Preface

This book is a revised and extended version of my introductory lectures on quantum mechanics that I delivered for many years at the Ecole Polytechnique. It is not a textbook. I was dragged into writing it by friends, among whom are many former students of mine.

I have published two books in the same Springer collection with my colleague and friend Jean Dalibard.

One is a textbook: *Quantum Mechanics*, J.-L. Basdevant and Jean Dalibard, Heidelberg: Springer-Verlag, 2002 (revised in 2005).

The other one is a collection of problems and their solutions: *The Quantum Mechanics Solver*, J.-L. Basdevant and Jean Dalibard, Heidelberg: Springer-Verlag, 2000 (completely revised in 2005). All of these problems concern contemporary experimental or theoretical developments, some of which had appeared in the specialized literature a year or so before we gave them as written examinations. Needless to say that if the second of these books is somewhat unusual, there are dozens of excellent textbooks on quantum mechanics, among which some masterpieces which I often consult and refer to.

The remarks that eventually convinced me to write the present text are twofold. The textbooks I had written on the subject, both in French and in English, were terribly deprived of life, action, thoughts, and questioning which I always liked to put in the narrative account of the ideas and applications of the subject, during my lectures. The human aspect of the experimental investigations and of the ensuing discovery of basic principles made the lectures lively (besides the fact that the minds need to rest for few minutes after following a difficult argument). I always thought that teaching science is incomplete if it does not incorporate the human dimension, be it of the lecturer, of the audience and of the topic to which it is devoted.

The second is that my original publication was totally deprived of any exercise or problem. Very many remarks were that the book helped a lot to understand quantum mechanics, but it did not help much to work out applications. Therefore it has been one of my major goals to fill that void. The present book contains ten

problems, placed when the tools to solve them have been treated, and followed by their solutions and possible comments. Many of them refer to quite modern physics (there is no overlap with *The Quantum Mechanics Solver*). It also contains sixty or so shorter exercises whose solutions are given at the end of the book.

I must say a few words about the content of this book. First, of course, my lectures evolved quite a lot in 25 years. Actually they were never the same from one year to the next. Minds evolve; student's minds as well as mine. Science evolves: during that period there appeared numerous crucial experimental and technological steps forward.

So each lecture itself must be considered as a superposition of texts and topics, which I could not have covered completely in about an hour and a half. I used to make selections according to my mood, to latest experimental results, to the evolution of the student's minds in mathematics, in physics, and in regard to the world they were facing. The first lecture always consisted of a general description of contemporary physics and of the various courses that students were offered in their curriculum. I have reproduced an example in Chap. 1.

Another point which is amusing and quite characteristic of the French higher educational system (devised more than two centuries ago) is that the students of the Ecole Polytechnique, who were all selected after a stiff entrance examination, and whose ambitions in life were diverse—in science, in industry, in business, and in high public office—all had to follow this introductory physics course. The official reason put forward was that whatever they were going to work on later, Quantum Mechanics and Fundamental physics would be indispensable in their occupation, as would Pure and Applied Mathematics. The famous mathematician Laurent Schwartz, the man I admired most, who was my colleague, liked to be asked the question: what's the use of doing mathematics? "It's very simple," he said.

> Mathematicians study $\mathcal{L}^p$ spaces, negligible sets, and representable functors. One must certainly do mathematics. Because mathematics allows to do physics. Physics allows to make refrigerators. Refrigerators allow to keep Lobsters, and Lobsters are useful for mathematicians who can eat them and therefore be in a good mood to do $\mathcal{L}^p$ spaces, negligible sets, and representable functors. It's obviously useful to do mathematics.

I also tried to attract students to physics. I must admit that when Laurent Schwartz retired, we discussed that point, and we came to the conclusion that obviously it was impossible to convince our students that what we had taught them would be indispensable, even if they were to manage a large company: "I do not manage to persuade them because they know very well that I am objectively wrong […] on that issue I failed completely," he said. And I fully agreed with him.

Nevertheless, quantum mechanics is an ideal subject because one can be interested in it for a variety of reasons such as the physics itself, the mathematical structure of the theory, its technological spinoffs, as well as its philosophical or cultural aspects. And the task was basically to think about the pedagogical aspects, in order to satisfy audiences that went up to 500 students during the last ten years. I do think it is a part of their indisputable personal culture. It seems difficult to grasp the concepts and the functioning of quantum mechanics past a certain age.

I thank Jean Dalibard, who is now my successor, and Philippe Grangier for their constant help during the last 10–15 years. They are in particular responsible for part of the text on quantum entanglement and Bell's inequalities, of which they are worldwide known specialists. I am deeply grateful to James Rich and to Alfred Vidal-Madjar. Both of them contributed immensely on all of this book. Discussing with them was an everlasting pleasure, and they taught me a lot of physics.

I want to thank Jean-Michel Bony and to pay a tribute to the memory of Laurent Schwartz. Both had the patience to explain to me with an incredible profoundness and clarity the mathematical subtleties of quantum mechanics. This enabled me to eliminate most of the unnecessary mathematical complications at this stage, and still to be able to answer the questions of my more mathematically minded students. Indeed, if quantum mechanics has been a rich field of investigation for mathematicians, it is really the physics that is subtle in it.

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