Quantum information and communication

Academic Year: (2023 / 2024) **Review date: 24/04/2023 12:47:22**

Department assigned to the subject: Signal and Communications Theory Department

Coordinating teacher: GARCIA MUÑOZ, LUIS ENRIQUE

Type: Compulsory ECTS Credits : 6.0

Year : 1 Semester : 2

OBJECTIVES

The aim of this course is for the student to acquire the basic fundamentals of quantum communications mechanisms as well as to introduce the most common procedures in practice for the application of quantum optics in communications. In order to achieve these objectives, the student must acquire a series of knowledge and skills.

In terms of knowledge, at the end of the course the student will be able to:

Understand the basis of electromagnetic wave propagation and know the parameters that describe this propagation.
Understand the non-classical states of light.
Understand the fundamental role played by non-classical states of light in quantum communications.
Understand a quantum communications link.
Compare a quantum communications link with its classical counterpart.
To understand the role of the different elements involved in a radio link in order to be able to evaluate them.

In terms of capabilities, these can be classified into two groups, one of specific capabilities and the other of more generic capabilities or skills.

As for the specific capacities, at the end of the course the student will be able to:

¿ Understand the meaning of the parameters that characterise the propagation of electromagnetic waves in a homogeneous medium or by physical support.
Interpret the parameters of a quantum communications link.
Classify the different elements necessary in quantum communications.
Analyse what happens with regard to the performance of a quantum communications link compared to a classical one.
Feasibility and practical implementation of a quantum communications link.

DESCRIPTION OF CONTENTS: PROGRAMME

1. Quantum Communications
Classical and Quantum Communications Systems
Scenarios of Classical Optical Communications
Poisson Processes
Optical Detection: Semiclassical Model
Simplified Theory of Photon Counting and Implementation

2. Quantum Decision Theory: Analysis and Optimization
Analysis of a Quantum Communications System
Binary Optimization with Pure States
State and Measurement Matrices with Pure States
Holevo¿s Theorem

Kennedy¿s Theorem
The Geometrically Uniform Symmetry (GUS)

3. Quantum Decision Theory: Suboptimization
Square Root Measurements (SRM)
Performance Evaluation with the SRM Decision
SRM with Mixed States
SRM with Geometrically Uniform States (GUS)
SRM with Mixed States Having the GUS
Quantum Compression with SRM

4. Quantum Communications Systems
Theory of Classical Optical Systems
Quantum Decision with Pure States
Quantum Binary Communications Systems
Quantum Systems with OOK Modulation
Quantum Systems with BPSK Modulation
Quantum Systems with QAM Modulation
Quantum Systems with PSK Modulation
Quantum Systems with PPM Modulation
Overview of Squeezed States
Quantum Communications with Squeezed States

LEARNING ACTIVITIES AND METHODOLOGY

The following activities will be combined as described in the detailed program of the course:

1- Theory lectures in the blackboard and with slides. Resolution of small exercises
2- Problems
3- Labs (four labs in computer room and experimental laboratories)
4- Office hours
5- Proposed exercises with solutions will be published in each chapter for self-studying.

ASSESSMENT SYSTEM

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

Global exam at the end of the semester (40% of the final grade (4 points)).
Theory exam (without books or notes): test and/or short questions: 40%
3 to 4 problems with a manuscript summary of equations (10 pages maximum): 60%.

The last 60% will be obtained by the continuous evaluation (6 points). This includes in the middle of the course an exam.
Realization of 4 lectures in the laboratory. Each assignment includes an evaluation test.

A minimum of 4 points in the final exam is required to consider the points achieved by the continuous evaluation.

BASIC BIBLIOGRAPHY

- Gianfranco Coriolaro Quantum Communications, Springer, 2014

ADDITIONAL BIBLIOGRAPHY

- P.A.M. Dirac Quantum Mechanics, Oxford, 1985