Preface

In many-particle spectroscopy a sample is disturbed by an approaching test particle with well-defined properties. The response of the system depends decisively on the amount of energy and momentum transferred during the interaction with the external particle. If allowed by energy- and momentum-conservation laws, the sample's constituents may be excited into continuum states where their quantum numbers can be resolved simultaneously with those of the testing particle. Scanning the reaction probability as a function of these quantum numbers one can investigate various aspects that may be categorized as follows: (i) One can study the single-particle spectrum of the sample and how it is modified by the presence of other degrees of freedom. (ii) One can assess the frequency and the momentum-dependent potential experienced by the test particle when it couples to the target. (iii) Momentum-space few-particle correlation functions can also be accessed. Due to its inherent many-body character, the many-particle coincidence or correlation spectroscopy is uniquely suited for the study of the latter two categories. Originally, the coincidence technique was developed and utilized to address problems in nuclear physics, and soon after the method was applied to atomic, molecular and condensed-matter systems. It is however only recently that the coincidence spectroscopic techniques have been advanced and refined to a level where their unique features can be fully exploited, in particular as far as the mapping of properties akin to correlated many-body systems is concerned.

This experimental advance is paralleled with equally important progress in the numerical and conceptual understanding of the physics of correlated finite and extended systems. The aim of the present treatise is not to review or even summarize all of the experimental and theoretical achievements in this field but to distill some simple but general mechanisms of how interacting electronic systems respond to an external perturbation induced by an incident particle. In a further step we reflect on how these mechanisms and the system's response can

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serve as a tool to map out the properties of interparticle correlations by means of many-particle spectroscopies. Only a small fraction of the available body of experimental and theoretical findings is employed for this purpose and I apologize to all the colleagues whose works and results could not be addressed and/or fully analyzed here.

The book starts with a qualitative analysis of the outcome of the two-particle correlation spectroscopy of localized and delocalized electronic systems, as they occur in atoms and solids. The second chapter addresses how spin-dependent interactions can be imaged by means of correlation spectroscopy and points out similarities and differences between finite spin-polarized systems (such as polarized atoms) and extended systems (ferromagnets).

A further chapter discusses possible pathways for the production of interacting two-particle continuum states and provides illustration and analysis using some of the available experimental data on atomic systems. In addition, we explore to what extent these mechanisms remain viable when the system size grows.

To connect to known concepts in condensed-matter physics we present briefly in a further chapter some established ways of quantifying electronic correlations and point out the relationship to correlation spectroscopy.

Furthermore, we address in a separate chapter how the frequency and the momentum-transfer dependent response of an electronic system can be assessed by means of two-particle spectroscopy and illustrate the ideas by some applications to fullerenes and metal clusters.

The last two chapters are devoted to the investigation of the potential of two-particle spectroscopy in studying ordered surfaces and disordered samples. In particular, we explore the main possible processes for the generation of interacting two-particle states at surfaces and draw some conclusions as to what novel information is extractable from this spectroscopy.

Throughout the book the material is analyzed using rather qualitative arguments and the results of more sophisticated numerical theories serve the purpose of endorsing the suggested physical scenarios. The foundations of some of these theories have been presented in a first volume of this book.

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