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Chaos – The Interplay Between Stochastic and Deterministic Behaviour

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PREFACE

Theoretical science up to the end of the nineteenth century can be viewed as the modeling of natural phenomena by deterministic solutions of differential equations. At that time it was at that time commonly thought that if all initial data could only be collected, one would be able to predict the future with certainty. The theory of chaos is fascinating if for no other reason than its blurring of the long-held distinction between random and deterministic phenomena. It is potentially capable of explaining very complex processes with simple, parsimonious models. However, there are many important questions about the new theory that remain currently unresolved, and it is likely that some of these issues will never find solution. The question of choosing between deterministic versus stochastic modeling of a process under study is such an issue, but the stochastic modeling presently has a clear advantage because of the rich variety of model-fitting tools provided by mathematical statistics and modern probability theory.

The discovery of chaos in mechanical systems and the subsequent development of mathematical and physical theories of nonequilibrium phenomena, of the relationship between a physical and algorithmic complexity, supported by the mathematical experimentation on powerful computers, may yet prove to be events of great importance. Undoubtedly, the quantitative description of chaos is one of the triumphs of nonlinear science. On the other side, there does not appear to be a universally accepted, mathematical nor physical definition of chaos. There are different ways to quantify what one might mean by complex or unpredictable behaviour. The primary concept appears to be the notion of sensitivity to initial conditions, albeit the detailed reason of this sensitivity in any particular problem, be it deterministic or stochastic, must be separately settled and justified by phenomenological data. Seemingly a trivial task on the theoretical level, it has proved to be a real problem, while fitting mathematical models to experimental situations, since the distinction between deterministic and essentially stochastic manifestations of chaos is not sharp.

Chaotic and random phenomena provide the area where certain frontiers of physics and mathematics can fully overlap on problems that are fundamental and yet have practical implications. The XXXI Karpacz Winter School of Theoretical Physics: "CHAOS: the Interplay Between Stochastics, Classics and Quanta" was organized by the Institute of Theoretical Physics of the Wrocław University during the period: February 13 – February 24, 1995 in Karpacz, Poland. The aim of this school was to provide a forum for the presentation and discussion of recent results on chaotic and essentially random phenomena with emphasis on their interaction (interplay) and application in a number of physical problems. A presentation of related mathematical lectures was an integral part of the School.

This volume contains the written and often extended versions of lectures, and contributed papers (seminar talks) presented in the course of Karpacz'95. A great majority of papers present new results in the field and the remaining are expository in nature. The collection demonstrates the broad range of interests of the school participants but, following our intention, focuses on the unifying *interplay* idea, expressed in the School title, to the extent that makes any traditional chapter-style organization of the material unprofitable. Therefore a major division into Lectures and Seminars is followed by the alphabetical ordering of contributions.

However, for the benefit of a potential readership some general hints towards the main subject-matter streamlines of the School, modulo their mingling and braiding, might be helpful. Therefore we shall give a brief survey of the content of the volume.

Its title is slightly different from that originally coined for Karpacz '95, and emphasizes the interplay between deterministic and stochastic manifestations of chaos. Neither of these terms should be assigned a narrow meaning. We commented before on the unsharpness of traditional intuitions about chaos, and in addition one should realise that what is meant by deterministic or stochastic usually remains ambiguous unless more detailed physical specifications are given to quantities involved in the theoretical (mathematical) framework.

We extract what can be interpreted as the (non-disjoint) subject-matter indicatives for the invited lectures presented in the course of Karpacz'95:

- Random walks, Brownian motion, diffusions, jump and compound jump processes, Lévy processes and their generalisations (Beck, Belavkin, Blanchard, Cetto, Garbaczewski, Grigolini, Haba, Hu, Klafter, Lasota, Reichl, Weron, Zambrini)
- Deterministic versus stochastic dynamics, classical and quantum (Beck, Cetto, Garbaczewski, Haba, Grigolini, Zambrini)
- Classical versus quantum stochastics (Belavkin, Blanchard, Graham, Grigolini)
- Semiclassical chaos (Graham, Grigolini, Jauslin, Lai, Reichl, Tomsovic)
- Turbulence, dissipation, order (Beck, Hu, Manneville)
- Nonlinear oscillations and strange attractors (Kapitaniak, Manneville, Szemplińska-Stupnicka, Vavriv)
- Mathematics of fractals and chaos (Hu, Keane, Lasota, Mrozek)
- Quantum qualitative measures of chaos–entropies and characteristic exponents (Vilela Mendes, Roepstorff)
- Computer experiments and theory (Mrozek, Tomsovic, Weron)

Seminars appear to complement these topics in a natural way.

We thank all the invited lecturers, contributing speakers and other participants for the lively meeting they created. It is this interaction between physicists, chemists, mathematicians, and computer scientists (and engineers) which enriches and propels this field.

The School was made possible through the financial support from a number of Institutions which are acknowledged separately. We have another obligation

to express our gratitude to at least a few colleagues, members of the Organizing Committee, Dr. A. Borowiec, Dr. M. Mozrzymas and Mr. P. Siemion, while extending our thanks to many other, unnamed persons. Last but not least, we would like to thank Ms Anna Jadczyk for her invaluable editorial assistance.

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[1] The names of the speakers are underlined where there are more than one author

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