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Book Review: *Quantum Dissipative Systems*

Quantum Dissipative Systems, U. Weiss, World Scientific, Singapore, 1993.

The book is written in the traditional style of physics journal articles, relying more on mathematical presentation than on verbal discussion. However, in spite of its concise nature, the book provides a satisfactory account of the development of our understanding of dissipation in quantum mechanical systems since the seminal work of Caldirola (1941), chronicling each of the major contributions since that time. Weiss gives a brief but complete account of projection methods based on the work of Mori and Zwanzig. After critiquing their method, within which it is difficult to go beyond the so-called Born approximation, the author addresses quantum dissipation with the path integral formalism, the major theoretical tool used in the book.

Weiss demonstrates how the path integral formalism can lead to formally exact results. The limitations are that the coupling between the system of interest and the bath is treated as bilinear and the bath itself is harmonic. These formal limitations should not repel those interested in nonlinear dynamics, since it is the quantum nature of the process that is of primary interest here. Further, in the special case where the system of interest is also linear, the formal equations yield explicit closed-form solutions resulting in an exact treatment of quantum mechanical fluctuations, dissipation, and the relation between them.

These various approximations are discussed in the context of real physical systems, such as the Josephson junction and particularly the SQUID made popular by the research investigations of Leggett and co-workers wherein they developed the field of study of the macroscopic effects of quantum mechanics.

The prototype problem of a double-well potential in which a particle escapes from one well into the other is a member of the family of quantum problems that are not exactly solvable, but which have provided great insight into quantum phenomena. Weiss has contributed significantly in

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this latter area of study, and in this book the reader may find a synthesized perspective of the entire subject of thermally activated rate processes, ranging from the classical treatment of Kramer's to the most recent studies. Of particular interest is the discussion of the so-called crossover temperature, namely, the temperature below which the escape from one well to the other is essentially tunnelling, and above which it is essentially stochastic, i.e., an Arrenhuis-like process. Weiss provides a clear exposition of how the crossover temperature is influenced by dissipation and by the details of the interaction between the system of interest and the bath.

Another generic problem discussed at some length is that of spin–boson dynamics, namely the evolution of a two-level quantum system interacting with a bath of harmonic oscillators. One of the more interesting applications of this Hamiltonian is to the description of macroscopic effects of quantum mechanics. The two-level system mimics a doublet and the coherent tunneling between the two levels, one of the most characteristic effects of quantum mechanics. The coherence must compete with the interaction of the system with the environment, which is to say compete with random operator fluctuations and dissipation, and the spin–boson Hamiltonian is the simplest model taking into account all the physical aspects of this problem. The author discusses in detail some of the more successful techniques used to study the competition between coherence and the environmental interactions. Among the successful approaches are the contributions of the author's own research group and those of the Leggett group. The reader can find an exhaustive treatment of how the tunneling properties are essentially quenched by dissipation.

Because of its style and content, the book is written for the advanced graduate student and/or researcher interested in the general problem of quantum mechanical dissipation. The book explicitly shows what has been done to increase our physical understanding of this phenomenon, and implicitly what the advantages are to using certain formal techniques. It is fairly fast reading and for those interested the author shows where the ground is well plowed and where it has been fallow. Readers will be able to reach an overview of the state of the art in this field without having to amass their own research library. The latter is by and large rather wide and confused, like most areas of active research, but the author does a good job in clearing away the confusion and presenting a well-organized account of this area of investigation.

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