Preface

Quantum systems on discrete spaces represent to date a rapidly growing research field lying at the interface between tight binding models in solid-state physics and theoretical developments like discrete and q-difference equations. The interplay between such directions provides a deeper understanding of nanoscaled structures which, since more than one decade look increasingly promising for technological applications in electronic devices. Such systems concern the two-dimensional (2D) electron gas under the influence of transversal magnetic fields, the conductor on the 1D lattice in the presence of electric fields, 1D rings in external fields and at last, but not at least, junctions between rings and leads, rings and quantum dots or dots and leads. Promising developments have also been done in the field of quantum LC-circuits. The space discretization has been successful in providing explanations needed for several phenomena like the dynamical localization on the 1D lattice under the influence of time dependent electric fields. It should be remarked, quite satisfactorily, that such phenomena have received evidence in high precision experiments with GaAl/GaAlAs, or other self assembled heterostructures. We also succeeded to establish period doubling in the flux dependent oscillations of total persistent currents in discretized Aharonov-Bohm rings, which deserve further attention.

From the theoretical point of view our main emphasis in this volume is on solvable quantum mechanical systems on the discrete space. Besides the discrete Schrödinger-equation, the most typical example is the second order discrete Harper-equation serving to the description of Bloch-electrons on 2D lattices threaded by a transversal and homogeneous magnetic field. Handling such systems is intimately connected with a lot of mathematical subtleties like orthogonal polynomials of a discrete variable, commensuration and incommensurability effects, periodic and quasiperiodic structures, q-deformed and discrete equations or relationships between localization effects and Lyapunov exponents. Such issues are able to be used for an updated study of thermodynamic and transport properties, but useful details concerning the quantum Hall effect are also included. We would like to emphasize that the presented matter reveals the increasing perspective concerning the role of space-discreteness for a deeper understanding of nanoscaled systems. To this aim mathematical details needed have been introduced in as transparent a manner as possible.

We found it reasonable to restrict ourselves to 11 chapters. In addition, there are more than 300 alphabetically ordered citations, titles of papers included. It is understood that other special matters, such as discrete Klein-Gordon and Dirac equations, or nonlinear lattices, go beyond the immediate scope of this volume. However, the main point remains, namely to solve discrete Schrödinger-equations and especially tight binding models under the influence of external fields. Accordingly, there are reasons to say that we succeeded in reviewing interesting developments within a reasonable amount of space. For the sake of complementary information in the field of semiconductor supperlattices monographs by Bastard (1992), Datta (1995) and Akkermans and Montambaux (2004) are quite useful.

The present volume can be recommended first of all to graduate students and doctoral fellows dealing with Theoretical Physics and its applications. The presented matter is also profitable for advanced students in solid-state physics, applied mathematics and microelectronics. Moreover, useful information for researchers interested in the field is also provided. This volume originates from the updated and revised formulation of our previous lecture in the field (Papp and Micu (2005)).

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