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LAPHIA Seminar

Quantum Physics with Ultra-Cold Atoms: from Bose-Einstein Condensation to Quantum Simulation

Prof. Dr. Gerhard Birkl
Institut für Angewandte Physik, Technische Universität Darmstadt

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Auditorium - Institut d'Optique d'Aquitaine – Rue François Mitterrand – 33 400 Talence

Research on ultra-cold atomic systems has developed an important role in the investigation of fundamental quantum principles and the quantum physical behavior of matter. Two important fields of research can be identified in the study of quantum degenerate gases, such as Bose-Einstein condensates, as well as in quantum simulation and quantum information processing.

In this presentation, recent developments in our work towards these objectives are presented: we generate samples of BECs and of single ultracold atoms and apply external potential structures created by optical fields for the manipulation of atomic matter waves and for the development of a scalable architecture for quantum computing with ultra-cold atoms.

We present the experimental investigation of Bose-Einstein condensates in external guiding potentials, such as a novel optical storage ring based on the application of conical refraction as a new technique for creation of toroidal potentials and review the experimental progress towards quantum information processing and quantum simulation using neutral atoms in two-dimensional (2D) arrays of optical microtraps as 2D registers of qubits. We describe a scalable quantum information architecture based on micro-fabricated optical elements, simultaneously targeting the important issues of single-site addressability and scalability. An extension of these techniques towards the investigation of strongly interacting systems in highly flexible geometries can open new prospects for quantum simulation in periodic potentials including defects, impurities, external constraints, etc.

LAPHIA (Laser & Photonics in Aquitaine)
Institut d'Optique d'Aquitaine – Université de Bordeaux
Rue François Mitterand – 33 400 Talence Cedex
T 33 (0)5 40 00 34 75
Info.laphia@univ-bordeaux.fr