Quantum control

Academic Year: (2023 / 2024)   **Review date: 11/04/2023 17:16:25**

Department assigned to the subject: Mathematics Department

Coordinating teacher: PEREZ PARDO, JUAN MANUEL

Type: Electives ECTS Credits : 3.0

Year : 2 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Ordinary differential equations, Linear Algebra

OBJECTIVES

Control Theory is the conceptual framework that encompasses the modeling of control systems. The control problem can be summarized in a simplified way as follows. Given a physical system, it is intended to guide or control its temporal evolution, from a given initial state, to reach a final state that meets certain characteristics.

The objectives of the course will be to obtain basic knowledge of Control Theory through elementary examples explaining key concepts such as controllability, bilinear control systems or the optimal control problem applied to the specific case of quantum systems. More specifically, explain the different notions of controllability, such as controllability of pure states or controllability of mixed states or the control problem in minimum time. These concepts will be applied to simple models such as molecular control or spin states but of direct and immediate importance in applications such as quantum control of chemical reactions, quantum computing or quantum metrology.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction to control theory in Quantum Mechanics:

   - Bilinear control systems.

   - Controllability of pure states, mixed states and simultaneous control.

   - Characterizations of controllability.

   - Applications

2. Optimal Control Problems in Quantum Mechanics:

   - Pontryaguin's Maximum Principle

   - Bounded Controls and minimal time control.

   - Krotov's method

   - Applications

LEARNING ACTIVITIES AND METHODOLOGY

- AF1: Theoretical classes
- AF2: Practical classes
- AF3: Tutorials
- AF4: Group work

- AF5: Individual student work
- AF6: Final exam

ASSESSMENT SYSTEM

% end-of-term-examination/test:	25
% of continuous assessment (assigments, laboratory, practicals…):	75

- SE1: Class participation
- SE2: Individual or group work carried out during the course
- SE3: Final exam

BASIC BIBLIOGRAPHY

- D'Alessandro, Domenico Introduction to Quantum Control and Dynamics, Chapman and Hall/CRC, 2007

- H.Mabuchi and N. Khaneja Principles and applications of control in quantum systems, International Journal of Robust and Nonlinear Control, 15, 647-667, 2005

- Nielsen, Michael A and Chuang, Isaac L Quantum Computation and Quantum Information, Cambridge University Press, 2010

- O. V. Morzhin and A. N. Pechen Krotov method for optimal control of closed quantum systems, Russ. Math. Surv. 74, 851, 2019

ADDITIONAL BIBLIOGRAPHY

- Agrachev, Andrei A and Sachkov, Yuri Control theory from the geometric viewpoint, Springer Science & Business Media, 2013

- Jurdjevic, Velimir Geometric control theory, Cambridge university press, 1997

BASIC ELECTRONIC RESOURCES

- H.Mabuchi and N. Khaneja . Principles and applications of control in quantum systems:
http://doi.org/10.1002/rnc.1016

- O. V. Morzhin and A. N. Pechen . Krotov method for optimal control of closed quantum systems:
http://doi.org/10.1070/RM9835