# JUNIQ Summer School on Quantum Computing - Gate-based and Annealing Systems - Remote

# Report of Contributions

Contribution ID: **1**  Type: **not specified**

# Welcome and Introduction to the JSC

*Monday, 26 August 2024 10:10 (20 minutes)*

**Presenter:**   Prof. MICHIELSEN, Kristel

Contribution ID: **2** · · · · · · · · · · · · · · · · · · · · · · Type: **not specified**

# Introduction to Gate-based Quantum Computing

*Monday, 26 August 2024 10:30 (1 hour)*

Introduction to quantum bits and quantum gates
Programming and Simulating quantum circuits
Applications: QFT, Quantum Adder, QAOA

**Presenter:** Dr WILLSCH, Dennis

Contribution ID: **3**                                          Type: **not specified**

# Introduction to Quantum Annealing

*Monday, 26 August 2024 12:30 (1h 30m)*

This talk is a general introduction to quantum annealing. It covers:
- how does a quantum annealer work in theory and what can it be used for;
- what are the theoretical and practical limitations;
- how to solve problems on quantum annealers, in particular D-Wave quantum annealers as the one hosted by JSC;
- the basic information about the architecture of D-Wave quantum annealers;
- how to formulate an optimization problem as a QUBO or Ising problem;
- different encoding strategies;
- how to incorporate constraints;
- how to embed a (logical) problem onto the given hardware graph (considering physical connectivity);
- how to send a problem to the quantum annealer using D-Wave's Ocean SDK and how to interpret the response;
Finally, some small examples are presented and the talk ends with a short hands-on exercise.

**Presenter:**   Dr WILLSCH, Madita

Contribution ID: **4**    Type: **not specified**

# Introduction to Neutral Atom Quantum Computing

*Monday, 26 August 2024 15:00 (1 hour)*

**Presenter:** Dr VODEB, Jaka

Contribution ID: **5**

Type: **not specified**

# QUBO Formulation and QAOA: A Tutorial on Encoding and Solving Combinatorial Optimization Problems - Part I

*Tuesday, 27 August 2024 09:00 (1 hour)*

In this tutorial, we will dive into combinatorial optimization problems and explore how effectively encode these problems using the Quadratic Unconstrained Binary Optimization (QUBO) formulation and how to tackle them using the Quantum Approximate Optimization Algorithm (QAOA).

**Presenter:** Dr MONTANEZ-BARRERA, Jhon Alejandro

Contribution ID: **6**                                                         Type: **not specified**

# Introduction of Hands-on Topics

*Tuesday, 27 August 2024 10:00 (20 minutes)*

In this session, the topics for the hands-on sessions will be introduced.

Contribution ID: **7**                   Type: **not specified**

# Hardware & Software Setup

*Tuesday, 27 August 2024 10:20 (40 minutes)*

Contribution ID: **8**                                                Type: **not specified**

# Hands-on Session

*Tuesday, 27 August 2024 11:00 (1 hour)*

Contribution ID: **9**                                                    Type: **not specified**

# QUBO Formulation and QAOA: A Tutorial on Encoding and Solving Combinatorial Optimization Problems - Part II

*Tuesday, 27 August 2024 13:00 (1 hour)*

In this tutorial, we will dive into combinatorial optimization problems and explore how effectively encode these problems using the Quadratic Unconstrained Binary Optimization (QUBO) formulation and how to tackle them using the Quantum Approximate Optimization Algorithm (QAOA).

**Presenter:**   Dr MONTANEZ-BARRERA, Jhon Alejandro

Contribution ID: **10** Type: **not specified**

# Hands-on Session

*Tuesday, 27 August 2024 14:00 (2 hours)*

Contribution ID: **11**                                                          Type: **not specified**

# Emulating Quantum Systems

*Tuesday, 27 August 2024 16:00 (1 hour)*

Full dynamics of a CLOSED quantum spin-1/2 system: gate-based quantum computer & quantum annealer;
Full dynamics of an OPEN quantum spin-1/2 system: gate-based quantum computer & quantum annealer;
Solving the time-dependent Schrödinger equation numerically;
(Part of) our history of emulating quantum computers;

**Presenter:**   Prof. MICHIELSEN, Kristel

Contribution ID: **12**                                        Type: **not specified**

# Quantum Annealing Applications

*Wednesday, 28 August 2024 09:00 (1 hour)*

Optimization Problems: Airline Scheduling, TSP, Garden Optimization
Constraint Problem: 2-SAT
Machine Learning Problem: Quantum Support Vector Machine
Sampling Problem: Quantum Boltzmann Machin

**Presenter:**   Dr WILLSCH, Dennis

Contribution ID: **13**                                                Type: **not specified**

# Quantum Simulation

*Wednesday, 28 August 2024 10:00 (1 hour)*

I will talk about the first experimental signatures of two-dimensional many-body false vacuum decay in a quantum material emerging from microscopic interactions. We used a programmable noisy superconducting quantum simulator with 2008 qubits in order to perform simulations corresponding to our specific experiment on quantum domain reconfiguration in a topical electronic crystal. We carefully chose a simulator with the same measured noise spectrum to ensure the fidelity of the model correspondence between the two systems, thereby presenting a realization of simulating real-world open quantum systems according to the original vision of Feynman.

**Presenter:** Dr VODEB, Jaka

Contribution ID: **14**                                    Type: **not specified**

# Hands-on Session

*Wednesday, 28 August 2024 11:00 (1 hour)*

Contribution ID: **15**                                Type: **not specified**

# Simulating Noise of Quantum Computers

*Wednesday, 28 August 2024 13:00 (1 hour)*

As much as we want to isolate them, we must see quantum machines as open systems. Interactions happen between the quantum machine and its environment leading to decoherence. This effectively give different types of noise at the level of the machine. What are they and how can we take them into account when doing simulation on our classical computer?

**Presenter:**   Dr SELLAPILLAY, Kevissen

Contribution ID: **16**                                    Type: **not specified**

# Hands-on Session

*Wednesday, 28 August 2024 14:00 (1 hour)*

Contribution ID: **17**    Type: **not specified**

# Building a Superconducting Quantum Computer

*Thursday, 29 August 2024 11:00 (1 hour)*

**Presenter:** Prof. BARENDS, Rami (PGI-13)

Contribution ID: **18**                                    Type: **not specified**

# Hands-on Session

*Thursday, 29 August 2024 13:00 (2 hours)*

Contribution ID: **19**　　　　　　　　　　　　　　　　Type: **not specified**

# Quantum Annealing - A Broader Perspective

*Thursday, 29 August 2024 15:00 (1 hour)*

**Presenter:**　Prof. WARBURTON, Paul

Contribution ID: **20**                           Type: **not specified**

# Hands-on Session

*Friday, 30 August 2024 10:00 (1h 45m)*

Contribution ID: **21**　　　　　　　　　　　　　　　　　　Type: **not specified**

# The Future of Quantum Computing

*Friday, 30 August 2024 14:00 (1 hour)*

**Presenter:** Prof. WILHELM-MAUCH, Frank

Contribution ID: **22**                                                Type: **not specified**

# Wrap-up and Goodbye

*Friday, 30 August 2024 15:00 (30 minutes)*

**Presenter:**   Mr FAZITO REZENDE FERNANDES, Gabriel (JSC)