EPFL

PHYS-550 **Quantum information theory**

Holmes Zoë

| Cursus | Sem. | Type |
|---|---|---|
| Ing.-phys | MA2, MA4 | Opt. |
| Physicien | MA2, MA4 | Opt. |
| Quantum Science and Engineering | MA2, MA4 | Opt. |

| | |
|---|---|
| Language of teaching | English |
| Credits | 4 |
| Session | Summer |
| Semester | Spring |
| Exam | Written |
| Workload | 120h |
| Weeks | 14 |
| **Hours** | **4 weekly** |
| Lecture | 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
- State tomography
- The measurement problem
- Quantifying shot noise

**Quantum channels**

- Definition and examples of quantum channels
- Stinespring Dilation Theorem
- Choi representation of channels
- Channel tomography

**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**
Highly beneficial:
Some knowledge of the basics of quantum computing will be assumed. Therefore this course would follow on nicely from Vincenzo Savona's Quantum Computing Course **PHYS-641.** Alternatively, the basic introduction to quantum computing provided in **QUANT-400** would suffice.
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 will 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.

## Teaching methods

Lectures and weekly exercises.

## Assessment methods

60% Written exam, 40% assessed homework tasks.

## Resources

### Moodle Link

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