ATHENS week at Télécom Paris — 16–20 November 2026

A one-week intensive course of the ATHENS European exchange programme

Language of instruction: English — no prior knowledge of quantum physics required

A gentle introduction to quantum mathematics

(*the mathematical foundations of quantum information, from first postulates*)

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This course offers a step-by-step introduction to the mathematical foundations of quantum information, starting from simple postulates within finite-dimensional systems. A central emphasis is placed on quantum measurement and its inherently probabilistic nature, from which the linear evolution of quantum states and the derivation of the Schrödinger differential equation for isolated systems can be mathematically derived.

The course then addresses more realistic scenarios involving noise or interactions with an external environment. In such settings, quantum states are described by density matrices, while their transformations are modeled by quantum channels, together with a general framework for quantum measurements.

If time permits, the course will also explore mathematical tools used to define and compare distances, divergences or similarities between quantum states, highlighting their connections with quantum channels and measurement processes.

Main themes, in the order they are covered during the week:
1. States and measurement. The postulates of quantum mechanics in finite dimension; quantum measurement and its probabilistic nature; Hermitian (Hilbert) spaces, Dirac notations, spectral decompositions.
2. Observables and evolution. Observables and projective measurements; the uncertainty principle; quantum evolution via Wigner's and Stone's theorems, leading to the Schrödinger equation.
3. Composite systems. Tensor products of Hermitian spaces and of operators; partial measurements and POVMs; cloning and discrimination of quantum states.
4. Mixed states. Partial and global trace, Schmidt decomposition and SVD; density operators, and how measurement and evolution extend to them.
5. Quantum channels and beyond. Quantum channels, classical versus quantum information; trace distance, fidelity and entropies.

Prerequisites. Participants are recommended to be familiar with linear algebra, complex numbers, and elementary probability theory and information theory. Although the course does not presuppose knowledge of Hilbert spaces, it does presuppose a fairly comprehensive knowledge of finite-dimensional complex scalar product spaces (also known as Hermitian spaces, the natural generalization of Euclidean spaces over the complex numbers). This course does not presuppose any knowledge of quantum physics but focuses on the mathematics of quantum information.

Who should attend? The course is intended for a broad audience of enthusiast students from all fields who wish to develop a solid theoretical understanding of the principles underlying quantum computing and quantum information.

Practical information

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Course at a glance.

Programme	ATHENS, a European exchange network of some fifteen universities: each November the partner institutions exchange their students for one intensive course week.
Dates	Monday 16 to Friday 20 November 2026 (30 hours over five days).
Venue	Télécom Paris, 19 place Marguerite Perey, 91120 Palaiseau (Institut Polytechnique de Paris campus).
Language	English.
Audience	Students of the ATHENS network and of Télécom Paris, from all fields; registration through the ATHENS programme of your home institution.
Prerequisites	Linear algebra, complex numbers, elementary probability and information theory; no quantum physics required.

Weekly schedule.

	Morning 9:00–12:15	**Afternoon 13:30–16:45**
Mon 16/11	Welcome reception; Introduction; Quantum measurement	Hermitian (Hilbert) spaces; Dirac notations; Spectral decompositions
Tue 17/11	Observables, projective measurement; Uncertainty principle	Quantum evolution, Wigner's theorem; Stone's theorem, Schrödinger equation
Wed 18/11	Tensor products of Hermitian spaces — and of operators	Partial measurement, POVM; Cloning and discrimination of states
Thu 19/11	Partial/global trace; Schmidt decomposition, SVD	Mixed states, density operators; Measurement, evolution
Fri 20/11	Quantum channels; Classical vs quantum	Trace distance, fidelity, entropies

Why this course? Quantum computing and quantum information are usually taught either as physics — with the mathematics kept in the background — or as algorithmics, with the underlying formalism taken for granted. This course takes a third route: it builds the whole edifice *mathematically*, step by step, from a handful of postulates about measurement in finite-dimensional Hermitian spaces. Everything else — unitary evolution, the Schrödinger equation, density operators, quantum channels — is then *derived*, not postulated. Students leave with a self-contained theoretical toolbox on which any further study of quantum algorithms, cryptography or information theory can rest.

About the ATHENS week at Télécom Paris. Every year, Télécom Paris sends about two hundred of its students to its European partners and hosts as many international students on its campus during the ATHENS week. Courses are one-week, self-contained "opening" courses, accessible to all students provided the displayed prerequisites are met. It is also an opportunity to discover the school and the Institut Polytechnique de Paris campus.

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Course page. `https://perso.telecom-paristech.fr/rioul/cours/quantum-athens.html`