Last update: 15-07-2016

230579 - FCTBEC - From Cooling and Trapping of Neutral Atoms to Bose-Einstein Condensates

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering

Teaching unit: 1022 - UAB - (ANG) pendent

Academic year: 2016

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: Jordi Mompart (UAB)

Others: Verónica Ahufinger (UAB)

Degree competences to which the subject contributes

Specific:

CE5. (ENG) Màster en Fotònica:
Saber realizar y comprender experimentos básicos que demuestren los principales fenómenos de óptica y fotónica.

Transversal:

CT1. (ENG) Màster en Fotònica:
EMPRENDIMIENTO E INNOVACIÓN. Conocer y entender los mecanismos en que se basa la investigación científica, así como los mecanismos e instrumentos de transferencia de resultados entre los diferentes agentes socioeconómicos implicados en los procesos de I+D+i.

CT5. (ENG) Màster en Fotònica:
INGLÉS. Acreditar un nivel adecuado de este idioma, tanto de forma oral como por escrito, en consonancia con las necesidades que tendrán las tituladas y los titulados.

CT3. (ENG) Màster en Fotònica:
TRABAJO EN EQUIPO. Ser capaz de trabajar como miembro de un equipo interdisciplinar ya sea como un miembro más, o realizando tareas de dirección con la finalidad de contribuir a desarrollar proyectos con pragmatismo y sentido de la responsabilidad, asumiendo compromisos teniendo en cuenta los recursos disponibles

CT4. (ENG) Màster en Fotònica:
USO SOLVENTE DE LOS RECURSOS DE INFORMACIÓN. Gestionar la adquisición, la estructuración, el análisis y la visualización de datos e información en el ámbito de la especialidad y valorar de forma crítica los resultados de esta gestión.

Teaching methodology

- Lectures
- Activities

Learning objectives of the subject

The objective of this course is to give an introduction into the developments in the field of atom optics which exploits the particle-wave duality of atoms. This field emerged with the cooling and trapping of neutral 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 to standard optics. Moreover, the achievement of Bose-Einstein condensation in 1995 opened the possibility to develop a coherent source of atoms, in analogy with light sources of coherent radiation. The phenomena of condensation offers, however, much more possibilities and a much richer dynamics that will be discussed along the course.

Study load

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

Content

Introduction

Learning time: 2h

Theory classes: 2h

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

Cooling, trapping of neutral atoms and linear atom optics

Learning time: 6h

Theory classes: 6h

Description:

Light forces on atoms: dipolar force and radiation pressure force. Cooling: Laser cooling. Atomic traps: optical traps, magneto-optical traps, magnetic traps. Linear atom optics: focusing, atomic mirrors, atomic diffraction, atom interferometry.

Bose Einstein Condensation

Learning time: 8h

Theory classes: 8h

Description:

The ideal gas of bosons. Weakly interacting bosons. Mean field approach: The Gross-Pitaevskii equation, Bogoliubov de Gennes equations, hydrodynamic theory. One and two dimensional bosonic trapped gases.

Nonlinear and quantum atom optics

Learning time: 4h

Theory classes: 4h

Description:

Matter-wave coherence and phase manipulation. Atom lasers. Matter-wave solitons. Atomic four-wave mixing. Superfluidity and vortices.

And more...

Learning time: 2h 30m

Theory classes: 2h 30m

Description:

Disorder and Anderson localization. Tonks-Girardeau gas. Two-component Bose-Einstein condensates. Spinor condensates.

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Qualification system

Written exam (60%)
Homework assessments (40%)

Bibliography

Basic:

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.

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.

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.

J. Dalibard. "Collisional dynamics of ultra-cold atomic gases". Proceedings of the International School of Physics Enrico Fermi, Course CXL.

Complementary:

A.J. Legget. "Bose-Einstein condensation in the alkali gases: Some fundamental concepts". Rev. Mod. Phys..

K. Bongs and K. Sengstock. "Physics with coherent matter waves". Rep. Prog. Phys.

F. Dalfovo, S. Giorgini, L. P. Pitaevskii, and S. Stringari,. "Theory of Bose-Einstein condensation in trapped gases". Rev. Mod. Phys. .

W. Ketterle, D. S. Durfee, and D. M. Stamper-Kurn. "Making, probing and understanding Bose-Einstein condensates". Proceedings of the Enrico Fermi International School of Physics, Course CXL.

Others resources:

Hyperlink

Lectures du College de France by C. Cohen-Tannoudji. courses 1998-1999, 1999-2000.

http://www.phys.ens.fr/cours/college-de-france/