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The Aspen Workshop on Coherence and Chaos in Complex Dynamical Systems was attended by 25 scientists. There was much dialogue between scientists interested in rotating fluids, trapped electrons, turbulence, and chaos theory.

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SUMMARY OF THE 1991 ACP WORKSHOP

on

COHERENCE AND CHAOS IN COMPLEX DYNAMICAL SYSTEMS

The workshop was attended by 25 scientists, most of whom
are specialists in various aspects of dynamical systems
theory. A major success of the workshop was the opening
of lines of communication between researchers from different
areas. There was much dialogue between scientists interested
in rotating fluids, trapped electrons, turbulence, and
chaos theory. Thirteen lectures were given during the
three weeks. A list of the lecturers, and a short summary
of each of their talks is given below. The structure
of the workshop was informal with one lecture per day
with an afternoon tea. A keywords directory of the participants
was compiled summarizing the participants backgrounds
and interests: a copy is attached to this report, as
is a list of the participants. Those attending the lectures
usually included several participants from outside the
workshop.

Organizers

J. D. Meiss
P. J. Morrison
J. Tennyson

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COHERENCE AND CHAOS IN COMPLEX DYNAMICAL SYSTEMS

TALKS WITH SUMMARIES

JUNE, 1991

5/29   "Subtle Symmetries in Quantum and Surface Wave Systems"
            J. D. Crawford, Physics Dept., University of Pittsburgh

            A brief review of bifurcation theory and a discussion
            of the role of symmetry were given. These tools were
            used to understand wave phenomena in the Faraday experiment
            of Gollub et al and to clear up a misunderstanding of
            the role of symmetry in quantum well problems.

5/30   "Complexity Made Simple"
            Seth Lloyd, Physics Dept., Caltech

            A survey of notions and advances in "Complexity Theory"
            such as algorithmic complexity, computational complexity,
            logical depth, mutual information and the amount of
            information processed by a system was given. These terms
            were brought to life by a series of examples ranging from
            modern art to the dripping faucet.

5/31   "The Gluing Bifurcation and Anomalous Period Doubling"
            Bob Williams, Math Dept., University of Texas at Austin

            A review of the history of the Lorentz Attractor and period
            doubling bifurcation in the logistic map was given.
            Knottedness of the period doubling bifurcation sequence
            and the gluing bifurcation, which occurs in dynamical
            systems and maps with a discontinuity, were discussed.

6/3   "Nonlinearity in One-Dimensional Maps"
            Peter Veerman, Math. Dept. SUNY

            A review of circle map phenomena such as periodic orbits,
            mode locking, Arnold tongues and the devil's staircase
            behavior of the rotation number were given. A summary
            of recent results for unimodel maps based on the bounded
            nonlinearity principle and Koebe's principle was given.

6/4   "Hidden Symmetries Using Lie Group Methods"
            Barbara Shrauner, EE Dept. Washington University

            A discussion of how Lie symmetry techniques can be used
            to solve a variety of ordinary and partial differential
            equations for physical phenomena ranging from semi-
            conductors to plasma phenomena was given. A special kind
            of "hidden" symmetry was explained.

6/5   "Turbulence and Coherent Structure in Shallow Rotating Flows"
Lee Panetta, Meterology, Texas A&M

Fluid equations used to model oceans and atmospheres were presented along with notions such as the Beta effect and potential vorticity. Results of recent computations for the earth's jet stream revealed the formation of coherent structures out of turbulence.

6/6   "Hamiltonian Contour Dynamics"
George Bell, Jr., Boulder, Colorado

Contour dynamics is an approximation to vorticity advection models such as that describing quasigeostrophic motion in oceans and atmospheres. The Hamiltonian structure of this approximation was discussed and results of numerical simulation were presented and interpreted by making use of ideas from finite degree-of-freedom Hamiltonian chaos theory.

6/7   "Canonical Formalism for Wigner Functions"
Iwo Bialynicki-Birula, Phys. Dept., Univ. of Arizona

A general formalism for writing quantum mechanics in the Weyl-Wigner representation in terms of a generalization of Nambu dynamics was presented. The general Lie algebraic setting was shown how to be represented in terms of canonical Hamiltonian variables.

6/10   "Transient Chaos in Nonlocal Cellular Automata"
Wentian Li, Santa Fe Institute

Transient chaos and cellular automata were reviewed. A specific nonlocal cellular automata model was discussed in detail. An analogy to group meeting dynamics motivated the model and numerical observations of transient chaos behavior were given.

6/11   "Dynamics and Transport in Quasigeostrophic Flow"
Tom Solomon and Phil Morrison, Phys. Dept., Univ. of Texas

Theory and experiment of fluid flow in a rapidly rotating annulus were presented. It was observed that finite degree-of-freedom Hamiltonian dynamics explains features of the transport of a passive scalar in the experiment. A discussion of such chaotic advection was given.

6/12   "The Anti-Integrable Limit for Area Preserving Maps"
Jim Meiss, Applied Math, Univer. of Colorado

Twist maps such as the standard map are generally studied
as a function of a parameter k that measures the effect
of "potential energy." Generally researchers have been
interested in k near zero where the KAM theorem applies.
The anti-integrable limit is the case where k approaches
infinity. This limit provides a means for proving the
existence of cantori.

6/13   "Resolution of Contradictions in Turbulent Diffusion
Theory"
John Cary, Physics Dept., University of Colorado

A model known as quasilinear theory, developed in the
60's, for describing the turbulent relaxation of a
weak beam in a plasma has recently come into dispute.
Ideas from Hamiltonian chaos theory, such as island overlap,
were shown to shed light on this dispute.

6/14   "Variable Stars as Dynamical Systems"
Robert Buchler, Physics Dept., Univ. of Florida

It was shown how a mixutre of numerical hydrodynamical
and an analytical amplitude equation formalism sheds
light on the nonlinear pulsations of stars. An explanation
of the bump in classical Cepheids and of period doubling
and chaos in the W. Virginia models were given.

Coherence and Chaos in Complex Dynamical Systems

Bell, George, Jr. Hamiltonian dynamics, Geophysical fluid dynamics, contour dynamics.

Bialynicki-Birula, I. Quantum electrodynamics, quantum optics, field theory, nonlinear PDE's.

Buchler, Robert Astrophysics, Variable stars, Non-linear dynamics, chaos.

Cary, John Dynamical systems, esp. plasmas, accelerators.

Colgate, Stirling Astrophysics, supernova, hydrodynamics.

Crawford, J.D. Plasma physics (collisionless plasma); nonlinear dynamics (bifurcation theory for symmetric systems.)

Drozda, Stan Many-body problem, Quantum Chaos, Tunneling.

Eubank, Stephen Time series analysis; nonlinear modeling and prediction.

Hanson, Jim Magnetic Field Line Flow, Kinematic dynamos.

Kandrup, Henry Galactic dynamics, Vlasov-Poisson, Vlasov-Einstein, quantum cosmology

Kaufman, Allan Poisson Brackets for complex manifolds in dynamics.

Li, Wentian Higher-dimensional dynamical systems (e.g. cellular automata), connection between dynamical systems and statistical physics.

Lloyd, Seth Physics of Information, Foundations of quantum mechanics, measuring complexity.

Meiss, Jim Dynamical systems, Hamiltonian Chaos.

Morrison, Phil Hamiltonian systems (infinite and few degree-of-freedom), Plasma Physics, Hamiltonian transport in e.g. quasi geostrophic flows.

Oberman, C. All aspects of nonlinear plasma dynamics (turbulence, chaos, coherent)

O'Neil, Tom Nonneutral plasmas, transport, turbulence.

Panetta, Lee Geophysical fluid dynamics, coherent structures in turbulence, non-standard analysis.

Shrauner, Barbara Plasmas: processing, collisionless, transport in III-V semiconductors, Lie group methods for nonlinear systems.

Shrauner, Ely	QFT, QCD pedagogy of nonlinearity.
Solomon, Tom	Transport & mixing; Hamiltonian dynamics; Geophysical fluid dynamics.
Taylor, Bryan	Plasma physics, relaxations, turbulence.
Uhlenbeck, Karen	Non-linear PDE and geometry, integrable systems.
Veerman, Peter	Twist maps, Unimodal maps, circle maps, scalings, renormalization, Thurston's Algorithm.
Williams, Bob	Strange attractors, knotted periodic orbits, symbolic dynamics.