PHYS-550

Quantum information theory

Holmes Zoë

Cursus	Sem.	Type
Ing.-phys	MA1, MA3	Opt.
Minor in Quantum Science and Engineering	H	Opt.
Physicien	MA1, MA3	Opt.
Quantum Science and Engineering	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	2 weekly
Number of positions	

Summary

After recapping the basics of quantum theory from an information theoretic perspective, we will cover more advanced topics in quantum information theory. This includes introducing measures of quantum information, and developing a more advanced understanding quantum states, channels and measurements.

Content

An operational introduction to quantum information theory

- Classical state spaces, measurements and operations
- The quantum state spaces, quantum measurements and operations
- Multiple qubit systems, reduced states and purifications.

Quantum Measurements

- POVM Measurements
- Naimark's Dilation Theorem
- Distinguishing quantum states
- The measurement problem
- Quantifying shot noise

Quantum channels

- Definition and examples of quantum channels
- Stinespring Dilation Theorem
- Choi representation of channels
- Vectorization notation for channels (and beyond)

Measures of information

- Shannon entropy
- Shannon's noiseless coding theorem
- Von Neumann entropy
- Schumacher's quantum noiseless channel coding theorem
- Entropic inequalities
- Matrix distance measures

Entanglement Theory

- Resource theory of entanglement
- Entanglement entropy
- Witnessing entanglement
- The problem of mixed state entanglement

Learning Prerequisites

Required courses

Essential:
Quantum Physics I, Quantum Physics II

Some knowledge of the basics of quantum computing would be helpful to provide context to the topics studied here. I recommend taking this course in parallel with Vincenzo Savona's Quantum Computing Course PHYS-641 (or attending the basic introduction to quantum computing provided in QUANT-400).

It is worth nothing that in the first half of the course there will be some overlap with Jean-Philippe Brantut's Quantum Optics and Quantum Information Course PHYS-454. However, the two courses take different perspectives and so will be complementary.

Learning Outcomes

By the end of the course, the student must be able to:

- Demonstrate an advanced understanding of quantum information theory.
- Demonstrate an advanced understanding of quantum information theory.

Teaching methods

Lectures and weekly exercises.

Assessment methods

90% Written exam, 10% assessed homework tasks.

Resources

Moodle Link

- https://go.epfl.ch/PHYS-550