

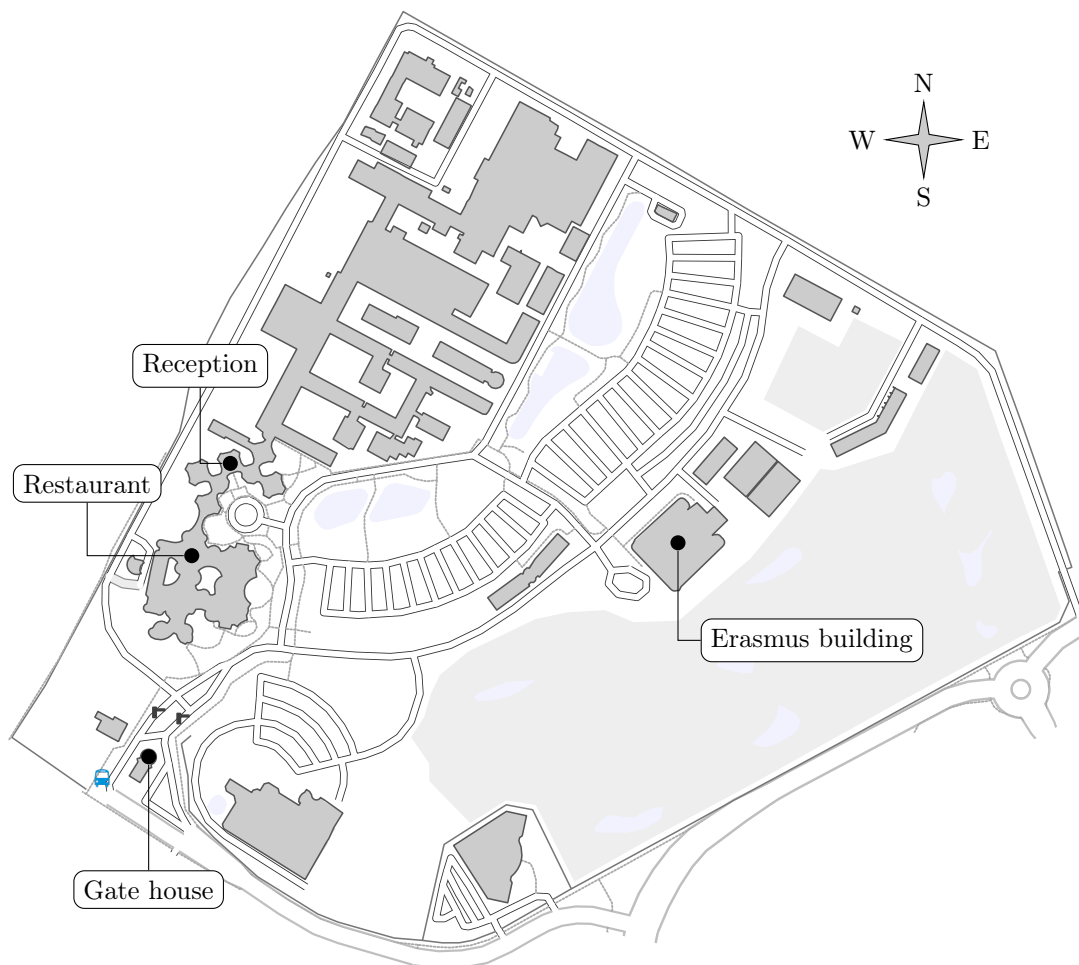
Open Questions in Quantum Physics

Information, Computation and Foundations

Erasmus High Bay, ESTEC

14th - 15th of November 2019

	Thursday 14	Friday 15
9:00	Registration and coffee	Coffee
9:30	Opening	Large Scale Quantum Simulations using Ultracold Atoms <i>Immanuel Bloch</i>
10:00	Exploring and exploiting the quantum with Rydberg atoms <i>Jean-Michel Raimond</i>	
10:30		Coffee
11:00	Coffee	Quantum microwave optics in simple Josephson junction circuits <i>Daniel Estève</i>
11:30	Hyper and microgravity experiment using entangled photons <i>Rupert Ursin</i>	
12:00		Precision Quantum Measurements on Earth and in Space <i>Christophe Salomon</i>
12:30	The ESA Voyage2050 Strategic Plan <i>Günther Hasinger</i>	
13:00		Closure
13:30	Lunch	
14:00	Quantum Algorithms <i>Ronald de Wolf</i>	
14:30		
15:00		
15:30	Witnessing entanglement with statistical speeds: from fundamental physics to quantum technologies <i>Augusto Smerzi</i>	
16:00		
16:30	Coffee	
17:00	Various interpretations of quantum mechanics, relations with gravity <i>Franck Laloe</i>	
17:30		
18:00		



Coming to ESTEC

To go to ESTEC from Leiden, you can take the buses 230 (before 9:15) or 30 (after 9:15) from Leiden Centraal to the terminus “Katwijk ESA ESTEC”. For further details and up-to-date information, you can consult the timetables on <https://9292.nl>.

How to check in

Once you have reached ESTEC, you will have to go to the gatehouse, across from the bus stop. Please bring a government-issued ID (ID card, passport or driver license), as it will be required to go through security. You should be directed to the Erasmus building, where the conference is held.

Coffee breaks and lunches

The coffee breaks will be in High Bay. For lunch, you can go to the main restaurant, accessible from the reception.

Thursday 14

09:00 – 09:30 Registration and coffee

09:30 – 09:40 Opening

09:40 – 10:55 Exploring and exploiting the quantum with Rydberg atoms

Jean-Michel Raimond (*Laboratoire Kastler Brossel, Collège de France, ENS, CNRS and Sorbonne Université*)

The exploration of the puzzling features of the quantum, like state superpositions, entanglement or measurement processes is a thriving experimental field. It is driven by fascinating applications of the quantum, like quantum metrology, quantum information processing or quantum simulation.

Rydberg atoms, long-lived and extremely strongly coupled to external fields, are ideal tools to explore these basic quantum features. We will review a few explorations of the quantum performed at Collège de France using these remarkable states.

The strong interaction of circular Rydberg states with microwave fields in high quality superconducting cavities lead to illustrations of the quantum measurement postulates, or to the generation of field states reminiscent of the famous Schrödinger cat. Coherent manipulations in the complex Rydberg manifold lead to the observation of quantum Zeno dynamics and to the realization of ultra-sensitive electric and magnetic field measurements. Finally, I will present a quantum simulator project emulating spin chains with laser-trapped circular Rydberg atoms.

10:55 – 11:15 Coffee

11:15 – 12:30 Hyper and microgravity experiment using entangled photons

Rupert Ursin (*Institute for Quantum Optics and Quantum Information*)

12:30 – 13:00 The ESA Voyage2050 Strategic Plan

Günther Hasinger (*European Space Agency*)

13:00 – 14:00 Lunch

14:00 – 15:15 Quantum Algorithms

Ronald de Wolf (*QuSoft, CWI and University of Amsterdam*)

This talk will give an introduction to quantum algorithms, which are the core of the “software” of quantum computers. We will go into algorithms relevant for cryptography (such as Shor’s factoring algorithm), for optimization tasks (such as Grover search and the HHL algorithm), and for simulation of physical systems. We will also briefly look at known limitations of quantum computers.

15:15 – 16:30 Witnessing entanglement with statistical speeds: from fundamental physics to quantum technologies

Augusto Smerzi (*QSTAR, INO-CNR and LENS*)

We discuss the profound relation provided by quantum mechanics between the possibility to statistically distinguish quantum states and multipartite entanglement. This relation provides a general framework to investigate different technologies, including quantum precision measurements (interferometric phase estimations and metrology) as well as fundamental problems like the nature of the resources exploited in the Grover search algorithm and the violation of the CHSH-Bell inequality.

16:30 – 16:50 Coffee

16:50 – 18:05 Various interpretations of quantum mechanics, relations with gravity

Franck Laloë (*Laboratoire Kastler Brossel, École Normale Supérieure*)

In most fields of physics (atomic and molecular physics, condensed matter, quantum electrodynamics, etc.), the way quantum mechanics should be applied in practice is perfectly consensual. Nevertheless, how it should be interpreted and really understood is less clear; new articles are still constantly published to propose various interpretations, and controversies may even take place. Another difficulty is the connection with gravity, which is for instance necessary in quantum cosmogenesis. The talk will give an overview of the major families of interpretations of quantum mechanics and their specificities. It will in particular discuss interpretations relating quantum collapse to the effects of gravity (Diosi, Penrose, Bohmian collapse).

Friday 15

09:00 – 09:15 Coffee

09:15 – 10:30 Large Scale Quantum Simulations using Ultracold Atoms

Immanuel Bloch (*Max-Planck-Institut für Quantenoptik*)

More than 30 years ago, Richard Feynman outlined his vision of a quantum simulator for carrying out complex calculations on physical problems. Today, his dream is a reality in laboratories around the world. This has become possible by using complex experimental setups of thousands of optical elements, which allow atoms to be cooled to nanokelvin temperatures, where they almost come to rest. In my talk I will discuss the different platforms for quantum simulation using neutral atoms and ions and discuss selected application highlights ranging from material science to optimisation schemes. I will discuss the status of the field and give an outlook on future scalability of the different underlying systems.

10:30 – 10:50 Coffee

10:50 – 12:05 Quantum microwave optics in simple Josephson junction circuits

Daniel Estève (*SPEC, Université Paris-Saclay, CEA-Saclay*)

A Josephson junction in series with an impedance and voltage biased below the gap provides a simple quantum electrodynamics system in which the coupling constant between charge transfer across the junction and each mode of the impedance is determined by the ratio between the mode impedance and the relevant resistance quantum. Circuit engineering allows to implement interesting situations beyond reach of quantum optics in atomic physics, and noticeably to reach large values of the coupling constant.

In the simplest case of a single mode resonator, the transfer of a single Cooper pair only occurs when its energy $2eV$ can be transformed in $1, 2, \dots, n$ excitations in the resonator. This inelastic tunneling phenomenon is the essence of Dynamical Coulomb Blockade. In the strong coupling regime, a single Cooper pair transfer can be associated to the emission of a few photons in the external circuit. The presence of a single excitation in the resonator can even block the creation of a second one, which then forces the resonator to emit a single photon in the external circuit before another Cooper pair can pass and re-excite it. This phenomenon provides a very simple single photon source.

In a two resonator circuit with different frequencies, the transfer of a single Cooper pair can simultaneously excite a single excitation in each resonator. The photons leaking out of the two resonators in the measurement lines are then entangled, which was probed. In the particular case of two resonators respectively with a high (low) quality factor, the stabilization of a single excitation Fock state in the high Q resonator could furthermore be achieved.

Applications are sought for these non-classical sources of radiation in the microwave domain that could be extended up to the THz frequency range, a quite unexplored domain of the electromagnetic radiation spectrum.

12:05 – 13:20 Precision Quantum Measurements on Earth and in Space

Christophe Salomon (*Laboratoire Kastler Brossel, École Normale Supérieure*)

13:20 – 13:30 Closure