FIAS Seminar

Thursday, May 14, 2009, 14:30
FIAS, Ruth-Moufang-Str. 1, 60438 Frankfurt am Main
Lecture Hall 0.100

Speaker: Priv.-Doz. Dr. Axel Pelster, Freie Universität Berlin and Universität Duisburg-Essen

Title: Modern Topics of Ultracold Quantum Gases

Since 1995, when Bose-Einstein condensation in ultracold atomic gases has been realized experimentally, there has been a number of further substantial breakthroughs. Today, systems of ultracold bosonic and/or fermionic quantum gases allow for experimental control on a very high level concerning, e.g., the underlying trap geometry and the interaction strength. Moreover, they lend themselves to precise theoretical calculations of their static and dynamic properties, thus leading to highly accurate comparisons of experiment and theory. Ultracold atomic and molecular matter can be employed to provide practically ideal realizations of paradigmatically important many-body models considered in various fields, such as atomic and molecular physics, solid-state physics, and even nuclear physics. At first, the talk provides a historical overview and reviews the essential experimental and theoretical principles of the modern research field of Bose-Einstein condensation.

Then we discuss recent progress on understanding the properties of ultracold bosonic atoms in potentials with quenched disorder. This so-called "dirty bosons" problem is experimentally relevant for the miniaturization of BECs on chips and can also be studied by tailoring disorder potentials via laser speckle fields. Theoretically it is intriguing because of the competition of localization and interaction, of Anderson localization and the elusive Bose-glass phase, as well as of disorder and superfluidity.

Finally, we discuss the properties of bosonic gases in optical lattices which can exist in two different phases depending on the depth of the potential wells generated by the optical waves. For shallow lattices the ground state is superfluid, as the bosons are delocalized and phase coherent over the whole lattice. In the opposite limit of deep lattices, the ground state is a Mott insulator, as each boson is trapped in one of the respective potential minima. These different phases are observable, for instance, in time-of-flight absorption pictures which are taken after switching off the lattice potential. While the superfluid phase yields distinct Bragg-like interference peaks, the Mott phase is characterized by a broad diffusive interference pattern.