Numerical methods for quantum mechanics

Academic Year: (2023 / 2024) **Review date: 28-04-2023**

Department assigned to the subject: Physics Department

Coordinating teacher: PUEBLA ANTUNES, RICARDO

Type: Electives ECTS Credits : 3.0

Year : 2 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

- Quantum physics (Matrix and wave quantum mechanics)
- Quantum computation
- Laboratory on quantum computation
- Quantum optics
- Basic knowledge of numerical programming languages (e.g. python)

OBJECTIVES

CB6. To possess and understand concepts and ideas that provide a basis or opportunity to be original in the development and/or application of ideas, often in a research context.
CB9. That students know how to communicate their conclusions and the ultimate knowledge and reasons that support them to specialized and non-specialized audiences in a clear and unambiguous manner.
CB10. That students possess the learning skills that will enable them to continue studying in a manner that will be largely self-directed or autonomous.
CG2. Knowledge of scientific and technical subjects that enable them to learn new methods and technologies, as well as to
be highly versatile in adapting to new situations.
CG4. Ability to solve scientific and technological problems that may arise within the framework of the applications of quantum technologies in various fields of physics and engineering.
CG5. Ability to use the theoretical and practical knowledge acquired in the definition, approach and resolution of problems within the framework of the exercise of their profession.
CG6. Ability to develop new products and services based on the use and exploitation of new quantum technologies.
CG7. Ability and knowledge to enable the enrolment in specialized studies at the PhD level, either in related fields of physics or in the various branches of engineering.
CE2. Ability to apply the concepts of quantum mechanics and its postulates to various quantum problems and systems of technological interest.
CE3. Ability to use the main formalisms and more common mathematical tools from quantum mechanics.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Ecuación de Schrödinger
   - Método de Euler
   - Runge-Kutta
   - Trotterización
   - Método de Chebyshev
2. Métodos variacionales
3. Estados producto de matrices
   - DMRG
4. Matriz densidad y ecuaciones maestras
   - Monte Carlo y trayectorias cuánticas

LEARNING ACTIVITIES AND METHODOLOGY

AF1. Theoretical classes.
AF2. Practical classes.
AF3. Computational practical sessions.
AF4. Group work.
AF5. Student individual work.

AF6. Midterm and final exam.
MD1. Class presentations by professor using electronic and audiovisual resources to convey the main key concepts of the subject, providing relevant bibliography to complement the learning by the students.
MD3. Resolution of practical cases in an individual or group manner.
MD4. Class presentation and discussion, chaired by the professor, of topics related to the subject.
MD5. Individual or group work and reports.

ASSESSMENT SYSTEM

SE1. Class attendance and participation (5%)
SE2. Individual or group works and reports done during the course (35%)
SE3. Final exam (60%)

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

BASIC BIBLIOGRAPHY

- C. Gardiner , P. Zoller Quantum Noise: A Handbook of Markovian and Non-Markovian Quantum Stochastic Methods with Applications to Quantum Optics, Springer, 2004
- H. J. Carmichael Statistical Methods in Quantum Optics 1 & 2, Springer, 1999