

Foreword

This book contains the material taught at the school "Quantum Gases in Low Dimensions" held at the Centre de Physique des Houches (France) from April 15 to April 25, 2003. The choice of this subject resulted from our common interest in the physics of cold gases in low dimensions. One year before the event, we thought useful to propose a school on this very rapidly evolving subject to train young scientists, to promote scientific exchanges and more generally to encourage new people entering the field of low dimensional atomic quantum gases.

From the "revolution" of 1995, the field of ultra-cold atoms has continuously enlarged its frontiers. After the first pioneer experiments on Bose-Einstein condensation, the natural trends in the field are now to investigate situations where quantum correlations play a more and more central role. Low dimensional systems are natural laboratories for such investigations. For instance, the properties of 1D and 2D homogeneous systems are deeply modified with respect to the usual three dimensional situation, not only at the many-body level, as expected by the k -2 Bogoliubov and Hohenberg-Mermin-Wagner theorems, but also in the modelling of low energy effective interactions itself. More generally, the field leads to problematics borrowed from condensed matter, as for example the observation of the Mott-Insulator transition in an optical lattice. In this respect, cold trapped atoms play the role of a model system for condensed matter physics (the expected observation of the Kosterlitz-Thouless transition and of $1/2$ -anyons in a two-dimensional Bose gas also finely illustrates this idea). Quantum gases in low dimensions are also interesting systems in the point of view of quantum information processing: atom chips and optical lattices are promising devices for quantum computing. Furthermore, several prospective applications of quantum gases in low dimensions are under study, while others are already within reach. Among them are: atomic waves guiding, "integrated" atom optics, "atom LASER" and many others.

Understanding the various aspects of quantum gases in low dimensions requires specific materials that deserve to be taught in a whole meeting. Along the lines of this book it will appear that this subject stands at the junction of several fields: atomic physics, atom optics, many-body physics, low temperature physics, condensed matter and quantum information. We have tried to illustrate this key feature in the various experimental and theoretical talks. The lectures of Gora Shlyapnikov and Yvan Castin are essential for a deep understanding of general properties of low dimensional quantum gases. The lecture of Sandro Stringari is not only interesting for the specific field of low dimensional physics but it illustrates also nicely the powerfulness of general many body approaches including the so-called sum rule approach. The course of Maxim Olshanii developing the general concepts of scattering theory applied in quasi-1D wave guides shows the way to construct low energy effective interactions between atoms in low dimensional devices. The link with condensed matter physics and quantum information is realised in the lectures of Benoît Douçot and Ignacio Cirac. All these theoretical lectures are completed and/or illustrated by seminars giving an overview of the most advanced experimental results in the field at the moment. Note that since April 2003, the subject of the school has developed dramatically, including the observation of the Tonks Girardeau regime in 1D and the realization of a 2D BEC in a gravito-optical trap for example.

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We thank all the speakers of this school for their effort in making fascinating talks. The success of this school is due to their investment. We thank all the authors who have contributed to this book. We are confident that their effort in writing pedagogical courses and comprehensive reviews of their experimental results will be appreciated by the reader. We don't forget also all the participants of this school, the intensive scientific exchanges during and after the talks, their enthusiastic participation even during the informal seminars and the night sessions devoted to specific questions of the audience. They have contributed to establish a very warm atmosphere. We present special thanks to Isabel Lelièvre and Brigitte Rousset for their local enthusiastic support, Martial Ducloy for providing us the opportunity to organize the school in such a wonderful environment and Bertrand Guillot for his patient support in Paris.

The organizers