of Mathematics
Department of Foundations, Topology and Analysis
Auburn University, AL 36849-5310

3:20 PM

An Explicit Procedure for Solution of Dynamical Systems

An algorithm is presented using the decomposition method and its recent developments to solve initial or boundary-value problems involving partial differential equations. The method has significant advantages in obtaining physically realistic solutions for nonlinear dynamical systems without restrictive assumptions. A specific example will show explicit procedures.

G. Adomian
Center for Applied Mathematics
University of Georgia
Athens, Georgia 30602

THURSDAY, MAY 10 - 4:30 - 6:30 PM
Room: Tangerine B
Minisymposium 40
Understanding Biological Dynamics
Chair: Michael C. Mackey

4:30 PM
L. Glass
No abstract submitted.

5:00 PM
Initiation of Ventricular Fibrillation in the Heart Caused by a Non-Linear Response to Electrical Stimulation

Ventricular fibrillation is a cardiac arrhythmia responsible for over 300,000 deaths annually in the United States. By recording simultaneously from 120 electrodes placed on the hearts of animals, we followed the spread of the excitation impulse across the heart immediately after a large electrical stimulus was given to induce fibrillation. The potentials created at these same electrodes by the large stimulus were also recorded and used to calculate the potential gradient field by a finite element method. The impulses leading to fibrillation formed rotors that spiraled about critical points formed by the intersection of a certain critical value of stimulus potential gradient with a certain critical value of the state of the cardiac cells. Thus, fibrillation was initiated by a non-linear response forming a critical point in this two phase dynamical system.

Raymond E. Ideker, M.D., Ph.D., David W. Frazier, M.D., William M. Smith, Ph.D.

Departments of Medicine and Pathology, Duke University Medical Center, Engineering Research Center for Emerging Cardiovascular Technologies, Duke University, P. O. Box 3140, Durham, North Carolina, 27710.

5:30 PM
A SYMMETRY BREAKING MODEL THAT REGULATES OVARIAN FOLLICLE DEVELOPMENT

A nonlinear system of differential equations is proposed to explain the mechanism that regulates the number of ovarian follicles that mature to ovulation in each higher vertebrate cycle. The assumption of follicle interaction through circulatory feedback leads to a special type of many body problem not generally studied in physics, chemistry or engineering. The model satisfies Lipschütz's Law of Follicular Constancy and for certain choices of parameter values, produces solutions that correspond to pathological non-ovulatory states. The model also suggests an important physiological function for the large number of follicles that atrophy and disappear from the ovary in each cycle.

Michael Lacker M.D., Ph.D.
Departments of Biomathematical Sciences and
Physiology & Biophysics
Mount Sinai School of Medicine,
The City University of New York
One Gustave L. Levy Place
New York, New York 10029-6574

6:00 PM
DYNAMICS OF SCROLL WAVE FILAMENTS

A summary of recent work to understand the dynamic behavior of scroll wave filaments in excitable chemical and biological media is given. Some of the analytical results and corresponding experimental tests of the theory are described. In addition, some predictions of the behavior of filaments with complicated topology, including helices and knots, are given. Applications of the theory for the motion of vortex filaments in an ideal fluid are also described.

James P. Keener
Dept. of Mathematics
University of Utah
Salt Lake City, Utah 94112

THURSDAY, MAY 10 - 4:30-6:30 PM
Room: Jasmine Room
Minisymposium 41
Computer Programs for Dynamical Systems
Chair: Hoseyin Kocak

4:30 PM
E. G. Doedel
No abstract submitted

5:10 PM
J. Guckenheimer
No abstract submitted

5:50 PM
J. A. Yorke
No abstract submitted

(Addition: Poster Sess. Mon. 3:30 PM)
Quantum Ergodicity: A Numerical Test of a Recent Conjecture

Recently the conjecture has been made that a quantum system having discrete spectrum is "ergodic" if the corresponding eigenvalues are real numbers independent on the rationals. Testing analitically such a conjecture appears to be very difficult. In the present work a method is devised to carry out such a test, obviously in an approximate way, by numerical computation. The technique is presented together with an application to the study of the spectrum of the "quantum baker transformation". Results are in agreement with the conjecture but, clearly, much more work needs to be done to reach a satisfactory substantiation.

Paolo Bellomo, Antonio Scotti, Fabio Zanzucchi
Dept. of Physics, Univ. of Parma, Parma, Italy
43010

THURSDAY, MAY 10 - 4:30 - 6:30 PM
Room: Hybiscus
Minisymposium 42
Fractals in Fluids
Chair: Celso Grebogi

4:30 PM

Experiments on Turbulence at Low Reynolds Numbers

To study turbulence it is of value to measure the instantaneous velocity difference $\delta V(R)$ at points in the fluid separated by a distance R. We used a novel homodyne light scattering (HLS) scheme for measuring its average value of $(\delta V(R))$, and compare our results with those obtained using Laser Doppler Velocimetry (LDV). The LDV scheme, which requires invoking the Taylor frozen turbulence assumption to obtain $(\delta V(R))$, gives very different results than the homodyne method at low Reynolds numbers. The scaling behavior of grid-generated turbulence and Couette flow have been studied.

Walter I. Goldburg and H. K. Pak
Department of Physics and Astronomy
University of Pittsburgh
Pittsburgh, PA 15260

5:00 PM

Fractal Mesures of Passively Convected Scalar Gradients in Chaotic Fluid Flows

The passive convection of scalar functions by a prescribed incompressible fluid flow $\mathbf{v}(\mathbf{x},t)$ is considered for the case where $\mathbf{v}(\mathbf{x},t)$ is chaotic. By chaotic $\mathbf{v}(\mathbf{x},t)$ it is meant that typical nearby fluid elements diverge from each other exponentially in time. It is shown that in such cases, as time increases, the gradient of a convected scalar will generally concentrate on a set which is fractal.[1] At the same time the power spectrum of the spatial autocorrelation function of the passive scalar will exhibit a characteristic dependence on wavenumber. The present work relates the stretching properties of the flow to both the resulting fractal dimension spectrum of the gradient as well as to the wavenumber dependence of the power spectrum of the autocorrelation function.

1. Edward Ott and Thomas M. Antonsen Jr., Phys. Rev. Lett. **61**, 2839 (1988) and Phys. Rev. A **39**, 3660 (1989).

Thomas M. Antonsen, Jr.
Laboratory for Plasma Research
University of Maryland
College Park, MD 20742

5:30 PM

Fractal Characterization of Cloud Radiance

The graph of radiance against angle at fixed time displays variations in the intensity of light emitted from the corresponding visible part of a cloud. The radiance dependence is naturally modeled as that of a random process. If clouds possess spatial fractal structure, we should expect this to be reflected in statistical properties of radiance data. We describe a possible fractal-based approach to modeling such processes; we also describe the Navy Background Measurement and Analysis Program (BMAP) field tests, from which infrared radiance data of this kind are obtained, and we give some results of fractal analysis of these data.

Patricia H. Carter
Robert Cawley
Information and Mathematical Sciences Branch
Naval Surface Warfare Center
Silver Spring, MD 20903-5000

6:00 PM

Fractal Structure in the Dispersal of Aerosols and Bubbles in Fluids

For very small particles in a flowing fluid it is a useful approximation to treat them as if they were simply convected with the fluid, $d\vec{x}/dt = \vec{v}(\vec{x},t)$, where $\vec{x}$ is the particle position and $\vec{v}$ the fluid velocity. For larger particles, however, we must include the effect of inertia, buoyancy, Stokes' drag and gravity forces. The trajectories then obey a more complicated system of equations than $d\vec{x}/dt = \vec{v}(\vec{x},t)$. This more complicated system can display typical dissipative chaotic phenomena. In particular, we discuss the conditions under which the presence of strange attractors in this system means that the concentration of particles in physical space can be restricted to a fractal.[1]

1. L. Yu, C. Grebogi and E. Ott, to be published.

Celso Grebogi
Laboratory for Plasma Research
University of Maryland
College Park, MD 20742

THURSDAY, MAY 10 - 4:30 - 6:30 PM
Room: Lemon-Lime
Minisymposium 43
Lie and Differential Algebraic Methods in Accelerator Physics
Chair: Alex J. Dragt

4:30 PM
Overview of Mapping Methods in Accelerator Physics

The action of any beam-line element in an accelerator or charged particle beam transport system can be described by a map. The overall map for a complicated composite system can be found by multiplying together the maps for the individual elements comprising the system. Once the overall map is found, the behavior of the composite system can be studied by bringing the overall map to a normal form.

An overview is given of how maps may be parameterized, computed, multiplied, and manipulated. Some attention is also devoted to evaluating the repeated action of maps on phase space and the long-term behavior of a dynamical system.

Alex J. Dragt
Physics Department
University of Maryland
College Park, Maryland 20742

5:10 PM
The Use of Maps in Circular Accelerators

In accelerator physics the motion of a single particle is controlled by a very complex Hamiltonian. The analysis of the resulting motion is facilitated by introducing the concept of finite time maps between the surfaces of section under study. When dealing with a periodic system, we often want to understand and parametrized the quasi-invariants on which the motion takes place. In this talk, we will show how this forces us to use certain Lie parametrizations of the map. In particular, we will explain how the Differential Algebra tools of Berz can be used to extract different Lie representations of a complex system for analysis and tracking simulation.

Etienne Forest and John Irwin
47-112
Lawrence Berkeley Laboratory
1 Cyclotron Road
Berkeley, CA 94720

THURSDAY, MAY 10 - 4:30 - 6:30 PM
Room: Tangerine A
Contributed Presentations 16
Modeling, Prediction, and Chaos
Chair:

4:30 PM
Weak Turbulence in Coupled-Map Lattices

Weak turbulence refers to an important intermediate state beteen a nonlinear flow with a few degrees of freedom and fully developed tubulence. The Problem addressed here is how to describe the spatio-temporal intermittent regime of weak turbulence quantitatively. One method involves an arbitrary cutoff, defining the flow to be turbulent if the fluctuations of the flow exceed the cutoff. This leads to a description in terms of percolation theory. We suggest another route based on a direct measurement of the velocity field and its spatial derivatives. We consider a coupled-map lattice, identify a coherence lengh, and determine its scaling properties.

*Dimitris Stassinopoulos *Greg Huber and $ Preben Alstrom

*Department of Physics, Boston University
Boston,Ma 02215, U.S.A.

$University of Copenhagen, Universitetparken 5,
DK-2100 Copenhagen Ø, Demmark

4:50 PM
Sudden Change in Size of Chaotic Attractor: How Does it Occur?

For an interior crisis, there is a sudden increase in the size of the chaotic attractor as the parameter passes through a critical value. This means that the number of unstable periodic orbits increases suddenly at the crisis. We show that the incremental portion of the chaotic attractor comes from an already existing strange saddle that collides with the attractor at the crisis. We investigate the origin and evolution of this strange set and, in particular, we show that the new unstable periodic orbits come from this strange saddle formed for parameter values before the crisis.

Yingcheng Lai and Celso Grebogi
Laboratory for Plasma Research
University of Maryland
College Park, MD 20742

James A. Yorke
Institute for Physical Science and Technology
University of Maryland
College Park, MD 20742

5:10 PM
Transition to Chaotic Scattering

This paper addresses the question of how chaotic scattering arises and evolves as a system parameter is continuously varied starting from a value for which the scattering is regular (i.e. not chaotic). We show that the transition from regular to chaotic scattering can occur via a saddle-node bifurcation, with further qualitative changes in the chaotic set resulting from a sequence of homoclinic and heteroclinic intersections. Observable consequences related to qualitative changes in the chaotic sets are also discussed. The main results of the papers are drawn from numerical experiments. Attempts to make the results more rigorous will be discussed.

Mingzhou Ding
Lab. for Plasma Research and Dept. of Physics

Celso Grebogi
Lab. for Plasma Research

Edward Ott
Lab. for Plasma Research and Dept. of Physics and Dept. of Electrical Engineering
James A. Yorke
Institute of Physical Science and Technology and Dept. of Mathematics
University of Maryland, College Park, MD 20742

5:30 PM

Quantifying Local Predictability in Phase Space

The Lyapunov exponents and the local divergence rates (LDR's) measure predictability by quantifying the behavior of adjacent trajectories in phase space. The LDR's quantify short-term predictability as a function of time and phase space position; the exponents are long-time averages of the LDR's. The LDR's are computed for chaotic attractors of the classic Lorenz system and for several low-order atmospheric general circulation models. The variability of local predictability is summarized using traditional probability distributions. More significantly, the local predictability is shown to exhibit an organized phase-spatial structure which, in some cases, allows a forecast of forecast skill to be provided.

Dr. Jon M. Nese, Assistant Professor
Department of Environmental Sciences
Penn State Beaver Campus
Brodhead Road
Monaca, PA 15061

5:50 PM

Modeling and Prediction with Low-dimensional Representations of Nonlinear Dynamic Processes

Parametric models derived from nonlinear times series data are typically based on prespecified functional forms or on series expansions, such as the Volterra series. When estimating the latter, one often imposes certain smoothness restrictions, to obtain finite-dimensional parameter spaces.

Here we propose alternatives to reducing the parameter space for Volterra-type expansions by employing singular value decomposition techniques and empirical Bayesian methods and demonstrate their application to nonlinear forecasting problems.

Stefan Mittnik
Department of Economics
State University of New York
Stony Brook, NY 11794-4384

6:10 PM

Estimation of Lyapunov Exponents Using a Semi-discrete Formulation

This presentation details an efficient method of estimating the Lyapunov spectrum of continuous dynamical systems. The standard procedure for the averaging of local convergence and divergence rates of trajectories near an attractor involves the linearization of the vector field near the test trajectory. The developed technique, based on Lie series expansions of the flow, can be readily implemented to yield very accurate estimates for the Lyapunov exponents of dynamical systems governed by a system of ordinary differential equations.

Joseph S. Torok
Department of Mechanical Engineering
Rochester Institute of Technology
Rochester, NY 14623

THURSDAY, MAY 10 - 4:30 - 6:30 PM
Room: Azalea
Contributed Presentations 17
Applications 4
Chair: Terry Herdman

4:30 PM

Dynamics of a Suspended Railway Axle.

We consider the motion of an axle of a railway car moving with constant speed on a straight, level track. Above a certain speed the axle oscillates in the plane of the track perpendicular to the track center line. The phenomenon is called hunting.
The problem is often linearized and solved, but due to the strongly nonlinear wheel-rail force relationship a full nonlinear analysis is necessary in order to explain the phenomenon of hunting.
We present a bifurcation diagram with the speed as the control parameter and show evidence of chaotic motion through projections of numerically computed trajectories, Poincare maps and Lyapunov dimensions. The transition to chaos occurs in connection with period doublings.

Hans True, Rasmus Feldberg and Carsten Knudsen
MIDIT and LAMF, The Technical University of Denmark, Lyngby, DK-2800 Denmark.
Telephone (4542) 88 36 99, ext. 4316.

4:50 PM

Power Flow In Coupled Mechanical Systems: New Results Using M-Matrix Theory

It is well known from thermodynamics that energy flows from hot objects to cold objects. It is less well known however, that a similar phenomenon occurs in coupled mechanical systems with modal energy playing the role of temperature. Energy flow amoung coupled modes is the subject of Statistical Energy Analysis (SEA). Originally motivated by problems in acoustics involving numerous vibational modes, SEA is based upon equations governing energy flow among individual modes or sets of modes. Such energy flow equations can be useful in modeling the response of lightly damped structures. In this paper we derive a generalized theory of energy flow which allows arbitrary coupling of arbitrary strength. Previous theoretical results were limted to either identical couplings or weak interactions. These new results utilize Kronecker matrix algebra to derive an energy flow equation involving the diagonal elements of the solution to a Lyapunov equation. The analysis of the equations uses the M-Matrix theory.

THURSDAY, 4:30 PM

David C. Hyland and Dennis S. Bernstein
Harris Corporation
Government Aerospace Systems Division
MS 22/4842
Melbourne, FL 32902

5:10 PM
Dynamics of Cross-Flow-Induced Vibrations of Heat-Exchanger Tubes Impacting on Loose Supports

The chaotic dynamics of heat exchanger tubes impacting on the generally loose baffle plates, beyond the critical flow for the flow-induced negative-damping Hopf bifurcation is studied with an analytical model involving delay differential equations. Numerical solutions show that, with increasing flow beyond the critical, the system suffers period-increasing bifurcations, leading to chaos. To better understand the system behavior, an impacting, one-degree-of-freedom, forced, negative-damping oscillator is studied. The response is quite complex and results in chaos for certain parameter ranges. The analysis is performed by finding periodic solutions and determining their stability with the Poincaré map technique.

G.X. Li and M.P. Païdoussis
Department of Mechanical Engineering
McGill University
817 Sherbrooke Street West
Montreal, Québec H3A 2K6 Canada

5:30 PM
Effect of Joint Flexibility on the Motion of a Flexible-arm Robot

Once flexibility is introduced into the arm-joint of the robot, severe problems in the accuracy and stability are likely to occur. In this paper, the behaviour of a three degree of freedom joint-arm robot is studied. The two variable expansion perturbation method is used to show the existence of various nonlinear resonances and to arrive at approximate closed form solutions. Numerical simulation concurs with the analytical results for small motions.

Tarunraj Singh
M. Farid Golnaraghi
Rajendra N. Dubey
Department of Mechanical Engineering
University of Waterloo
Waterloo, Ontario, Canada
N2L 3G1

5:50 PM
Simulation of Constrained Mechanical Systems Using Bond Graph Techniques

This paper shows the use of the BONDYN program for the simulation of dynamical systems, with particular application to mechanical systems. This program is based on bond graph theory and provides a means for treating dynamical systems that simultaneously include various physical domains.

The first part of the paper shows how it is possible to model multibody systems using bond graph representation of a rigid body and modelization of kinematical constraints are also included.
Some particular features concerning the equations obtained and the integration method used by the program are indicated.

To conclude, an example including simulation results is described so as to illustrate the accuracy of the program and the proposed method.

Felez, J. & San Jose, I.
Aragon Institute of Technology
Maria De Luna, 8
50015 Zaragoza
Spain

6:10 PM
Bond Graph Simulation of Flexible Multibody Systems

Computer simulation of controlled mechanisms is usually developed analysing separately all the different problems concerning the study. On the one hand, the kinematic and dynamic behavior of the mechanism is simulated considering the bodies as rigid bodies.

On the other hand, eigenvalues and eigenvectors of structural elements are also analysed. Control is studied with the results obtained from the previous results.

The separate development of these studies involves an important time cost and a losening of reliability for the model analysed. In this paper, a method based on bond graph technique is introduced in order to solve this problem. The method allows to model together the highly nonlinear behavior of mechanical systems, their structural flexibility and system control. The algorithm developed shows how it it possible to include the flexibility of the structure in multibody systems. Finally, several cases are analysed showing the advantages of the proposed method.

Vera, C. & Buil, F.
Aragon Institute of Technology
Maria De Luna, 8
50015-Zaragoza
Spain

THURSDAY, MAY 10 - 4:30 - 6:30 PM
Room: Oleander B
Contributed Presentations 17a
Session on Late Contributions
Chair: David Green

4:30 PM
An Approximate Stress Field Equations For The Solutions of Arbitrary Oriented Cracks

Dynamic systems consisting of shafts and spindles are susceptible to structural failure where cracks may develop in an arbitrary fashion. Existing stress field equations have significant limitations to address the type of problems. Sneddon's solution does not provide closed form results; asymptotic solutions yield greater percent of error and William's solutions are difficult to generate with higher order terms under specific boundary conditions and geometric considerations. To surmount these difficulties, an approximate stress field equations have been developed by using optimization technique and a personal computer based software known as MathCAD (MathSoft Inc.). The proposed field equations are simple, easy to formulate and closed form solutions for the present analysis can be obtained.

M. Sayeed Hasan
Division of Mathematic, Engineering & Computer Science
Adirondack Community College
Bay Road
Queensbury, NY 12801

4:50 PM

Stabilisation of Nonlinear Systems by Linearising Feedback Controls

A method for global state stabilisation is given that uses an input-output linearising state feedback. It extends and completes recent work of Byrnes and Isidori and Kappos. Since it has been shown that the strong relative degree is not definable globally, in general, we give a construction that takes into account the singular sets, where the control fails to change the output function. More precisely, the state feedback yields piecewise linear input-output relations in open sets that are the complements of closed neighborhoods of singular sets. To guarantee stability of the state-space trajectories, we assume zero dynamics that are globally dissipative. The difficulties of implementing state stabilisation are illustrated by examples. Since the viewpoint is geometrical throughout we make the remark that linearisation is one of many linearisation methods -not always the most practical one.

Efthimios Kappos,
Department of Electrical, Electronic and Information Engineering, City University,
London EC1V OHB, U.K.

5:10 PM

Fluxon Dynamics in Long Josephson Junctions with Inhomogeneities.

We study the motion of fluxons in Long Josephson Junctions (LJJ) with inhomogeneities, using collective coordinates to reduce the problem to two coupled nonlinear o.d.e s. We whow that fluxon trapping is determined by the relative location of the invariant manifolds of N unstable fixed points associated with the N inhomogeneities. In the experimentally interesting case of N "microresistors", we find parameter values such that each "microresistor" will trap one fluxon, thus turning the LJJ into a quantum flux "shuttle". Solving the p.d.e of the problem numerically we verify our results and discuss conditions under which the validity of the collective variables approach can be established.

Tassos Bountis
Department of Mathematics
University of Patras
Patras, Greece

Stephanos Pnevmatikos
Research Center of Crete
P.O. Box 1527
Heraclion, Grete, Greece

5:30 PM

Vibration Characteristics of Shell Structures : Formulation based on Plate Analogy

Shell structures including cylinders are common mechanical components in many vibration and noise issues. Although lots of detailed analytical tools are available for a shell structure, they are complicated in analysis and require too much computation. In the vibration and noise implementation, approximate formula that can provide an estimate on the vibration and noise level are very useful. The proposed model uses the plate input mobility, resonance modes, modal density and total number of modes within frequency bandwidth. The formula are simple and easy to use. The result shows that the proposed formula predict the vibration level very well. Also the dynamics of shell acts like a plate when the frequency bandwidth is above the ring frequency.

Dong H. Kim and Jeung T. Kim
Acoustics and Vibration Laboratory
Korea Standards Research Institute
DaeJon, KOREA 302-340

5:50 PM

A Method of Solution of Same Functional Equations of Theory Dynamical System

A method is proposed to solution same functional equations of theory of dynamical system.

The general idea of method is represented in consideration of the other functional equation and search a transformation what transit original equation is new. The form of new functional equation must read the same in the new variables. If you know one particular solution of this equation then can be obtained new solutions applied the transformation to this solution.

In report is considering Feygenbaum functional equation and other functional equations.

Vladimir S. Berman
Institute for Problem in Mechanics
Academy of Science of USSR
pr. Vernadsky 101
117526 Moscow USSR

FRIDAY, MAY 11 - 10:30 AM-12:30 PM
Room: Lemon-Lime
Minisymposium 44
Dynamical Systems and Stochastic Processes
Chair: Thomas J. S. Taylor

10:30 AM

Coalescing stochastic flows in dimensions one, two and three

This talk presents a survey of the work of T. E. Harris, H. Matsumoto, and R. W. R. Darling on the construction and properties of coalescing stochastic flows, and of a few unsolved problems.

R. W. R. Darling
Department of Mathematics
University of South Florida
Tampa, FL 33620

11:00 AM

Common Techniques in Dynamical and Stochastic Systems: Invariant Bundles, Invariant Manifolds and Spectra

Ordinary differential equations $\dot{x} = X(x, \xi_t)$ on a manifold M with stochastic perturbation ξ_t, can be viewed as dynamical systems on $U \times M$, where U is the trajectory space of ξ_t. For the linearized system on $U \times TM$, various spectra and associated subbundle decompositions will be studied, and compared to the Oseledeč and the dynamical spectrum with their decompositions. It turns out that the Markov property of ξ_t (+ some nondegeneracy) confines the stochastic spectrum to certain subintervals of the Oseledeč spectrum. A construction of the corresponding invariant manifolds on M will be presented.

Wolfgang Kliemann
Department of Mathematics
Iowa State University
Ames, IA 50011

11:30 AM
T. J. S. Taylor
No abstract submitted

12:00 PM
V. Wihstutz
No abstract submitted

FRIDAY, MAY 11 - 10:30 AM-12:30 PM
Room: Tangerine A
Minisymposium 45
Mathematical Epidemiology 3
Chair: Herbert W. Hethcote

10:30 AM

Epidemiological Models For STD's With Variable Population Size.

The effects of variable population size on the dynamics of heterogeneously mixing populations is discussed. Approaches to the estimation of the mixing parameters will be outlined.

C. Castillo-Chavez, Biometrics Unit, 341 Warren Hall, Cornell University, Ithaca, NY 14853

11:00 AM

Epidemic Models for Populations with Age and Risk Level Structure

The force of infection terms in epidemic models are usually derived on the basis of *ad hoc* heuristic reasoning. Here we derive general forms for the force of infection on the basis of three axioms and exhibit the mathematical assumptions needed to arrive at various widely used specific forms for these terms. We describe models for disease transmission through casual contacts and through long-term pair formation using force of infection terms that take age and risk level structure into account. We derive the basic disease reproduction number R_0 for these models and analyze the effect of various population parameters on R_0.

Stavros N. Busenberg
Department of Mathematics
Harvey Mudd College
Claremont, CA 91711

12:00 PM

Stability Conditions, Thresholds and Reproduction Numbers for Epidemiological Models

The AIDS epidemic has brought new challenges to mathematical epidemiologists, including concerns about aspects such as non-homogeneous populations with non-random contacts and non-constant population sizes. We will present some results of recent studies of models in which these aspects play a central role. These results use an appropriate Liapunov function to relate conditions for the local and global stability of the disease-free equilibrium, the threshold for epidemic take-off and reproduction numbers for non-constant heterogeneous populations with non-random contact numbers.

John Jacquez
University of Michigan
Ann Arbor, MI 48109

Carl Simon
University of Michigan
Ann Arbor, MI 48109

FRIDAY, MAY 11 - 10:30 AM-12:30 PM
Room: Tangerine B
Minisymposium 46
Hyperbolicity in Dynamical Systems 2
Chair: Kenneth Palmer

10:30 AM

Dimension Problems in Ordinary Differential Equations

In a dynamical system in $\mathbb{R}^n$, a k-dimensional 'volume' (k=1,2,...,n) is distorted by expansion in some directions and contraction in others. For ODEs, this evolution is described precisely by associated k-th compound, variational equations of which the first variational equation and the Louville equation are the cases k=1 and k=n. We study the implications of these equations for the Hausdorff dimension of attractors. Currently, this problem is usually addressed via Lyapunov exponents which give an indication of the exponential variation of lengths, areas, volumes, etc. These are however often difficult to estimate. An application to the Lorenz attractor is given.

YI LI and JAMES S. MULDOWNEY
Department of Mathematics
University of Alberta
Edmonton, Alberta
CANADA T6G 2G1

11:00 AM

The Shadowing Lemma and Numerical Computation of Orbits of Dynamical Systems

Chaotic dynamical systems are expanding. So a numerically computed orbit will always diverge from the true orbit with the same initial point. Now a numerically computed orbit may be regarded as a pseudo-orbit. If the dynamical system is uniformly hyperbolic, the shadowing lemma tells us that there is a true orbit near the computed orbit. The purpose of this lecture is to show that even when f is not uniformly hyperbolic the ideas of the shadowing lemma can be used to find a true orbit near a computed one. (Joint work with Shui-Nee Chow.)

Kenneth Palmer
Department of Mathematics and Computer Science
University of Miami
Coral Gables, FL 33124

11:30 AM

Simultaneous Equilibrium and Heteroclinic Bifurcation

We consider unfoldings of planar vector fields in which a semihyperbolic equilibrium p_0 is connected to a hyperbolic saddle q_0 by an orbit in the unstable manifold of p_0. We produce normal forms using singularity theory and the Melnikov integral. The normal forms consist of two polynomials, one to describe equilibrium bifurcation and one to describe heteroclinic bifurcation. We also show how to use the singularity theory/Melnikov integral method to study an infinite codimension heteroclinic bifurcation problem with a distinguished parameter; the problem arises in the study of shock wave solutions of hyperbolic conservation laws near umbilic points.

Stephen Schecter
Mathematics Department
North Carolina State University
Box 8205
Raleigh, NC 27695-8205

12:00 PM

Averaging for Almost Identical Maps and Weakly Attractive Tori

Assume an integrable Hamiltonian differential equation is perturbed dissipatively with perturbation of order eps. Under some general conditions the system admits an attractive invariant torus T(eps) for all small eps.

Apply a one step method of order p to the given system. For general integration methods the step size has to be chosen of order eps **(1/p) in order to admit an attractive invariant torus near T(eps). This step size may be very small if eps is small enough It is shown that if one uses a canonical integration method (preserving the symplectic structure of the system) then there exists an attractive invariant torus for step sizes which are considerably larger, namely of order log(1/eps)**(-C).

Daniel Stoffer, UCLA, Dept. of Math., Los Angeles CA 90024

FRIDAY, MAY 11 - 10:30 AM-12:30 PM
Room: Oleander B
Minisymposium 47
Chaotic Scattering
Chair: Edward Ott

10:30 AM

Bifurcations to Chaotic Scattering

We investigate how chaotic scattering comes about as a system parameter is varied. For example, for scattering of a point particle from a potential, it is common for the scattering to be regular (i.e., nonchaotic) when the particle energy is large but chaotic at lower energy. We find that chaos can come about in either of two different characteristics ways.[1] In the first type of chaos onset scattering is regular above a critical value of the parameter but then immediately becomes chaotic and hyperbolic past the critical value.[1] The second type of chaos-onset proceeds via a saddle-node bifurcation followed by a sequence of heteroclinic and homoclinic stable-unstable manifold crossings.[1,2] In this case the scattering is not hyperbolic at onset, but then can become so as the parameter is varied further. These phenomena will be illustrated and studied with numerical experiments.

1. Bleher, Ott and Grebogi, Phys. Rev. Lett. (1989).
2. Ding, Grebogi, Ott and Yorke, to be published.

Edward Ott
Laboratory for Plasma Research
University of Maryland
College Park, MD 20742

11:10 AM

Multifractal Properties of Chaotic Scattering

We show that scaling properties of chaotic repellers underlying irregular scattering in two degrees of freedom systems can be deduced by measuring simple length scales generated hierarchically along a straight line taken far away from the interaction region, or on a Poincaré plane, and analyzing them in the spirit of the thermodynamic formalism worked out for dynamical systems. One obtains in this way the spectra of generalized dimensions, entropies and Lyapunov exponents. The case of non-hyperbolic repellers is shortly discussed.

Tamás Tél
IFF, Forschungszentrum Jülich
Postfach 1913
D-5170 Jülich 1, FRG
On leave of absence from Institute for Theoretical Physics, Eötvös University, Budapest, Hungary

11:50 AM

Quantum Chaotic Scattering

How does classically chaotic scattering manifest itself in a quantum mechanical system? To answer this question we investigated analytically and numerically two time reversal symmetric scattering systems which show a transition to classically chaotic scattering as a function of a control parameter. In the irregular scattering domain, and for correlation ranges ~1/h, the statistical properties of the quantum scattering matrix (S-matrix) are consistent with Dyson's results for the random ensemble of unitary and symmetric matrices (DOE). This result provides strong evidence for the conjecture that the fingerprint of classical chaos in the quantum world is the universal behavior of fluctuations governed by the rules of random matrix theory. A molecular beam experiment is suggested to test our analytical and numerical results.

Reinhold Blumel
Department of Chemistry
University of Pennsylvania
Philadelphia, PA 19104-6323
USA

Uzi Smilansky
Department of Nuclear Physics
The Weizmann Institute
76100 Rehovot
ISRAEL

FRIDAY, MAY 11 - 10:30 AM-12:30 PM
Room: Hybiscus
Minisymposium 48
The Role of Coherent Structures in Two-Dimensional Turbulence
Chair: George F. Carnevale

10:30 AM

The Statistics of Vortex Merger in Two-Dimensional Turbulence

Decaying two-dimensional turbulence is dominated by the interactions of coherent vortices. For widely separated vortices, the basic interaction is simple mutual advection. In close encounters between like signed vortices, there is a possibility of irreversible merger, which is the main way that the distribution of vortices evolves. Thus to gain insight into the statistics of two-dimensional turbulence, we explore the general problem of the evolution of ensembles of particles which can merge according to various collision rules. We first present some analytic results from scaling theory and numerical simulations for a one-dimensional mechanical analog to the turbulence merger problem. Then the models for two-dimensional turbulence are discussed.

**George F. Carnevale
Scripps Institution of Oceanography
La Jolla, Ca., 92093, U.S.A.**

11:00 AM

The Coherent Structures of Two-dimensional Turbulence

Some high-resolution numerical simulations of two-dimensional turbulence are presented to show the spontaneous formation of stable coherent structures or vortices. The simulations also show a strong deviation from the energy spectrum expected from the classical phenomenological theories. This disagreement is definitively explained in terms of the properties of the vortices: these trap most of the fluid enstrophy, thus inhibiting the cascade process toward small scales. The influence of the initial conditions is studied in detail for decaying flows and it is found that the complex continuous dynamics of two-dimensional turbulence can be often described by a small number of degrees of freedom. Forced experiments are also investigated; these tend to confirm the previous results but also show the frequent formation of many stable dipolar and even tripolar coherent structures.

Paolo SANTANGELO

IBM ECSEC
European Center for Scientific and Engineering Computing

Via Giorgione 159, 00147 Rome, ITALY

11:30 AM
Coherent Jets in Geophysical Turbulence

Equations governing forced and damped flow in a rotating two-layer fluid system are integrated numerically. Allowing the rotation rate to vary in one horizontal direction (north-south) is observed to introduce low-frequency coherence in the strongly non-linear flow at statistical equilibrium. In a parametric regime of geophysical relevance, the flow organizes itself into a series of jets of alternating senses, oriented in the orthogonal direction (east-west). The jets exhibit considerable stability in spite of a vigorous eddy field whose intermittent bursts may obscure the presence of the jets in instantaneous snapshots. The spatial scale of the jets is well defined but appears difficult to predict from the parameters of the system, as is the long time scale on which the jets meander.

R. Lee Panetta
Department of Meteorology
Texas A&M University
College Station, TX 77843

12:00 PM
Coherent Structures in Two Dimensional Geophysical Turbulence

Numerical simulations of both forced and decaying two dimensional turbulence have revealed the existence of long-lived coherent vortices. Since geophysical fluids can behave approximately two dimensionally at relatively large scales, there may be some relationship between these types of simulations and the existence of persistent structures in real geophysical flows, such as Gulf Stream rings and atmospheric blocks. However, the addition of the geophysically important effect of differential rotation can significantly alter the flow. We will present an overview of coherent structures in two dimensional turbulence and describe numerical simulations that help quantify the conditions under which vortices form in such flows.

Mathew E. Maltrud
Scripps Institution of Oceanography, La Jolla CA 92093

Geoffrey K. Vallis
Department of Physics, U. C. Santa Cruz, Santa Cruz CA 95064

FRIDAY, MAY 11 - 10:30AM-12:30 PM
Room: Azalea
Contributed Presentations 18
Qualitative Theory of Differential Equations
Chair: Natalia Sternberg

10:30 AM
A New Kind of Stability

We give examples of invariant sets that are not asymptotically stable but are attractors in that any neighborhood contains a set of positive measure that is uniformly asymptotic to the invariant set. Moreover, the measure becomes full as the neighborhood shrinks. Indeed the complement of the set of positive measure is a cuspoidal region abutting the invariant set. Our examples consist of heteroclinic cycles occuring in the analysis of low codimension bifurcations with and without symmetry. However, it seems likely that this type of stability is prevalent in the situation of invariant sets that do not possess a hyperbolic structure.

Ian Melbourne
Department of Mathematics
University of Houston
Houston, TX 77204-3476

10:50 AM
Separatrix Crossing

Asymptotic techniques for slowing varying strongly nonlinear oscillations (including weak damping) are known to fail near the separatrix. We represent the solution near the separatrix as a large sequence of perturbed solitary pulses. By matching through the separatrix, we determine the number of oscillations to reach the last saddle approach (before capture), the crossing time, and its corresponding energy. Our results agree with those obtained using a standard numerical integration package. Furthermore, we determine asympotically the amplitude and the phase of the nonlinear oscillator after crossing the separatrix, showing these connection formulas to be sensitively dependent on the initial conditions.

F. Jay Bourland
Department of Applied Mathematics, FS-20
University of Washington
Seattle, WA 98915

Richard Haberman
Department of Mathematics
Southern Methodist University
Dallas, TX 75275

11:10 AM
Canards and excitability of Lienard equations

In singular perturbation systems, canards are limit cycles which link small limit cycles born in Hopf bifurcation with large relaxation oscillations as a parameter is varied. We propose a geometric analysis based on a theorem on existence of separating trajectories. Furthermore, we show that an unstable separating trajectory is a threshold for excitability. That is, the qualitative dynamical response to a perturbation of a steady state depends on whether the state has been perturbed outside threshold or not. The theory is applied to the Van der Pol equation, a 2d-model for the BZ reaction and the FitzHugh-Nagumo equations. Improved asymptotic expansions are obtained.

Morten Brøns
Mathematical Institute
The Technical University of Denmark
Building 303
DK-2800 Lyngby
Denmark.

11:30 AM

Normalization and Behavior of Flows in the Main Problem of Artificial Satellite Theory

This dynamical system is used to illustrate two major steps in analyzing perturbed integrable Hamiltonian systems with two degrees of freedom: automated normalization-a symmetrization by Lie transformation-and color visualization-"painting" the integral over the orbital sphere. These techniques have been applied to unravel the enigma of critical inclinations. Analysis pursued to third order shows how the four classical equilibria exchange stability through a sequence of pitchfork and reverse pitchfork bifurcations, a phenomenon encountered also when zonals other than J_2 are added. These techniques prove useful to aerospace engineers in planning satellite missions.

Shannon Coffey
Naval Research Laboratory, Washington, DC 20375

Andre Deprit
National Institute of Standards and Technology
Gaithersburg, MD 20899

Liam Healy
Code 8242
Naval Research Laboratory
Washington, DC 20375

11:50 AM

Floquent Equations

The classic Floquent Theorem says that, under a certain periodic transformation, a linear periodic ODE is equivalent to an autonomous linear ODE. Generalizing this idea, we classify a kind of linear periodic differential equations called Floquent equations (complete type, divisible type and dense type) which, in some sense, can apply the Floquent theorem. As an example, a scalar differential delay equation $dx/dt = a(t)x(t) + b(t)x(t - r)$, where r is a positive constant, $a(t)$ and $b(t)$ are periodic functions with period r, is a Floquent equation (complete type or dense type).

Yulin Cao
Department of Mathematics
University of Georgia
Athens, GA 30602

12:10 PM

Time Dependent Normal Form Theory to Schrodinger Initial Value Problem

Time dependent normal form theory is introduced and studied in the context of Schrodinger initial value problem associated with Hamiltonians having time dependent perturbations to arrive at approximations with rigorous error estimates provided the initial vector is restricted to an appropriate dense subspace. The speaker will present applications of this theory to quantum mechanical anharmonic oscillator which changes trigonometrically with time. This method will be compared with the existing time averaging method applied to time independent anharmonic oscillator.

Raghu R. Gompa
Arts & Science
Math & Information Sciences Division
Indiana University
P.O. Box 9003
Kokomo, Indiana 46904-9003

12:30 PM

Quasiperiodic Systems and Their Linearization

Poincaré normal form theory plays an important role in the study of existence, stability, approximation and bifurcation of solutions of differential equations. We extend the principles of that theory to obtain a normal form theory for quasiperiodic systems of differential equations under certain small-divisor conditions. We use this to prove a linearization theorem under somewhat stronger small-divisor conditions. The result generalizes Siegel's linearization theorem for differential equations.

Shui-Nee Chow
Center for Dynamical Systems and Nonlinear Studies
School of Mathematics
Georgia Institute of Technology
Atlanta, GA 30332

Kening Lu
Institute for Mathematics and Its Applications
University of Minnesota
Minneapolis, MN 55455

Yun-Qiu Shen
Department of Mathematics
Western Washington University
Bellingham, WA 98225

FRIDAY, MAY 11 - 10:30 AM-12:30 PM
Room: Orange
Contributed Presentations 18a
Session on Late Contributions
Chair:

10:30 AM

Transitions Between Attractors of Coupled Map Lattices

It is known that a lattice of coupled dynamical systems can possess a large number of coexisting attractors as well as extremely long transient solutions even in the case of large dissipation. We present computational results of simulations of transitions between attractors in one and two dimensional lattices which are induced by external dynamical perturbations. The spatial dependence of the perturbation determines which attractors, localized in domains on the lattice, are influenced maximally. This method is used to select those attractors which are maximally robust under a given class of perturbations.

Gottfried Mayer-Kress
Department of Mathematics
University of California, Santa Cruz
Santa Cruz, CA 95064

10:50 AM

Chaos and order in the fisheries system in lake Superior

Data on the fisheries yield from Lake Superior have been accumulating for the last 100 years. Given the interspecific interactions of fish species, pollution, fisheries, and other processes, the system is considered to be complex and the data are believed noisy. The value of singular value decomposition (SVD) in noise reduction and identification of strange attractor dimension is examined. SVD is useful if some strong assumptions about noise are made. The data exhibit low dimensionality, but the question whether the system wonders on a strange attractor or reflects quasi-periodicity remains unresolved.

Yosef Cohen
Department of Fisheries and Wildlife
University of Minnesota
St. Paul, MN 55108

11:10 AM

Continuation Principle for Second Order System on Manifolds

Let M be an n-differential manifold, possibly with boundary, embedded in R^k, k> n, we consider on M the system of equations:

(1)∇ dk/dt dx/dt=f(t,x(t))

where F is a T-periodic continuous tangent vector field:

f(t+T,)=f(t,p) ∀ t∊R, p∊M

∇ is the covariant derivative of the Riemannian structure induced on M by R^k, and x(t) is a path on M, x:[0,T]--> M. We give a continuation principle for 2nd order system (1), on M. In fact we use topological result and priori estimates on TM for ensurer the existence of a T-periodic solution for (1). (We extend existence results given for 1nd-order system on manifold).

Beatrice Venturi
Via Rossini 62
09100 Cagliari
Italy

or

Universita di Cagliari
Dpto. di Matematica
Via Ospedole, 72
Cagliari, Italy

11:30 AM

Digital Simulation Technique for Modelling and Testing of Speed Control System

The paper present a digital model for simulating the speed control system of gas turbine used with electrical power generating units. The digital model is employed for dynamic performance testing of the gas turbine units. This is achieved by estimating the transient response parameteric sensitivity functions for the speed control and using these functions to construct checkout envelopes for the system transient response.

The test is performed on actual measured responses which are obtained from the gas turbine units, during their operation, and the results are satisfactory.

V. Y. Tawfik
Mechanical Engineering Department
College of Engineering
Mosul University
Baghdad, Iraq

Hameed H. Hashem and Hameed H. Haider
Mechanical Department
Institute of Technology
Zaafaranyia, P. O. Box 29008
Baghdad, Iraq

11:50 AM

Stability of Estimation Algorithms for Large Sparse Systems

The purpose of this paper is to present stability analysis and an application of new iterative methods for parallel/pipeline processing in estimation of large sparse dynamic systems. The methods are imitations of the classical Jacobi and Gaus-Seidel iterative methods for solving linear algebraic equations, but otherwise use entirely different concepts and techniques. One of the main motivations for this new development has been the fact that the resulting algorithms are suitable for implementation on multiple processor systems with all the advantages that such systems offer in off-line and especially on-line computations, such as cost, availability, response time, and program modularity. The stability properties of the proposed algorithms are discussed together with the partial ordering properties of the corresponding performance indices. An interesting practical example is used to illustrate the design.

Migdat I. Hodzic
Rudi Cajavec, Ro Pe
Brace Pavlica 23 a
78 000 Banja Luka, Yugoslavia

5:50 PM (Minisymposium 43, 4:30 PM Thur.)

Infinitely Small Numbers and Big Accelerators

The fundamentals of a new calculus on a nonarchimedean field are presented. It is shown that most classical theorems of calculus have an equivalent under similar conditions. Beyond that, the new structure allows a rigorous treatment of the intuitive concept of a differential quotient as a derivative. In this sense, similar results as in conventional nonstandard analysis are obtained. One advantage of the new structure, however, is that it is fully constructive without invoking the Axiom of Choice or one of its equivalents; so constructive, indeed, that the operations on the structure can be implemented on a Neumann computer.

Dr. Martin Berz
MS 47-112, LBL
University of California, Berkeley
1 Cyclotron Road
Berkeley, CA 94720

AUTHOR INDEX

* = Presenter
C/P = Contributed Presentation
M/S = Minisymposium Presentation
I/P = Invited Presentation
S/L = Special Lecture

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SIAM BOOKSHELF

Numerical Analysis: A Second Course
James M. Ortega

This book addresses some of the basic questions in numerical analysis: convergence theorems for iterative methods for both linear and nonlinear equations; discretization error, especially for ordinary differential equations; rounding error analysis; sensitivity of eigenvalues; and solutions of linear equations with respect to changes in the data.

Some reviews of the original edition contained the following comments:

"This is a concise account of certain topics in numerical analysis which a student is expected to know when he reaches an advanced course yet may not have been introduced to in his first course on the subject.

This book is organized around the notion of error. After the concepts of stability and ill-conditioning (important in gauging the effects of all kinds of error) are elucidated in a first part of the book, discretization error, convergence error, and rounding error are each studied separately in a few important situations in the last three parts of the book. A review chapter on the Jordan canonical form and on norms for vectors and matrices precedes all."

—Mathematics of Computation, July 1973, page 669.

201 pages, Softcover, ISBN 0-89871-250-5
Classics in Applied Mathematics
January 1990
List Price $25.50/SIAM Member Price $20.40
Order Code CL03

Proceedings of the Fourth Copper Mountain Conference on Multigrid Methods
Edited by Jan Mandel, Stephen F. McCormick, J.E. Dendy, Jr., Charbel Farhat, Guy Lonsdale, Seymour V. Parter, John W. Ruge, and Klaus Stüben

The entire spectrum of multigrid methods and their applications is reflected in this volume, from theoretical aspects to implementation on supercomputers and other realistic applications. More than 140 people attended the Fourth Copper Mountain Conference on Multigrid Methods in April 1989, and this book contains the proceedings of that conference—a careful selection of papers representing the mood and vigor of this topic.

Some specific areas covered in this work are numerical solutions of Navier-Stokes equations; adaptive refinements; numerical methods in structural mechanics; implementations on the CRAY-XMP, Intel Hypercube, and Connection Machine; nonconforming finite elements; anisotropic problems; and novel parallel methods.

The Copper Mountain Conferences, first held in 1983, continue to be the only regular professional meeting in the field of multigrid methods in the United States.

438 pages, Softcover, ISBN 0-89871-248-3
Proceedings in Applied Mathematics
October 1989
List Price $39.50/SIAM Member Price $31.60
Order Code PR41

Proceedings of the First ACM-SIAM Symposium on Discrete Algorithms

This volume contains the papers that were presented at the First Annual ACM-SIAM Symposium on Discrete Algorithms, which was held in January 1990 in San Francisco. The symposium was jointly sponsored by the ACM Special Interest Group for Automata Theory and the SIAM Activity Group on Discrete Mathematics. Many of the papers represent reports of continuing research. It is appropriate for anyone working in discrete mathematics.

523 pages, Softcover, ISBN 0-89871-251-3
January 1990
List Price $39.50/SIAM Member Price $31.60
Order Code OT18

Multilevel Adaptive Methods for Partial Differential Equations
Stephen F. McCormick

This volume is intended as a practical handbook on the fundamental concepts for a class of multilevel adaptive methods that are designed for efficient adaptive discretization and solution of partial differential equations.

It is becoming increasingly critical that highly accurate, efficient, and reliable solution methods for very large scale and complex physical models be developed. This book is intended to contribute in a practical way toward achieving this goal.

162 pages, Softcover, 0-89871-247-5
Frontiers in Applied Mathematics
November 1989
List Price $24.50/SIAM Member Price $19.60
Order Code FR06

Methods of Dynamic and Nonsmooth Optimization
Frank H. Clarke

This monograph presents the elements of a new unified approach to optimization based on "nonsmooth analysis," a term introduced in the 1970's by the author, who is considered a pioneer in the field. Based on a series of lectures given at Emory University in 1986, this volume presents many recent developments in an accessible and self-contained manner. The topics treated here have been in an active state of development, and this work therefore incorporates more recent results than those presented in 1986.

The book focuses mainly on deterministic optimal control, the calculus of variations, and mathematical programming. In addition, it features a tutorial in nonsmooth analysis and geometry and demonstrates that the method of value function analysis via proximal normals is a powerful tool in the study of necessary conditions, sufficient conditions, controllability, and sensitivity analysis. The distinction between inductive and deductive methods, the use of Hamiltonians, the verification technique, and penalization are also emphasized.

90 pages, Softcover, ISBN 0-89871-241-6
CBMS-NSF Regional Conference Series in Applied Mathematics
October 1989
List Price: $15.75
SIAM/CBMS Member Price: $12.60
Order Code CB57

Boundary Stabilization of Thin Plates
John E. Lagnese

This book presents one of the main directions of current research in the area of design and analysis of feedback stabilizers for distributed parameter systems of importance in structural dynamics. In recent years important progress has been made in this area, driven, to a large extent, by problems in modern structural engineering that require active feedback control mechanisms to stabilize structures which may possess only very weak natural damping. Much of the progress recently seen is due to the development of new methods to analyze the stabilizing effects of specific feedback mechanisms.

Boundary Stabilization of Thin Plates provides a comprehensive and unified treatment of asymptotic stability of a thin plate when appropriate stabilizing feedback mechanisms acting through forces and moments are introduced along a part of the edge of the plate. In particular, primary emphasis is placed on the derivation of explicit estimates of the asymptotic decay rate of the energy of the plate that are uniform with respect to the initial energy of the plate, that is, on uniform stabilization results.

The method that is systematically employed throughout this book is the use of multipliers as the basis for the derivation of a priori asymptotic estimates on plate energy. It is only in recent years that the power of the multiplier method in the context of boundary stabilization of hyperbolic partial differential equations came to be realized.

176 pages, Hardcover, ISBN 0-89871-237-8
SIAM Studies in Applied Mathematics
October 1989
List Price $36.50/SIAM Member Price $29.20
Order Code AM10

Proceedings of the Workshop on Random Media and Composites
Edited by Robert V. Kohn and Graeme W. Milton

The Workshop on Random Media and Composites took place in December 1988 at the Xerox Training Center in Leesburg, Virginia. Covering a broad range of topics related to the behavior of disordered systems, the workshop attracted a diverse audience including applied mathematicians and specialists in theoretical and experimental physics, mechanical engineering, and geophysics.

Among the workshop's specific areas of focus were percolation and breakdown in random resistor networks, bounds and mean fields theories for the effective moduli of composites, seismic inverse problems, localization in random media, and superconductivity.

This volume contains research articles corresponding to 11 of the 29 talks presented at the workshop, and abstracts for most of the remaining talks. The research articles are loosely organized into two categories: those primarily concerned with continuous systems, and those focused on discrete systems. Both the research articles and the abstracts have extensive bibliographies, providing an invaluable guide to recent scientific literature in this area.

214 pages, Softcover, ISBN 0-89871-246-7
Proceedings in Applied Mathematics
November 1989
List Price $27.50/SIAM Member Price $22.00
Order Code PR40

Augmented Lagrangian and Operator-Splitting Methods in Nonlinear Mechanics
Roland Glowinski and Patrick Le Tallec

When *Augmented Lagrangian Methods*, edited by M. Fortin and R. Glowinski, appeared in 1983, the authors of the present book quickly realized that a sequel was needed for a variety of reasons, including the emergence of new applications and the sophistication of existing ones; a deeper understanding of the convergence properties of augmented Lagrangian algorithms and of their relationship to operator-splitting methods such as alternating-direction methods; and the development of more efficient algorithms.

The decision was made to write a volume oriented to applications in continuum mechanics that would contain these new developments. The nature and structure of this book are derived from that choice.

This volume deals with the numerical simulation of the behavior of continuous media by augmented Lagrangian and operator-splitting methods (coupled to finite-element approximations). It begins with a description of the mechanical and mathematical frameworks of the considered applications as well as a general analysis of the basic numerical methods traditionally used to study them. These ideas are then applied to specific classes of mechanical problems.

295 pages, Hardcover, ISBN 0-89871-230-0
Studies in Applied Mathematics
October 1989
List Price $44.50 / SIAM Member Price $35.60
Order Code AM09

Stochastic Processes in the Neurosciences
Henry C. Tuckwell

This monograph is centered on quantitative analysis of nerve-cell behavior. The work is foundational, with many higher order problems still remaining, especially in connection with neural networks. Thoroughly addressed topics include stochastic problems in neurobiology, and the treatment of the theory of related Markov processes.

129 pages, Softcover, ISBN 0-89871-232-7
CBMS/NSF Regional Conference Series in Applied Mathematics
List Price: $24.50
SIAM/CBMS Member Price: $19.60
Order Code CB56

Spline Models for Observational Data
Grace Wahba

This book develops a theory and practice for the estimation of functions from noisy data on functionals. The simplest example is the estimation of a smooth curve, given noisy observations on a finite number of its values. The estimate is a polynomial smoothing spline. By placing this smoothing problem in the setting of reproducing kernel hilbert spaces, a theory is developed which includes univariate smoothing splines, thin plate splines in *d* dimensions, splines on the sphere, additive splines, and interaction splines in a single framework. A straightforward generalization allows the theory to encompass the very important area of (Tihonov) regularization methods for ill-posed inverse problems.

Convergence properties, data based smoothing parameter selection, confidence intervals, and numerical methods are established which are appropriate to a wide variety of problems which fall within this framework. Methods for including side conditions and other prior information in solving ill posed inverse problems are included. Data which involves samples of random variables with Gaussian, Poisson, binomial, and other distributions are treated in a unified optimization context. Experimental design questions, i.e. which functionals should be observed, are studied in a general context. Extensions to distributed parameter system identification problems are made by considering implicitly defined functionals.

208 pages, Softcover, ISBN 0-89871-244-0
CBMS-NSF Regional Conference Series in Applied Mathematics
March 1990
List Price $24.75
SIAM/CBMS Member Price $19.80
Order Code CB59

Symbolic Computation: Applications to Scientific Computing
Edited by Robert Grossman

The fifth book in SIAM's Frontiers in Applied Mathematics Series, this volume describes current research efforts in the application of symbolic computation to several areas in mathematics, applied mathematics, and engineering, including dynamical systems, differential geometry, Lie algebras, numerical analysis, fluid dynamics, perturbation theory, control theory, and mechanics.

The chapters, which illustrate how symbolic computations can be used to study various mathematical structures, are outgrowths of the invited talks that were presented at the NASA-Ames Workshop on The Use of Symbolic Methods to Solve Algebraic and Geometric Problems Arising in Engineering, which took place in 1987 at the NASA-Ames Research Center in Moffett Field, California.

186 pages, Softcover, ISBN 0-89871-239-4
Frontiers in Applied Mathematics
September 1989
List Price $24.50/SIAM Member Price: $19.60
Order Code FR05

A Survey of Lie Groups and Lie Algebras with Applications and Computational Methods
Johan G.F. Belinfante and Bernard Kolman

This monograph introduces the concepts and methods of the Lie theory in a form accessible to the non-specialist by keeping mathematical prerequisites to a minimum. Although the authors have concentrated on presenting results while omitting most of the proofs, they have compensated for these omissions by including many references to the original literature. Their treatment is directed toward the reader seeking a broad view of the subject rather than elaborate information about technical details.

In this reprint edition of the original 1972 monograph, the authors have resisted the temptation of including additional topics. Except for correcting a few minor misprints, the character of the book, especially its focus on classical representation theory and its computational aspects, has not been changed.

164 pages, Softcover, ISBN 0-89871-243-2
Classics In Applied Mathematics
August 1989
List Price $24.50 / SIAM Member Price $19.60
Order Code CL02

Inverse Problems in Partial Differential Equations
Edited by David Colton, Richard Ewing, and William Rundell

This volume contains 13 of the 16 invited talks presented at a conference on Inverse Problems in Partial Differential Equations which took place in 1989 in Arcata, California. All of the talks concentrate on the three main themes of the conference: coefficient identification problems for parabolic equations, impedance tomo-graphy, and inverse scattering. The conference was part of the Summer Research Conferences in the Mathematical Sciences sponsored by SIAM, the AMS, and the IMS.

214 pages, Softcover, ISBN 0-89871-252-1
Proceedings in Applied Mathematics
February 1990
List Price $31.50/SIAM Member Price $25.20
Order Code PR42

The Method of Equivalence and Its Applications
Robert B. Gardner

The ideas of Élie Cartan are combined with the tools of Felix Klein and Sophus Lie to present in this book the only detailed treatment of the method of equivalence. An algorithmic description of this method, which finds invariants of geometric objects under infinite dimensional pseudogroups, is presented for the first time.

As part of the algorithm, Gardner introduces several major new techniques. In particular, the use of Cartan's idea of principal components that appears in his theory of Repere Mobile, and the use of Lie algebras instead of Lie groups, effectively a linearization procedure, provide a tremendous simplification. One must know how to convert from one to the other, however, and the author provides the Rosetta stone to accomplish this. In complex problems, it is essential to be able to identify natural blocks in group actions and not just individual elements, and prior to this publication, there was no reference to block matrix techniques.

The Method of Equivalence and Applications details ten diverse applications including Lagrangian field theory, control theory, ordinary differential equations, and Riemannian and conformal geometry.

This volume contains a series of lectures, whose purpose was to describe the equivalence algorithm and to show, in particular, how it is applied to several pedagogical examples and to a problem in control theory called state estimation of plants under feedback. The lectures, and hence the book, focus on problems in real geometry.

127 pages, Softcover, ISBN 0-89871-240-8
CBMS-NSF Regional Conference Series in Applied Mathematics
November 1989
List Price $21.75
SIAM/CBMS Member Price $17.40
Order Code CB58

Adaptive Methods for Partial Differential Equations
Edited by Joseph E. Flaherty, Pamela J. Paslow, Mark S. Shephard, and John D. Vasilakis

The Adaptive Computational Methods for Partial Differential Equations workshop, held in October 1988 and sponsored by the U.S. Army Research Office, sought to update uses and the art of adaptive methods with significant innovations and discoveries of recent years. These advances include three-dimensional computations and transient problems addressed not only one-dimensionally, but also two- and three-dimensionally.

This active area of adaptive methods offers many challenging research problems. Because the field is young, the ideas presented are many and varied. Results discussed give a realistic and representative picture of today's state of the art.

The scope of this book includes a posteriori error estimation of finite difference and finite element methods; adaptive enrichment strategies, applications of adaptive methods to problems in mechanics, data structures, and parallel adaptive procedures.

265 pages, Softcover, ISBN 0-89871-242-4
Proceedings in Applied Mathematics
September 1989
List Price $31.50/SIAM Member Price $25.20
Order Code PR39

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GENERAL INFORMATION

REGISTRATION INFORMATION

The registration desk will be open as listed below:

Sunday, May 6	6:00 PM - 9:00 PM
Monday, May 7	7:00 AM - 5:00 PM
Tuesday, May 8	7:30 AM - 5:00 PM
Wednesday, May 9	7:30 AM - 12:00 PM
Thursday, May 10	8:00 AM - 5:00 PM
Friday, May 11	8:00 AM - 12:00 PM

Notice
There will be no prorated fees. No refunds will be issued once the conference has started.

If SIAM does not receive your Advance Registration Form by April 27, 1990, you will be asked to give us a check or a credit card number at the conference. We will not process either until we have ascertained that your registration form has gone astray. In the event that we receive your form after April 27, we will destroy your check or credit card slip.

REGISTRATION FEES:

		SIAG/DS	SIAM Member	Non-Member	Student
Conference	Advance	$115	$125	$150	$25
	On-Site	$145	$160	$190	$25

GET TOGETHERS

SIAM Welcoming Reception
Sunday, May 6, 1990
7:00 PM - 9:00 PM
Ballroom Foyer
Cash Bar

SIAM Idea Exchange
Monday, May 7, 1990
6:30 PM - 8:00 PM
Poolside
Cost $17
Come join in with colleagues to exchange ideas and catch up on current issues while enjoying a poolside get-together consisting of vegetables and cheese tray, assorted pastas, hoagies, tacos, beer, and sodas.

Dinner at Sea World
Tuesday, May 8, 1990
6:00 PM - 10:30 PM
Sea World
Cost: Adults $37.00   Children $32.00
Board the buses at 6:00 PM as we take you to Sea World to enjoy a country style dinner and cocktail with ample time to enjoy the park. We will arrive at Sea World at 6:30 PM where an open bar will be available complete with soft drinks until 7:00 PM. We will then be seated for dinner in the Shamu Pavilion where dinner will consist of a buffet of barbecued chicken, smoked sausage with sauteed peppers and onions, country potatoes with cheese, Rio Grande vegetable salad, baked beans Alamo, corn on the cob, lone star cole slaw, cornbread sticks, Texas toast and assorted rolls, apple cobbler, coffee or ice tea. Vegetarian platters will be available for those who request them. A cash bar will be available from 7:00 PM - 8:30 PM. The dinner will also include full admission to the park which you are free to enjoy after dinner which will be approximately 8:00 PM until 10:15 PM when we will board the buses and return to the hotel.

Credit Card
SIAM accepts VISA, MasterCard, and American Express for the payment of registration fees and special functions.

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Non-members attendees who are employed by the following institutions are entitled to the SIAM member rate.

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General Motors Corporation
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IMSL, Inc.
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Marathon Oil Company
Martin Marietta Energy Systems
Mathematical Sciences Research Institute
Schlumberger Industries
Supercomputing Research Center, a division of Institute for Defense Analyses
Texaco, Inc.
United Technologies Corporation

Special Notice to: All Conference Participants

SIAM requests attendees to refrain from smoking in the session rooms during lectures. Thank you.

BOOK EXHIBITS

The exhibits will be at the Orange Room of the hotel during Monday, Tuesday and Thursday; at the Ballroom Foyer during Wednesday and Friday. The exhibit hours are as follows:

Monday, May 7	9:30 AM - 5:00 PM
Tuesday, May 8	9:30 AM - 5:00 PM
Wednesday, May 9	9:30 AM - 12:00 PM
Thursday, May 10	9:30 AM - 5:00 PM
Friday, May 11	9:30 AM - 12:00 PM

Setup will be on Sunday, May 6, 6:00 PM to 9:00 PM; breakdown will be on Friday, May 11, 10:30 AM.

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Cathedral Hill Hotel
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