

230556 - QS-BEC - Quantum Simulators, Bose Einstein Condensates and Ultracold Quantum Gases

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 1022 - UAB - (ANG) pendent
Academic year: 2015
Degree: ERASMUS MUNDUS MASTER'S DEGREE IN PHOTONICS ENGINEERING, NANOPHOTONICS AND BIOPHOTONICS (Syllabus 2010). (Teaching unit Optional)
MASTER'S DEGREE IN PHOTONICS (Syllabus 2013). (Teaching unit Optional)
ECTS credits: 3 Teaching languages: English

Teaching staff

Coordinator: Anna Sanpera, UAB.
Others: Muntsa Guilleumas, UB.

Opening hours

Timetable: Anna.Sanpera@uab.cat
muntsa@ecm.ub.edu

Degree competences to which the subject contributes

Transversal:

1. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
2. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.
3. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.
4. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

Teaching methodology

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Learning objectives of the subject

BRIEF DESCRIPTION OF THE COURSE:

This course will provide an introduction into the recent developments of ultracold quantum gases comprising the fields of quantum optics and atomic physics. The achievement of Bose Einstein condensation in 1995 marks the beginning of a new era with unprecedented possibilities of control of many-body physics at a real quantum level. The phenomenon 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.

BIBLIOGRAPHY:

· On line

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Lectures du College de France by C. Cohen-Tannoudji. courses 1998-1999, 1999-2000.
<http://www.phys.ens.fr/cours/college-de-france/>

· Basic

M. Fox, Quantum Optics: An introduction, Oxford Master series in Atomic, Optical and Laser Physics, Oxford University Press, 2006.

P. v. d. Straten, H. Metcalf, Laser Cooling, Springer, 1999.

P. Meystre, Atom Optics, Springer, 2001.

C.J. Foot, Atomic Physics, Oxford Master series in Atomic, Optical and Laser Physics, Oxford Univ. Press, 2005.

C. Cohen-Tannoudji and D. Guery-Odelin, Advances in Atomic Physics: An overview, World Scientific, 2011.

C.J. Pethick and H. Smith, Bose-Einstein Condensation in Dilute Gases, Cambridge University Press, 2002.

L.P. Pitaevskii and S. Stringari, Bose Einstein condensation, Oxford University Press, 2004.

· Advanced

M. Lewenstein, A. Sanpera, V. Ahufinger, Ultracold gases in Optical lattices: simulating many-body systems, Oxford University Press, 2012.

A.J. Leggett, Bose-Einstein condensation in the alkali gases: Some fundamental concepts, Rev. Mod. Phys. 73, 307 (2001).

K. Bongs and K. Sengstock, Physics with coherent matter waves, Rep. Prog. Phys. 67, 907 (2004).

S. Giorgini, L.P. Pitaevski, S. Stringari, Theory of ultracold Fermi gases, Rev. Mod. Phys. 80, 1215 (2008).

Study load

Total learning time: 75h	Hours large group:	22h 30m	30.00%
	Hours medium group:	0h	0.00%
	Hours small group:	0h	0.00%
	Guided activities:	2h 15m	3.00%
	Self study:	50h 15m	67.00%

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Content

1. Introduction and motivation

Degree competences to which the content contributes:

Description:

Basic atomic physics. Atomic structure, degeneracy levels and symmetries. Fine and hyperfine levels. Interaction with external fields: Zeeman splitting, AC-Stark shift. Basic processes of atom-light interactions

2. Basic concepts on cooling and trapping of atoms

Degree competences to which the content contributes:

Description:

Light forces on atoms: dipolar force and radiation pressure force. Cooling: Laser cooling. Atomic traps: optical traps, magneto-optical traps, magnetic traps. Optical lattices

3. Bose Einstein Condensation

Degree competences to which the content contributes:

Description:

The ideal gas of bosons. Weakly interacting bosons. Mean field approach: The Gross-Pitaevskii equation, Bogoliubov de Gennes equations, hydrodynamic theory

4. Dilute Fermi gases

Degree competences to which the content contributes:

Description:

The ideal gas of fermions. Weakly interacting fermions. Pairing in dilute Fermi gases (BCS). BCS-BEC crossover. Excitations.

5. Ultracold gases in optical lattices

Degree competences to which the content contributes:

Description:

Basic concepts beyond mean field: from weakly interacting systems to strongly correlated systems. Quantum simulators. The Bose Hubbard model: superfluid-Mott insulator phase transition. Lattice gauge models



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Qualification system

Attendance to be evaluated: >80% of the lecture time

- Exam: written or oral (70%)
- Homework assessments (30%)

Bibliography