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Book Review: *The Quantum Statistics of Dynamic Processes*

The Quantum Statistics of Dynamic Processes, E. Fick and G. Sauerman (Springer Series in Solid-State Sciences, Vol. 86), Springer-Verlag, Berlin, 1990.

This volume is a combination of two volumes originally in German and appears in an excellent translation into English. In part 1, general aspects of quantum statistics are treated with emphasis on Liouville space. An interesting and careful discussion of information theory is presented. Parts 2 and 3 treat response and relaxation theory using Mori and Kubo theory for linear and quadratic response theory. The Mori approach to the derivation of generalized Langevin equations for dynamical variables is presented and contact is made with the thermodynamics of irreversible processes. In part 4, similar techniques are used to obtain Nakajima–Zwanzig theory and Robertson theory.

The book contains excellent formal presentations of the various topics covered. One of the most interesting chapters covers the information–theoretic construction of the quantum statistical operator. This chapter avoids most of the pitfalls that usually appear in discussions of the relationship between statistical mechanics and information theory. The reader might be surprised that a given system may have different entropies, depending on how many macroscopic variables are needed to specify its state. Hosever, the authors produce convincing arguments that this is a valid point of view.

Unfortunately, very few specific physical examples are treated in any detail and the uninitiate may be at a loss if he or she wishes to apply the formalism to a particular system. It is, of course, difficult, if not impossible, to provide a prescription for the treatment of time dependence in an arbitrary system, but more examples and more physical discussion would help.

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In sum, this is a fine book for experts in the field and for advanced graduate students.

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Book Review: *Chaos in Systems with Noise*

Chaos in Systems with Noise, 2nd ed., Tomacz Kapitaniak, World Scientific, Singapore, 1990.

Although, in contrast to high-temperature superconductivity and (of blessed memory) cold fusion, chaos in the scientific sense does not appear on the first pages of the *New York Times*, the phenomenon of deterministic chaos is well known in many fields of research these days. The most noticeable feature of chaos is the great sensitivity of chaotic solutions to initial conditions, i.e., "a small error in the initial conditions produces very great differences in the final phenomena." This citation dates back to 1913,[1] although the first record of chaos (which was later transformed into order!) appeared somewhat earlier.[2] However, the real burst of "chaotic" literature has only taken place during the last 20 years. Some general books on this subject are practically indistinguishable. The time has come to pass from general books to monographs covering some of the specific features of this exciting phenomenon.

The book under review belongs to the latter category, and is devoted to the simultaneous influence of deterministic and random chaos or, in the author's terminology, "regular stochastic processes" and "random stochastic processes." Deterministic chaos may appear in nonlinear equations of motion of at least three independent dynamical variables. Random ("Brownian") chaos appears as a result of adding a random noise to these equations. Both types of chaos arise in a variety of fields of physics, chemistry, biology, and social science, and this generates a need for their simultaneous study. This is precisely the subject of this book.

One perceives the smell of chaos from the book cover: the book, published by a Singapore publishing house, is written by a Polish scientist who acknowledges scientific discussions with a South African professor,

[1] H. Poincaré, *The Foundation of Science: Science and Method* (1913), p. 397 (English transl. Science Press, Lancaster, Pennsylvania).

[2] Genesis **1**:1 (Mount Sinai, a very old and hardly accessible edition; more recent editions are readily available).

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and the Kingdom of Saudi Arabia Fund for financial support. It this is not enough, this review is written by an Israeli physicist of Russian origin.

The author concentrates his attention on the influence of noise on period-doubling and Hopf bifurcations, as well as on the following methods of analysis of onset of chaos in noisy systems: (a) the generalized Melnikov criterion for the onset of the Smale horseshoe chaos; (b) analyses of the mean value of the (random) Lyapunov exponents; (c) time and coordinate dependence of the probability density functions; and (d) time dependence of the stochastic sensitivity functions.

All of these methods are applied to non-Hamiltonian systems described for the most part by the bistable Duffing oscillator with periodic and quasiperiodic excitations. Band-limited white noise is used in the analysis.

The main conclusion of the book is that noise causes a nonlinear system to become more stable with respect to an onset of chaos ("loss of chaos"). In other words, to introduce chaos, a noisy system must be driven by a larger external deterministic force than that in a noise-free case.

This book provides an extended version of the author's postdoctoral thesis. The first eight chapters of the book, which are added or rewritten in the present second edition, contain some general concepts of chaos and the useful tools for its study. Mathematicians will not find these chapters rigorous enough, and physicists will find them too abstract. In any case, it is not enough to read only the introductory part of the book in order to understand the second major part. I would therefore recommend to readers familiar with the principles of deterministic chaos to start reading from Chapter 9, then go to §11.4, and finally to read Chapters 12 and 13.

It should be noted that even the main part of the book is subject to criticism:

1. The author presents many examples of numerical solutions without any attempt to reveal some generic regularities.

2. He includes many mathematical details of articles published in the *Physical Review*, but omits details of scarcely available works of Polish scientists.

3. The book includes neither a section of conclusions nor a subject index.

4. Numerous misprints hinder reading. Here are some of them: (a) (9.3) instead of (9.1) on pp. 87–89; (b) Eq. (13.3) instead of (12.3) on p. 159; (c) Eqs. (3.4) and (8.6) are quoted in the text, but are not enumerated elsewhere. (d) c must be replaced by D_c in the table on p. 94; (e) references to Kapitaniak (1990a, 1990b) quoted on p. 206 do not

appear in the reference list; (f) the dot over variables is absent in Eqs. (10.1) and (13.3) and after Eq. (11.24), etc.

In spite of the obvious shortcomings of the book, credit must be given to the author for tackling the fascinating problem of the relationship between deterministic and random chaos. There are still many open questions in this field. Everywhere in the book the additive noise is considered, and this results in the above-mentioned "loss of chaos." It turns out, however, that the multiplicative noise both for the logistic map[3] and for the nonlinear oscillator[4] results in an "early chaos." This means that a shift in the onset of chaos has been found below the noise-free threshold (the "noise-induced chaos" (see footnote 4). One should also mention the recent results of the influence of noise on the onset of chaos in Hamiltonian systems[5] (in contrast to dissipative systems considered in the book under review). New results have been found for the time-averaged probability from the Fokker–Planck equation equivalent to a nonlinear oscillator with a constant periodic and random external force.[6] The results of this investigation are that the multiple maxima, found for the first time by the author of this book, are washed out for increasing noise strength.

It is to be hoped that this book will initiate new studies in the mutual influence of deterministic and random chaos.

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[3] J. Rossler, M. Kiwi, B. Hess, and M. Markus, *Phys. Rev. A* **39**:5954 (1989).
[4] W. C. Schieve and A. R. Bulsara, *Phys. Rev. A* **41**:1172 (1990).
[5] G. Györgyi and N. Tishby, *Phys. Rev. Lett.* **62**:353 (1989).
[6] P. Jung and P. Hanggi, *Phys. Rev. Lett.* **65**:3365 (1990).