Preface

The last few years have seen revolutionary advances in our understanding of the electronic properties of quantum heterostructures. An enormous amount of research has been undertaken on both the experimental and the theoretical aspects of electronic transport in nanostructures. The field now covers a vast spectrum of topics, and an extensive number of books, review articles, papers and conference proceedings continue to be published in this area. Complete coverage of this exciting and evolving field is beyond the scope of this book. We refer the interested reader to some of the excellent and comprehensive books and conference proceedings on this subject.

Much progress has been made in our understanding of quantum confined systems. As is well known, it is possible to construct quantum heterostructures which are well approximated as quasi-two-dimensional, one-dimensional or zero-dimensional systems. Our interest here is in the properties of particles and fields in quasi two-dimensional (2-D) systems. We provide a brief introduction to the physics of 2-D systems, in particular to motion in 2-D systems confined within a finite area. For simplicity, we will generally assume that the system boundary is defined by an infinite hard wall potential. Such a confined 2-D system will be referred to as a *tube*, or interchangably as a *wire*. We will investigate the behavior of particles moving in a tube with perfect hard-wall boundary conditions, with emphasis on the qualitative effects which govern binding and transmission of particles in confined 2-D systems.

Our goal is to convince the reader that rather simple models of binding and scattering in 2-D systems can be remarkably successful in describing even rather complicated phenomena. We will first review the general conditions which produce bound states for particles in confined tubes. Some powerful theorems guarantee the existence of bound states under rather simple and general physical conditions. Next we discuss the properties of transmission and reflection, conductance and quantum probability flow in 2-D systems. Physical situations are analyzed using a transfer-matrix approach. Although this is neither the most efficient nor the most elegant method for calculating transport in 2-D systems, it is shown that transfer matrix techniques have a very straightforward physical interpretation and that they provide considerable understanding of the physics which governs particle transport. We emphasize that much insight can be obtained from an analysis of quantum probability flow in 2-D systems.

This book is written to be accessible to anyone with an undergraduate background in quantum mechanics and electromagnetism, plus some elementary condensed matter physics. It emphasizes basic concepts throughout and describes simple models through which complex scattering phenomena can be observed and understood in these systems. For examples of these transport phenomena, we frequently refer to results involving electrons in mesoscopic systems. However, we show that analogous behavior can also be observed for electromagnetic fields in conventional waveguides. We emphasize the connections (and contrasts) between electron motion in quantum structures and electromagnetic states in waveguides. A third field, the study of optical states in photonic crystals, is much more recent and highly promising. Again, we show that the simple models employed in this book are capable of understanding the mechanisms for producing localized modes in photonic crystals, and we discuss similarities and differences between optical states in photonic crystals, electronic states in quantum heterostructures and electromagnetic fields in waveguides.

Acknowledgments

We have benefited greatly from the assistance provided by several colleagues and friends. We acknowledge especially comments and suggestions from Donald Sprung, Bob Jaffe and Pavel Exner, who carefully read all or part of this manuscript. We also thank K.-F. Berggren, Dan Goldbaum, Lee Harle, J.D. Joannopoulos, Kieran Mullen, W. Renger, Brian Serot, Dallas Trinkle, Hua Wu and Chris Yung for their contributions. The successes of this work are due largely to the assistance we have received from friends and colleagues; we take personal responsibility for any mistakes which remain.

We also wish to acknowledge several groups and institutes who have provided hospitality or support. David Murdock wishes to thank the Indiana University Nuclear Theory Center and Cyclotron Facility for their support for several visits. J.T. Londergan thanks the Special Research Centre for the Subatomic Structure of Matter, Adelaide, Australia, and particularly its Director, A.W. Thomas, for hospitality while part of this book was being written. Finally, we would like to thank the National Science Foundation for its partial support while this work was carried out. Research was supported under NSF contracts PHY-9722076 and DMR-9423088. Summer undergraduate students were supported under NSF Research Experiences for Undergraduates (REU) programs at the Indiana University Cyclotron Facility.

Bloomington, IN, September 1999

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