Manipulation and Phase Engineering of BEC

Wolfgang Ertmer

Institut für Quantenoptik, Universität Hannover, Welfengarten 1, 30167 Hannover, Germany
Tel +49 511 762 -2231, Fax +49 511 762 -2211
E-mail: ertmer@iqo.uni-hannover.de

The application of coherent matter waves in phase sensitive experiments, like interferometers, necessitates the understanding of their evolution when being manipulated by atom optical elements like mirrors and beam splitters. The dynamics of coherent matter waves during and after the interaction with these elements is in comparison to single-atom optics much more complex and may result in 'non linear atom optics'.

As one of the key elements, atom mirrors deserve a detailed investigation. I will discuss on bouncing of Bose condensed samples of rubidium (^{87}Rb) off a mirror formed by a repulsive dipole potential. The condensates are released from a magnetic trap falling under the influence of gravity and interact with a blue-detuned far-off-resonant sheet of light. A spatial splitting of the reflected emsemble and the appearance of self-interference substructures are observed.

The light sheet is formed by a 'tailored' laser field allowing to generate nearly any kind of reflective or diffractive optical element for the falling condensate. The dispersive nature is also well suited to split the matter-wave or to act as a phase plate.
Alternatively, focused far-off-resonant laser beams or 'hollow light fields' like Laguerre-Gaussian modes act as various traps or guides for the matter wave. The function of these optical elements as well as their application, e.g. as box potential, will be discussed.

The realization of Bose-Einstein condensation strongly stimulates the exploration of non linear properties of matter waves. This supports within the new field of nonlinear atom optics various types of excitations. Of particular interest are macroscopically excited Bose condensed states, such as vortices and solitons.

In this respect, I will present the new method of 'phase imprinting' on BEC. It is a very versatile tool to manipulate the density and phase of a condensate in order to form and to detect vortices, dark solitons and other matter-wave configurations. I will especially concentrate on experimental investigations of dark solitons in cigar-shaped Bose-Einstein condensates of ^{87}Rb.