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DYNAMICAL SYSTEMS
AND
MICROPHYSICS

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FOREWORD BY
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CONTENTS

| | page |
|---|------|
| Foreword by Louis de Broglie | V |
| Preface | VII |
| <i>PART I : Optimization theory and stochastic approaches to quantum mechanics</i> | |
| G. Leitmann: Optimal feedback control for dynamical systems with one or two controllers | 3 |
| A. Blaquière: Wave mechanics as a two-player game | 33 |
| E. Etim: Stochastic quantization on a Riemannian manifold | 71 |
| L. Morato: Kinematics and dynamics of Ito processes | 79 |
| L. Accardi: Quantum Markov processes | 88 |
| S. Diner: Stochastic electrodynamics (S.E.D.): general considerations | 99 |
| P. Claverie: S.E.D.: Methods and results | 111 |
| T.W. Marshall: The Kepler problem in S.E.D. | 135 |
| L. Pesquera: The anharmonic oscillator in S.E.D.: the problem of radiation balance at each frequency | 145 |
| <i>PART II : Evolution and irreversibility</i> | |
| R. Thom: Reversibility versus irreversibility in the physical universe | 155 |
| G. Lochak: Quantization as a stability problem | 167 |
| J. Vassalo Pereira: Adiabatical invariance in microphysics | 191 |
| P. Glansdorff: Evolution of non-equilibrium stable thermodynamic processes | 199 |
| M. Courbage: Intrinsic stochasticity and irreversibility of classical quantum systems | 225 |
| F. Fer: Irreversibility versus Hamiltonian dynamics in statistical thermodynamics | 233 |
| J. Salmon: Irreversibility and environmental forces | 253 |
| M. Grmela: Common structure of non-Hamiltonian dynamical theories of macroscopic physics | 265 |
| J.C. Willems: System theoretic foundations for modelling physical systems | 279 |
| G. Della Riccia: A Hamilton-Jacobi treatment of dissipative systems with one degree of freedom | 291 |

| | |
|---|-----|
| A. Avez: Symplectic group, quantum mechanics and Anosov's systems | 301 |
| C. Galles, C. Ruiz Garrido: Free Euclidean Markov fields of integer spin in the Landau gauge | 325 |
| F. Langouche, D. Roekaerts, E. Tirapegui: WKB-expansions for propagators | 331 |
| D.Fargue: Hamiltonian and hereditary properties of continuous electrical media | 335 |
| T.A. Minelli, A. Pascolini: Solitons of a nonlinear Schrödinger equation | 343 |
| <i>PART III: Non separability and non locality</i> | |
| G. Ghirardi: Non separability in quantum mechanics | 355 |
| O. Costa de Beauregard: The 1927 Einstein and the 1935 E.P.R. paradox | 383 |
| F. Selleri: Einstein locality and the quantum mechanical long-distance effects | 393 |

FOREWORD

Je me réjouis de voir paraître ce livre, car il est le premier à résulter de la réunion de faits de spécialistes des diverses branches de la Physique et des Mathématiques unissant leurs efforts pour toutes les résolutions des problèmes que posent l'interprétation et les difficultés actuelles de la Microphysique.

Je suis particulièrement heureux de retrouver parmi les noms de ceux qui ont participé à la rédaction de ce volume des noms de plusieurs de mes anciens élèves. Mais c'est aussi pour moi un grand plaisir de voir les noms de mathématiciens et de physiciens, venus de nombreux pays étrangers et représentants des tendances et esprits très diverses, voire même opposés, qui ont librement ~~exposé~~ exposé leurs idées durant ces deux semaines de

Travail.

Evidemment les opinions développées dans ce livre sont souvent très différentes, mais c'est souvent du choc des idées opposées que sont sorties les idées nouvelles et fructueuses.

On doit exprimer de bien vifs remerciements aux organisateurs de ces réunions et surtout au

C. I. S. M. et à la ville d'Udine

qui a accueilli le séminaire avec tout de cordialité

Louis de Broglie

I am particularly glad that this volume appears. It is actually the first one to be issued as a result of the meeting of so many specialists from various areas of physics and mathematics striving together towards solving the problems and difficulties of present microphysics.

I am personally pleased to see the names of several pupils of mine among the contributors to this volume. Also, I am delighted that mathematicians and physicists from many countries and representing different, sometimes even opposite trends of thought, freely discussed their ideas during this two working weeks. It often happened that new and fruitful theories came out from the contrast of antagonist ideas.

Thanks should be expressed to the organizers of this meeting and above all to C.I.S.M. and to the town of Udine which has so warmly welcomed the seminar.

Louis de Broglie

PREFACE

In spite of a half century of experimental verification of quantum predictions in an incredibly large variety of physical phenomena, with a very high accuracy, a number of features of quantum mechanics are still quite generally considered as unsatisfactory. According to what is reported among physicists, we find for example in the list: can Quantum Mechanics really account for anything else than stationary states and reversible processes? Did it succeed in the explanation of intricate properties of high energy particles? What about the highly controverted question of quantum non-separability?

As the concern of physicists for the above mentioned aspects of quantum mechanics increased, a new mathematical discipline has emerged from the bustling scientific activity of the last two decades, namely the mathematical theory of dynamical systems, or more concisely system theory. Its applications increased in range and importance with each passing year and rapidly reached various areas such as mathematical physics, economics, biology, operations research, and related fields.

Among other topics, system theory is concerned with: optimal control and differential games; that is, more generally, optimization theory, stability theory, linear and nonlinear oscillators, stochastic and hereditary dynamical systems.

This bunch of new techniques and concepts has thrown a new light on dynamic analysis of systems, in the areas on which we shall focus our attention in this book. It has thus disclosed new paths for approaching modern physics, and made questionable some of the arguments which led to a discontinuity in the course of physics, about fifty years ago.

With the objectives of exploring the current and potential areas of interactions of system theory with modern physics and of fostering active exchange of ideas among people with different backgrounds, a two-week seminar was organized in September 1979 with the theme "Mathematical Theory of Dynamical Systems and Microphysics", at the International Centre for Mechanical Sciences (CISM) in Udine, Italy. We record here some of the results of fruitful discussions among the participants of the seminar.

The material published in this volume can be ideally divided into three parts, though the reader will find several overlaps between them.

In Part I we present papers dealing with optimization theory and stochastic approaches

to quantum mechanics. This set of papers is, itself, subdivided into three groups. In the first group, optimization theory is presented in introductory lectures by Leitmann. They prepare the ground for the lectures by Blaqui ere which make the junction between optimization theory (e.g. an extension of the least action principle and of the theory of Hamilton-Jacobi) and a relativistic stochastic approach to quantum mechanics. The second group to which the papers by Accardi, Etim-Etim, Mitter and Morato belong, is more specifically concerned with the existing parallelism between the theory of stochastic processes (in the mathematical sense) and quantum theory. The third group, represented by the papers of Claverie, Diner, Marshall and Pesquera deals with Stochastic Electrodynamics (S.E.D.). In contrast to the theories above, S.E.D. is basically classical electrodynamics with radiation damping and a non-white stochastic electromagnetic field.

For instance stochasticity enters thermodynamics, and causality is obviously concerned with time symmetry or asymmetry as in some discussions of the EPR paradox.

Part II is devoted to "Evolution and irreversibility", which is maybe a too broad subject to keep a thorough homogeneity; but no classification is perfect. This part may be divided in four groups. The first one bears on general aspects of the question: a lecture of Thom on reversibility versus irreversibility; one of Lochak on stability and irreversibility; and a paper of Vassalo-Pereira about relations between stationarity and adiabatic invariance.

The second group is a more thermodynamical one: a review by Glansdorff of the modern views of non-equilibrium stable processes; a paper of Courbage on irreversibility and stochasticity in dynamical systems; papers of Fer on the comparison of irreversibility and hamiltonian character, Della Riccia on the Hamilton-Jacobi treatment of one sort of dissipative systems, of Salmon on the irreversibility axioms in Thermodynamics, and of Grmela on an inversion structure of non-hamiltonian dynamics.

The third group is centered about the notion of state: papers of Willems on System theoretic foundations for modelling physical systems, of Avez on a new method of quantization starting from symplectic dynamics, of Galles et al. on euclidean Markov fields of integer spin, of Tirapegui et al. on a W.K.B. expansion.

The last group deals with models which go out of the frame of classical quantum mechanics: a paper of Fargue on the hereditary evolution of continuous electric media, and of Minelli and Pascolini on a soliton-like solution of a non-linear Schr odinger equation.

Part III contains a contribution to the question of E.P.R. paradox and related topics. The reader will find a paper of Ghirardi on quantum non-separability, another of Selleri on the einsteinian view of locality, a paper of Costa de Beauregard on the same debate, and on experiment proposals by Gutkowski.

We take this opportunity to express our gratitude to CISM which originated the idea of

this seminar and shared the major part in its scientific and practical organization. We wish to thank Dr. Vinicio Turello, president of CISM for his generous hospitality, and all CISM staff, and in particular Mr. Carlo Tasso, for their able and competent assistance.

We are also indebted to UNESCO and IFAC (International Federation for Automatic Control) for their sponsorships. In particular, the former provided financial assistance to several researchers from developing countries and made possible their participation. Also thanks are due to the Fondation Louis de Broglie for its participation to the seminar.

A. Blaquière, F. Fer, A. Marzollo

January 1980