Last update: 05-07-2019

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: 2019

Degree: MASTER'S DEGREE IN PHOTONICS (Syllabus 2013). (Teaching unit Optional)
ERASMUS MUNDUS MASTER'S DEGREE IN PHOTONICS ENGINEERING, NANOPHOTONICS AND BIOPHOTONICS (Syllabus 2010). (Teaching unit Optional)

ECTS credits: 3 Teaching languages: English

Teaching staff

Coordinator: Artur Polls (U.B.)

Others: Montserrat Guilleumas (U.B.)

Opening hours

Timetable: Contact to artur@fqa.ub.edu or muntsa@fqa.ub.edu

Prior skills

Basic knowledge on quantum physics and quantum optics

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
- Resolution of exercises in the classroom

Learning objectives of the subject

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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:	24h	32.00%
	Self study:	51h	68.00%

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Content

Introduction

Learning time: 2h
Theory classes: 2h

Description:
Basic atomic physics. Atomic structure, levels degeneracy, and symmetries. Fine and hyperfine levels. Interaction with external fields: Zeeman effect, 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

Two activities will be evaluated:
- Written exam (60%)
- Homework assessments (40%)

In addition, there will be an oral recovery exam for those students who have not passed the subject once the written exam and the delivery of problems have been evaluated.

Bibliography

Basic:

Pethick, C.J; Smith, H. Bose-Einstein condensation in dilute gases. 2nd ed. Cambridge ; New York: Cambridge University Press, 2008. ISBN 9780521846516.

Pitaevskii, L.P.; Stringari, S. Bose Einstein condensation. Oxford University Press: Clarendon Press, 2003. ISBN 0198507194.

Fox, M. Quantum optics : an introduction. 2006. ISBN 0198566727.

Metcalf, H.J.; Van der Straten, P. Laser cooling and trapping. New York: Springer, 1999. ISBN 0387987479.

Foot, C.J. Atomic physics. 2005. ISBN 0198506953.

Cohen-Tannoudji, C.; Guery-Odelin, D. Advances in atomic physics : an overview. Singapore: World Scientific, 2011. ISBN 9789812774972.

Dalibard, J. "Collisional dynamics of ultra-cold atomic gases". Proceedings of the International School of Physics Enrico Fermi, Course CXL [on line]. 1998 [Consultation: 28/04/2017]. Available on: <www.phys.ens.fr/~dalibard/publications/varenna98.pdf>.

Complementary:

Legget, A.J. "Bose-Einstein condensation in the alkali gases: Some fundamental concepts". Reviews of modern physics [on line]. 2001, vol. 73, núm 2, pag 307-356 (April 2001) [Consultation: 17/07/2017]. Available on: <https://www.researchgate.net/publication/239443683_Bose-Einstein_condensation_in_the_alkali_gases_Some_fundamental_concepts>.

Bongs, K.; Sengstock, K. "Physics with coherent matter waves". Reports on progress in physics [on line]. 2004, v. 67 , núm. 6, p. 907-963 [Consultation: 17/07/2017]. Available on: <https://arxiv.org/abs/cond-mat/0403128v1>.

Dalfovo, F.; Giorgini, S.; Pitaevskii, L.P.; Stringari, S. "Theory of Bose-Einstein condensation in trapped gases". Reviews of modern physics [on line]. 71, 463 (1 April 1999) [Consultation: 17/07/2017]. Available on: <https://arxiv.org/abs/cond-mat/9806038>.

Ketterle, W.; Durfee, D.S.; Stamper-Kurn, D.M. "Making, probing and understanding Bose-Einstein condensates". International School of Physics "Enrico Fermi". (1998: Varenna, Itàlia) [on line]. 1999, vol 40 (p.67-166) [Consultation: 17/07/2017]. Available on: <https://arxiv.org/abs/cond-mat/9904034v2>.

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/