

JUNIQ Spring School on Quantum Computing - Gate-based and Annealing Systems

Report of Contributions

Contribution ID: 1

Type: **not specified**

Introduction to Gate-based Quantum Computing

Monday 31 March 2025 10:15 (1h 15m)

Introduction to quantum bits and quantum gates

Programming and Simulating quantum circuits

Applications: QFT, Quantum Adder, QAOA

Presenter: Dr WILLSCH, Dennis (JSC)

Contribution ID: 2

Type: **not specified**

Introduction to Quantum Annealing

Monday 31 March 2025 11:30 (1 hour)

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 (JSC)

Contribution ID: 3

Type: **not specified**

Pen&Paper (Quantum Annealing)

Monday 31 March 2025 14:00 (1 hour)

Presenter: Dr WILLSCH, Madita (JSC)

Contribution ID: 4

Type: **not specified**

Welcome and Introduction to the JSC

Monday 31 March 2025 10:00 (15 minutes)

Presenter: FAZITO, Gabriel (JSC)

Contribution ID: 5

Type: **not specified**

Emulating Quantum Systems

Wednesday 2 April 2025 14:15 (1h 15m)

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: Dr MEHTA, Vrinda (JSC)

Contribution ID: 6

Type: **not specified**

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

Tuesday 1 April 2025 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 (JSC)

Contribution ID: 7

Type: **not specified**

Introduction of Hands-on Topics

Tuesday 1 April 2025 10:00 (20 minutes)

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

Contribution ID: 8

Type: **not specified**

Hardware & Software Setup

Tuesday 1 April 2025 10:20 (40 minutes)

Contribution ID: 9

Type: **not specified**

Hands-on Session

Tuesday 1 April 2025 11:00 (1 hour)

Contribution ID: **10**

Type: **not specified**

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

Tuesday 1 April 2025 13:00 (1h 15m)

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 (JSC)

Contribution ID: **11**

Type: **not specified**

Hands-on Session

Tuesday 1 April 2025 14:15 (1h 15m)

Contribution ID: 12

Type: **not specified**

Introduction to Neutral Atom Quantum Computing

Monday 31 March 2025 16:00 (1 hour)

Presenter: Dr VODEB, Jaka

Contribution ID: **13**

Type: **not specified**

Quantum Annealing Applications

Wednesday 2 April 2025 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 Machine

Presenter: Dr WILLSCH, Dennis (JSC)

Contribution ID: 14

Type: **not specified**

Quantum Simulation

Tuesday 1 April 2025 15:30 (1h 15m)

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 topological 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: **15**

Type: **not specified**

Hands-on Session

Wednesday 2 April 2025 10:00 (2 hours)

Contribution ID: **16**

Type: **not specified**

Introduction to Quantum Error Correction

Wednesday 2 April 2025 13:00 (1h 15m)

Presenter: Prof. MÜLLER, Markus (PGI/RWTH)

Contribution ID: 17

Type: **not specified**

Cooling to Compute: Millikelvin Cryogenics for Quantum Information Processing

Thursday 3 April 2025 09:00 (1 hour)

Presenter: Dr RABANUS, David (JSC)

Contribution ID: **18**

Type: **not specified**

Hands-on Session

Contribution ID: **19**

Type: **not specified**

Hands-on Session

Thursday 3 April 2025 12:30 (2h 30m)

Contribution ID: 20

Type: **not specified**

Meta Perspective on Gate-based Quantum Computing

Thursday 3 April 2025 15:00 (1h 30m)

Presenter: Prof. POP, Ioan (KIT/Stuttgart University)

Contribution ID: **21**

Type: **not specified**

Hands-on Session

Friday 4 April 2025 10:00 (2 hours)

Contribution ID: 22

Type: **not specified**

The Future of Quantum Computing

Friday 4 April 2025 14:00 (1 hour)

Presenter: Prof. CALARCO, Tommaso (PGI-8)

Contribution ID: 23

Type: **not specified**

Wrap-up and Goodbye

Friday 4 April 2025 15:00 (30 minutes)