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Green's Functions in Quantum Physics

With 49 Figures

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Preface

This text grew out of a series of lectures addressed to solid-state experimentalists and graduate students beginning their research career in solid-state physics.

The first part consisting of Chaps.1 and 2 is a rather extensive mathematical introduction which covers the material about Green's functions usually included in a graduate course on mathematical physics. Emphasis is given to those topics which are of significance in quantum physics. On the other hand, little attention is given to the important question of determining the Green's functions associated with boundary conditions on surfaces at finite distance from the source.

The second and main part of the book is, in my opinion, a first effort to collect in a systematic but concise way various topics of quantum physics, where the Green's functions (as defined in Part I) can be successfully applied. Chapter 3 is a direct application of the formalism developed in Part I. In Chap.4 the perturbation theory for Green's functions is presented and applied to scattering and to the question of formation of bound states. Next the Green's functions for the so-called Tight Binding Hamiltonian (TBH) are calculated. The TBH is of central importance for solid-state physics because it is the simplest example of wave propagation in periodic structures. It is also important for quantum physics in general, because it is rich in physical phenomena (e.g., negative effective mass, creation of a bound state by a repulsive perturbation) and, at the same time, simple in its mathematical treatment. Thus one can derive *simple, exact* expressions for scattering cross sections and for bound and resonance levels. The multiple scattering formalism is presented within the framework of the TBH, and it is applied to questions related with the behavior of disordered systems (such as amorphous semiconductors). The material of Part II is of interest not only to solid-state physicists but to students of a graduate course in quantum mechanics (or scattering theory) as well.

In Part III, with the help of the second quantization formalism, the many-body Green's functions are introduced and utilized in extracting physical information about interacting many particle systems. Many excellent books have been devoted to the material of Part III (e.g., FETTER and WALECKA: *Quantum Theory of Many-Particle Systems* [4.1]). Thus the present-treatment must be viewed as a brief introduction to the subject; this introduction may help the solid-state theorist approach the existing thorough treatments of the subject and the solid-state experimentalist to be acquainted with the formalism.

At the beginning of each chapter, there is a brief summary of what the reader will find in the particular chapter. The summary contains also the most important equations numbered as in the main text of the chapter.

I would like to thank Nuclear Research Center "Demokritos" and the Greek Atomic Energy Commission for their hospitality during the writing of the second half of this book.

November 1978 E.N. Economou

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