TEACHING GUIDE OF THE COURSE

New Developments in Quantum Physics

(updated: 23/05/2019)
Academic year: 2019-20

MASTER MODULE	TOPIC	SUBJECT		SEMESTER	CREDITS ECTS	COURSE TYPE
		New Developments in Quantum Physics		2nd	6	Optative

LECTURERS	CONTACT
• María Cruz Boscá Díaz-Pintado • Carmen García Recio	• María Cruz Boscá Díaz-Pintado Dpto. Física Atómica Molecular y Nuclear Sección Físicas. Despacho 127. Correo electrónico: bosca@ugr.es • Carmen García Recio Dpto. Física Atómica, Molecular y Nuclear Sección de Físicas. Despacho 131. Correo electrónico: g_recio@ugr.es
	TUTORING SCHEDULE
	• María Cruz Boscá Díaz-Pintado: Tuesday 18:00-21:00 and Wednesday, 12:00-15:00 • Carmen García Recio: Tuesday: 17:00-19:00 Thursday 18:00-19:00 and Friday 10:00-12:00
MASTER	
Máster Universitario en Física: Radiaciones, Nanotecnología, Partículas y Astrofísica	

REQUISITES AND/OR RECOMMENDATIONS

All candidates must have a minimum level of Spanish language proficiency for attending this subject.

BRIEF DESCRIPTION OF CONTENTS

Quantum contextuality. Correlations and locality. Entanglement. Quantum optics. Coherence. Quantum information with photons. New experiments in quantum physics.

OBJETIVES

The student will know/understand:

- The theoretical foundations of modern physics and the application to new experiments
- The relevance of new applications coming from the new phenomenology

***The student will be able to*:**

- To tackle the subject to address new fields of study independently
- To develop an analytical thinking in order to judge the validity of the scientific information coming from different sources.
- To solve the proposed problems using the appropriate numerical and mathematical methods.
- To extract the keys for applying the quantum theory to new technologies in current development.

CONTENTS OF THE COURSE

- 1. Contextuality and no-locality: Einstein-Podolsky-Rosen, Bell and Bell-Kochen-Specker theorems. Local realism and quantum correlations. Entanglement.

- **2. Quantum Optics:** Coherence. Interferometry. Entangled photon experiments.

- **3. New experiments in Quantum Physics:** Complementarity. Quantum teleportation. Deferred measurement.

- **4. Quantum computation:** Quantum gates and quantum circuits. Quantum algorithms. Quantum Fourier transform. Search algorithms: Grover algorithm. Shor's algorithm for factoring.

REFERENCES

- Bertlmann, R. A. and Zeilinger, A.; *Quantum [Un]speakables. From Bell to Quantum Information*. Springer; 2002. ISBN: 3-540-42756-2.
- Espagnat, B. D'; *Veiled Reality. An analysis of Present-day Quantum Mechanical Concepts.* Addison-Wesley, 1995.
- Fox, M.; *Quantum Optic. An introduction.* Oxford Univ. Press; Oxford, 2004. ISBN: 0–19–856672–7, 978–0–19–856672–4.
- Garrison, J. C. and R. Y. Chiao, *Quantum Optics*, Oxford Univ. Press, Oxford, 2008. ISBN: 978-0-19-850886-1.
- Gerry, C. C. and Knight, P. L., *Introductory Quantum Optics*, Cambridge Univ. Press, Cambridge, 2005. ISBN: 0-521-82035-9.
- Home, D., Kar, G. and Majumdar A. S.; *75 years of quantum entanglement: Foundations and Information Theoretic Applications*. American Institute of Physics; New York, 2011. ISBN: 978-0-7354-0945-3.
- Jaeger, Gregg. *Quantum Information, an overview*. Springer, 2007. ISBN: 0-387-35725-4.
- Nielsen, Michael A. & Chuang, Isaac L.; *Quantum Computation and Quantum Information.* Cambridge University Press; Cambridge, 2010. ISBN: 978-1-107-00217-3.
- Paul, H.; *Introduction to Quantum Optics. From light Quanta to Quantum Teleportation*. Cambridge Univ. Press; Cambridge, 2004. ISBN: 0-521-83563-1.
- Yeung, Raymond W.; *A first course in information theory*. Kluver Academic / Plenum Publishers; 2002. ISBN: 0-306-46791-7, 978-0-306-46791-2.

USEFUL LINKS

- E-prints: http://arxiv.org/archive/quant-ph
http://vcq.quantum.at/publications/all-publications.html
- Quantum Computing in *Nature*:
http://www.nature.com/nature/journal/v463/n7280/full/463441a.html
- Noticias: http://faeuat0.us.es/Qubit/
- Grupos de investigación:
http://faeuat0.us.es/QIGUS/links.htm , www.quantumoptics.net y http://oxfordquantum.org/
- Cursos relacionados (con apuntes):
http://wdb.ugr.es/~bosca/InformacionCuantica
Ph219/CS219 Quantum Computation
http://www.cse.iitd.ernet.in/~suban/quantum/
http://www.cs.berkeley.edu/~vazirani/
http://www.theory.caltech.edu/people/preskill/ph229/

METHODOLOGY

Lectures: To transmit the contents of the subject, motivating the students to reflection, facilitating the discovery of relationships between different concepts and promoting a critical mindset.

Seminars: To develop in the students the cognitive and procedural skills of the subject.

Academic tutoring: To guide the autonomous and team work of students, focusing on different aspects of the subjects and guide the comprehensive academic training of the student.

Study and independent work of students: To foster in the student the ability to self-regulate their learning, by planning, designing, evaluating and adapting it to their particular conditions and interests.

Teamwork: To encourage students in the generation and exchange of ideas, identification and analysis of different views on a topic, generalization or transfer of knowledge and critical assessment of it.

EVALUATION SYSTEM

1. Evaluation of the results of the activities and problem solving proposed by the teacher

2. Evaluation of the projects/reports developed independently

3. Evaluation of the development, oral presentation and defense of a final work project on the subject

ADDITIONAL INFORMATION

Useful links to other courses of Quantum Physics and Quantum Computation:

- Videolectures of Stanford University: Quantum Entanglement course de Leonard Susskind. (each lecture lasts for two hours approximately; very good, they worth the time they take).
- *Lectures Notes on Physics*: Notes of Quantum Entanglement course, by Leonard Susskind. (supplementary to the previous youtube videolectures).
- From Stanford University (Stanford Enclyclopedia of Philosophy): Quantum Computing. Bell's Theorem

| Church-Turing Thesis | computability and complexity | quantum mechanics | quantum mechanics: collapse theories | quantum mechanics: the role of decoherence in | quantum theory: measurement in | quantum theory: quantum entanglement and information | quantum theory: the Einstein-Podolsky-Rosen argument in | Turing, Alan | Turing machines.

- Quantum Computation Course from Department of Computer Science & Engineering, University of Washington: CSE-599d Quantum Computing course , por Dave Bacon.
- From MIT: The classical polarization of light, by the (in-)famous professor of Physics, Prof. Walter Lewin
- From “Tout est Quantique”: 'Quantum made easy', with videos and animations.