The quantum statistics of dynamic processes

P. I. Arseev

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E. Fick and G. Sauermann, *The Quantum Statistics of Dynamic Processes*, Springer-Verlag, Berlin, New York, Heidelberg, 1990, p. 395 (Springer Series in Solid State Sciences, Vol. 86).

This book is an English translation of a supplemented and revised version of the two-volume textbook "Quantenstatistik Dynamischer Prozesse" (Vol. I, IIa), published in West Germany in 1986. The authors have undertaken the problem of writing a textbook in which all of the most important methods and results obtained in the area of a microscopic description of dynamic processes would be collected. Considering that the application of quantum mechanics is necessary for a microscopic description, the authors from the very beginning adhere rigorously to the framework of quantum theory. To a large degree the presentation is made in terms of evolution in Liouville space, which, together with the projection formalism, constitutes an important mathematical tool of statistical physics. The book consists of 18 chapters, combined into four parts, and two appendices.

The first part is introductory in nature. Certain general aspects of quantum statistics are considered in it, starting with definitions of a statistical operator and Liouville space and a derivation of the basic equations of quantum dynamics. The reduction of a statistical operator for a subsystem, the possibility of determining a generalized canonical statistical operator through the use of the procedure of maximizing the measure of indeterminacy, and similar questions are also discussed.

The second part is devoted to the theory of the response of systems to time-dependent external field. The formalism of Mohr scalar product, application of which makes it possible to look at the kubo formula for linear response in a new light, is described at length. Numerous corollaries of the kubo formula are developed for specific physical systems. By not limiting themselves to linear response theory, the authors consider in considerable detail the theory of quadratic response also.

The third part, in essence, is the core of the book. In it are derived the equations for the evolutuion observed in the presence of small deviations of a system from equilibrium. The transition from the most general and complete equations of system dynamics to equations for slow variables, containing damping, is traced in detail. Considerable attention is paid to a discussion of those aproximations that make it possible to introduce damping constants (relaxation time or finite line width) into the quantum mechanical description. The theory is illustrated by specific physical examples which certainly make it easier to understand the general topics presented.

The concept of the essential part of a statistical operator is introduced in the fourth section and the question of modifying the von Neumann equation for different cases of projection of the statistical operator onto the essential part is investigated. It is shown that the linear projection operation leads to the Nakajima–Zwanzig equation. In the special case of projection onto the statistical operator of a subsystem this equation is the starting point for studying dissipation processes. In addition to the linear theory, relations of a more general nature are also established for the case of nonlinear mapping of a statistical operator onto the essential part.

For a fuller explanation two topics of a handbook nature are covered in the appendices. The relation between the equation for the statistical operator of a subsystem and the generalized Langevin equation is characterized in the first of these appendices. General questions of the symmetry of kinetic coefficients are considered in the second appendix.

On the whole, the positive aspects of the book include the order of the presentation and the striving to combine different known results within the framework of a common mathematical apparatus. Since this book was considered by the authors as a textbook, all of the mathematical concepts that are used are defined in detail and are explained during the course of the presentation. Therefore, despite the considerable rigor and generality of the presentation, it does not raise problems for nonspecialists to understand the mathematical apparatus being used. In addition to illustrations of the results by physical examples, each section includes problems that contribute to a deeper understanding of the application of the methods to specific problems.

The book is definitely of interest for a fairly wide circle of readers: from students in the higher courses to scientific workers that wish to become more familiar with the problems of the quantum statistical description of dynamic processes.