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## Preface

Lectures on Quantum Mechanics will, in most cases, stop at Clebsch–Gordan coefficients and, perhaps, mention the Wigner–Eckart Theorem. Any student venturing beyond this limit into the theory of atomic states will, of course, be immediately confronted with further coupling coefficients of higher order.

Once familiar with these concepts and quantities, it is quite natural to seek and explore the conditions and options available. Drawing from our own experiences, we realized that a text like this introduction could encourage and facilitate getting deeper into the subject. However, an introductory chapter presents notation, relations between and symmetry properties of, more or less, familiar coupling coefficients as a bridge-head into unknown territory.

The graphical representations and methods for treating and manipulating higher-order coupling coefficients represent the main topic of this book. Although the graphical theory presented here has been around for some time, it has, perhaps, not received the attention it merits.

Starting from the simplest building blocks we gradually introduce more complex elements. Initially the emphasis is on the equivalence between algebraic and graphical representations, but later we shift to solving problems with the help of graphical methods. The solutions to these problems are derived in a step-by-step manner to provide the option of self-study. Most of the results are known from the literature, but it would be negligent not to demonstrate that the power of the graphical method enables one to transcend the set of known results, as we do in a few cases.

The final, and rather difficult, chapter is devoted to an application of the graphical theory within a calculation relevant in the area of atomic physics. There we demonstrate the elegance and superiority of the graphical method in deriving a result for which the algebraic method is only a theoretical option.

This book contains, perhaps, less written text than might be expected but many more figures. It is thus obvious that the diagrams represent an essential part of the presentation and merit detailed study. We have tried hard to provide enough explanatory figure captions to soften the impact of complex diagrams.

Only the future will tell whether we were successful in compiling a useful and reader-friendly book, as was our intention. Although great care was exercised in the preparation of text and diagrams, we have to accept the blame for all errors escaping unnoticed in the final copy.

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PS: Looking back, it could be said, this project may have started a long time ago, when we had first contact with coupling coefficients in quantum mechanics. For one of us (E.B.) it was his teacher, mentor and friend Prof. Otto Hittmair, who introduced him to these strange entities, that govern even stranger nuclear reactions. In later years both authors had the privilege of working as postdocs with Walter Marshall (later Lord Marshall of Goring), and again, we encountered these vector coupling coefficients as essential ingredients of many-electron wave functions describing magnetic neutron scattering.

On and off through the years, due to our mutual influence and collaboration, familiarity with the vector coupling coefficients of higher rank increased and culminated in the developments of a program<sup>1</sup> for the algebraic values of these coefficients as a tool for theoretical physicists working in this field.

It was only in recent past, when the focus of our work shifted from neutrons to x-rays, that we became aware of the potential and promise offered by mastering the graphical technique for manipulating vector coupling coefficients. In order to profit from this potential one has, however, to suffer the labours of the plain acquiring enough skills before attempting to climb. The urge to facilitate the hard work by providing a ‘how-to’ manual for mastering the graphical theory of angular momentum supplied the primary momentum for assembling the material collected in this book.

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<sup>1</sup> In order to obtain this Windows program please contact one of the authors by e-mail.

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Momentum

Case Studies

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