

Lecture Notes in Physics

Edited by J. Ehlers, München, K. Hepp, Zürich
R. Kippenhahn, München, H. A. Weidenmüller, Heidelberg
and J. Zittartz, Köln
Managing Editor: W. Beiglböck, Heidelberg

93

Stochastic Behavior in Classical and Quantum Hamiltonian Systems

Volta Memorial Conference,
Como, 1977

Edited by G. Casati and J. Ford



Springer-Verlag
Berlin Heidelberg New York 1979

Editors

Giulio Casati
Istituto Scienze Fisiche
„Aldo Pontremoli”
Università Degli Studi di Milano
Milano
Italy

Joseph Ford
Georgia Institute of Technology
School of Physics
Atlanta, Georgia 30332/USA

Library of Congress Cataloging in Publication Data

Volta Memorial Conference, Como, Italy, 1977.

Stochastic behavior in classical and quantum Hamiltonian systems.

(Lecture notes in physics ; 93)

Includes bibliographies and index.

1. Hamiltonian systems--Congresses. 2. Stochastic processes--Congresses. I. Casati, Giulio, 1942-
II. Ford, Joseph, 1927- III. Title. IV. Series.
QC174.17.H3V64 1977 530.1'2 79-12135

ISBN 3-540-09120-3 Springer-Verlag Berlin Heidelberg New York
ISBN 0-387-09120-3 Springer-Verlag New York Heidelberg Berlin

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically those of translation, reprinting, re-use of illustrations, broadcasting, reproduction by photocopying machine or similar means, and storage in data banks. Under § 54 of the German Copyright Law where copies are made for other than private use, a fee is payable to the publisher, the amount of the fee to be determined by agreement with the publisher.

© by Springer-Verlag Berlin Heidelberg 1979
Printed in Germany

Printing and binding: Beltz Offsetdruck, Hemsbach/Bergstr.
2153/3140-543210

PREFACE

The fact that completely deterministic, nonlinear systems can yield wildly chaotic solution behavior has, over the past two decades, been independently discovered and re-discovered by numerous scientists working in a host of distinct scientific disciplines. Separated from each other by thickets of specialized jargon and by specialized journals catering to mutually exclusive audiences, these workers had remained largely unaware of the communality of their work. In an effort to break down this scientific provincialism, the undersigned organized and held during the summer of 1977 a conference on stochastic behavior in classical and quantum Hamiltonian systems which, to our knowledge, brought together for the first time astronomers, biologists, economists, physicists, and mathematicians working in this common area. This volume includes some but far from all of the talks presented at that conference. Indeed, we deeply regret the fact that, for various reasons, many of the excellent presentations made during the conference do not appear in these pages. Despite this fact, we hope that the present volume will nonetheless focus the attention of a wider audience upon this subject area.

Historically, this is the second scientific conference to be sponsored by the city of Como as part of its traditional festivals honoring the memory of Alessandro Volta, a native son. The now-famous first Como Conference of 1927, which involved ten Nobel laureates among other notable physicists, was deeply concerned with the then young quantum mechanics and contributed significantly to its further development. The 1977 Como Conference therefore represents a continuation of this earlier conference in the sense that the 1977 Conference was also deeply concerned with quantum mechanics. In particular, much of its time was devoted to the problem of quantizing chaotic classical nonlinear systems, a difficulty anticipated by Einstein as early as 1917

IV

but largely overlooked during the intervening decades. Here also, we hope that the beginning work described herein will be furthered by a larger audience.

To the Mayor of Como, Antonio Spallino, and to the Mayor of Campione, Felice De Baggis, we wish to relay the deep appreciation felt by all participants for the gracious hospitality provided by both their cities. Finally, to Dr. Barbara Giovannini, for service as that organizational mainspring without which a conference cannot succeed, we wish to express our own personal heartfelt gratitude.

Giulio Casati

Joseph Ford

TABLE OF CONTENTS

		<u>Page</u>
1.	G. Contopoulos	Integrable and Stochastic Behavior in Dynamical Astronomy..... 1
2.	A. J. Lichtenberg	Adiabatic and Stochastic Motion of Charged Particles in the Field of a Single Wave..... 18
3.	Gary R. Smith	Numerical Study of Particle Motion in Two Waves..... 35
4.	C. F. F. Karney and A. Bers	Stochastic Ion Heating by a Perpendicularly Propagating Electrostatic Wave..... 44
5.	A. N. Kolmogorov	Preservation of Conditionally Periodic Movements with Small Change in the Hamilton Function..... 51
6.	Martin Kummer	On Resonant Hamiltonians with Two Degrees of Freedom Near an Equilibrium Point..... 57
7.	R. C. Churchill, G. Pecelli, and D. L. Rod	A Survey of the Henon-Heiles Hamiltonian with Applications to Related Examples..... 76
8.	N. Saito and A. Ichimura	Ergodic Components in the Stochastic Region in a Hamiltonian System..... 137
9.	M. Toda	A Question About the Localized Mode Due to a Light Impurity..... 145
10.	O. I. Bogoyavlensky	Nonlinear Oscillation Regimes in Some Physical Problems..... 151
11.	M. J. Feigenbaum	Metric Universality in Nonlinear Recurrence..... 163
12.	A. C. Scott	Magnetic Flux Annihilation in a Large Josephson Junction..... 167
13.	S. Aubry	Some Nonlinear Physics in Crystallographic Structures..... 201
14.	H. Haken and A. Wunderlin	Laser Instabilities - An Example from Synergetics..... 213
15.	J. L. van Hemmen	Dynamics and Ergodicity of the Infinite Harmonic Crystal - A Review of Some Salient Features..... 232
16.	D. Dohrn and F. Guerra	Goedesic Correction to Stochastic Parallel Displacement of Tensors..... 241
17.	S. Albeverio and R. Höpgh-Krohn	The Method of Dirichlet Forms..... 250

		<u>Page</u>
18. Ian C. Percival	Regular and Irregular Spectra of Molecules.....	259
19. R. A. Marcus, D. W. Noid, and M. L. Koszykowski	Semiclassical Studies of Bound States and Molecular Dynamics.....	283
20. M. Tabor	The Role of Periodic Orbits in Semiclassical Quantization.....	293
21. S. M. Colwell, N. C. Handy, and W. H. Miller	Semiclassical Eigenvalues for Rotating Triatomic Molecules.....	299
22. R. T. Swimm and J. B. Delos	Semiclassical Calculation of Vibrational Energy Levels for Nonseparable Potentials.....	306
23. Martin C. Gutzwiller	Classical Quantization Conditions for a Dynamical System with Stochastic Behavior?.....	316
24. A. Voros	Semiclassical Ergodicity of Quantum Eigenstates in the Wigner Representation.....	326
25. G. Casati, B. V. Chirikov, F. M. Izraelev, and J. Ford	Stochastic Behavior of a Quantum Pendulum Under a Periodic Perturbation.....	334
26. R. H. G. Helleman and T. Bountis	Periodic Solutions of Arbitrary Period, Variational Methods.....	353