The objective of this course is to give an introduction into the recent developments in the field of atom optics which exploits the duality particle-wave of individual atoms. This field emerged in the 80's with the cooling and trapping of individual atoms to very low temperatures. At these temperatures, it is possible to implement mirrors, beam splitters, diffraction gratings and interferometers for atoms, in close analogy of optics, thus the name atom-optics. Moreover, the achievement of Bose-Einstein condensation in 1995 has opened the possibility to develop a coherent source of atoms, in analogy with the sources of coherent radiation (lasers). The phenomena of condensation, has, however, a quantum statistical origin, which leads to many different physical processes that will be discussed. In this course we will give an overview of the state of the art and discuss possible applications.
# Quantum Simulators, Bose Einstein Condensates and Ultracold Quantum Gases

## Content

1. **Introduction and Motivation**
   The importance of quantum optics and BEC, physical systems where BEC is present (e.g. Helium, Neutron Stars, etc.), overview of the field.

2. **Basic concepts on cooling and trapping of atoms.**
   Laser cooling, Doppler cooling, Beam deceleration, Sub-Doppler cooling: Polarization gradient or Sisyphus cooling, Below the recoil limit: Velocity Selective Coherent Population Trapping, Evaporative cooling.

3. **Atomic traps:**
   Optical traps, magnetooptical traps, magnetic traps. Optical lattices

4. **Bose Einstein Condensation**
   What is a BEC?, How to create a BEC, Ideal gas of bosons, Weakly interacting bosons, Gross-Pitaevskii equation, BogoliubovdeGennes equations, hydrodynamic theory.

5. **Ultracold gases in optical lattices:**
   Basic concepts From weakly interacting systems to strongly correlated systems.

6. **Quantum simulators**

## Qualification system

Delivery of homework proposed during the lectures Short oral presentation of a subject present in the contents but worked by the student.

## Regulations for carrying out activities

The usual in university teaching
32071 - AOBEC - Quantum Simulators, Bose Einstein Condensates and Ultracold Quantum Gases

Bibliography

Basic:


Complementary: