NeQST

Next level Quantum information processing for Science and Technology

Deliverable D5.7 First NeQST Conference

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History of change

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0.1	27.11.2022	Philipp Hauke (UNITN)	Set-up of the deliverable and first content
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Executive Summary

The NeQST kickoff meeting (first NeQST conference) was held on 17./18.11.2022 at the location of the partner UIBK. The venue was the Institute of Quantum Optics and Quantum Information (IQOQI). About half of the meeting was dedicated to formal and administrative aspects, including the presentation of partners and work packages as well as meetings of the General Assembly and the Steering Board. The other half was dedicated to predominantly scientific content, including tutorials, discussions, and laboratory visits. All partners were present at the meeting and contributed to its content, with a significant participation also of younger researchers (> 50%).

Table of Contents

1. Main purpose of kick-off meeting

The kick off meeting took place on November 17 and 18, 2022 at the University of Innsbruck and the Institute for Quantum Optics and Quantum Information (IQOQI), Innsbruck.

The NeQST consortium consists of 6 partners and 1 affiliated entity. While several of these already have demonstrated the ability to work together and produce outstanding collaborative results, NeQST's declared aim is to closely bundle the know-how present in the consortium in order to generate added value beyond the possibilities of any individual partnerships.

The main purpose of this kick-off meeting was thus two-fold.

(a) Formal consortium constitution, including

- Align partners on the objectives of the NeQST project
- Make partners aware of duties and rights (e.g., timelines of Deliverables and Milestones)
- Make partners aware of mutual roles (e.g., WP leaderships, contributions to Tasks)
- First meetings of General Assembly and Steering Board

(b) Construction of a collaborative research network, including

- Educate all partners about main research thrust and expertise of each group
- Identify points of collaborations, also beyond those described in the project proposal
- Interconnect previous research cliques

2. Structure and execution of kick-off meeting

This two-fold purpose was reflected in the entire structure of the kickoff meeting, such as the agenda as well as the selection of participants including in particular a sizeable number of young researchers (>50% on PhD and Postdoctoral level).

2.1 Participants

For the team building, essential at this early stage of the project, participation to the workshop was restricted to members of the project partners (a workshop is foreseen at month 18 organized by HRI, to which external researchers will be invited, and a scientific conference is planned for month 36, to be organized by UNITN, which will be open to all researchers in the field). Particular effort was undertaken to have—besides the participation of the PIs of the groups—a strong representation also of younger researchers.

The participants were 7 Senior Researchers (Professor/Group leader/PI), 3 Postdoctoral fellows, and 6 PhD students, as well as 1 Research Manager & Administrator and 1 Technology Transfer Manager, for a total of 18 participants.

The full list can be found in Table 2 and a workshop photo, taken on Day 2, is presented in Figure 1.

Name	Partner	Level
Philipp Hauke	UNITN	Associate Professor / PI
Alessandro Roggero	UNITN	Assistant Professor
Edoardo Ballini	UNITN	PhD Student
Alberto Bottarelli	UNITN	PhD Student
Elisa Chiarani (remotely)	UNITN	Research Manager & Administrator
Francesco Placentino	HIT	Technology Transfer Manager
Robert Wille	TUM	Professor / PI
Stefan Hillmich	TUM	Postdoc
Sebastian Schmitt	HRI	Group Leader / PI
Steve Lenk	IOSB-AST	Research associate (Postdoc) / PI
Daniel Müssig	IOSB-AST	Research associate (PhD level)
Marika Federer	IOSB-AST	Research associate (PhD level)
Antonio Acin	ICFO	Professor / PI
Pavel Popov	ICFO	PhD Student
Paolo Stornati	ICFO	Postdoc
Martin Ringbauer	UIBK	Postdoc / PI
Claire Edmunds	UIBK	Postdoc
Michael Meth	UIBK	PhD Student

Table 2: Participants to NeQST kickoff meeting.

Figure 1: Participant photo of the NeQST kickoff meeting, taken on day 2 on the terrace of the meeting Venue (IQOQI Innsbruck)

2.2 Venue

As the venue for the kickoff meeting, the partners had chosen already during the project preparation the Institute for Quantum Optics and Quantum Information (IQOQI), Innsbruck. This was indeed the ideal choice (i) for the excellent infrastructure and administrative support for meetings of this type, (ii) for the central position and proximity to various partners, and (iii) most importantly for the presence of the trapped-ion qudit hardware. Indeed, a particular highlight of day 2 was the visit to the laboratories of the trapped-ion group at IQOQI and the University of Innsbruck.

2.3 Dissemination activities

As part of our dissemination activities, we have posted announcements of our kickoff meeting at various social media outlets, such as linked-in, see, e.g.,

https://www.linkedin.com/feed/update/urn:li:activity:7001233258092883968

https://www.linkedin.com/feed/update/urn:li:activity:7002948785723035648

We are planning to ramp these activities further up once the administrative project assistant to work on the project will be hired (a selection procedure is currently open at UNITN, from which we hope to identify suitable candidates).

In this context, an important part of the lively open discussions as well as the discussions of the Steering Committee were how to most efficiently structure and maintain the webpage under construction, how to most successfully retrieve input, and related issues.

For this kickoff meeting, talks were for internal use only, but for future workshops it is planned to make selected talks publicly available (e.g., through project and group webpages or youtube).

3. Agenda

The Agenda of the NeQST kickoff meeting can be found in Table 1. Below follows a description of the main contents. All sessions were chaired jointly by PH and MR.

Part 1

The morning of the first day and most of that afternoon were dedicated in particular to purpose **(a), the formal consortium constitution.** These sessions, in particular 1.2-1.3, foresaw ample time for questions and discussions by all participants,

Session 1.1—Greetings, project overview, partner presentations

A greeting by the local organizer MR, UIBK, was followed by a brief project overview by PH, UNITN, with the purpose of reminding the participants of the main aspects of the project and the overall connection between various work packages. All partners presented their institution as a whole, their research group and researchers involved in the project, their expertise, and the formal role in the project, in particular in view of WP and Task responsibilities.

Session 1.2—Presentation of scientific WPs 1-4

The respective lead partners presented the WPs, including the individual scientific thrusts, main research motivations and challenges, connections to other WPs, involvements of partners, and the respective deliverables and milestones. In order of appearance, these were WP1: *Advanced qudit control and design* (MR, UIBK), WP2: *Quantum simulation algorithms for Abelian and non-Abelian gauge theories* (PH, UNITN), WP3: *Quantum optimization with qudits for energy management applications* (SL, IOSB-AST), WP4: *Certification of qudit systems and their performance* (AA, ICFO). Scientific and methodological details were mostly delegated to Part 2 (see below).

Session 1.3—Presentation of WP5, *Management, Dissemination, Communication, and Exploitation*

EC (UNITN, connected remotely) presented WP5 with focus, i.a., on discussing administrative and financial requirements, establishing best practices for the future collaboration, quality assurance and reporting, timelines of deliverables and milestones, risk and data management, highlighting possibilities and importance of dissemination and communication activities, including obligations such as open science and visibility of funding.

FP (Affiliated Partner HIT) presented the exploitation aspects of NeQST (Task 5.4), which served to emphasize the importance of generating impact and looking for potential for exploitation. A timeline and required input by all partners for Deliverable D5.5 *IPR and exploitation plan* was presented.

Session 1.4—Meetings of General Assembly and Steering Committee

The formal-administrative aspects of the kickoff meeting were concluded by closed meetings. For organizational reasons, this session was temporally preceded by the first session of the scientific Part 2, described below. First, the General Assembly (GA) convened with participation of the project PIs of all partners (PH,MR,SS,SL,RW,AA), which formally established Steering Committee (same composition as GA) and Work Package Leaders (WP1: MR, WP2: PH, WP3: SL, WP4: AA, WP5: PH). The Steering Committee discussed several organizational issues, such as first deliverables and

assigning responsibles for each, the NeQST brand and visual identity as well as dissemination activities, a brief presentation of the hop on application by Remigiusz Augusiak (submitted 10.11.2022), as well as the organization of the implementation of scientific work.

Part 2

One afternoon session of day 1 as well as the entire day 2 were dedicated to purpose ***(b) Construction of a collaborative research network*.**

Particular measures to achieve this purpose were as follows.

- Each partner gave a tutorial on their main research thrust within the project, roughly aligned with the research topic of the WPs seeing each partner's main contribution. These tutorials were aimed at educating the other partners about the expertise present in the consortium and to identify possible contact points for collaborations, including those described in the project as well as new ones. These tutorials were the contents of sessions 2.1,2.3-2.7.
- Ample time was allotted for open discussions. These included informal meetings such as the coffee break and joint meals throughout the two-day workshop, as well as a dedicated slot in the afternoon of day 1 (session 2.2) and the time slot following the laboratory visits (session 2.8). The success of these discussion sessions was demonstrated by the active participation of all researchers, through all levels of experience and in particular also among groups that previously had less direct contact.
- The participants were given a guided tour through the laboratories of UIBK (session 2.8) as the trapped-ion qudit architecture constitutes a central focus point of the project, with strong connection to all WPs, in particular also the theoretical ones. This guided tour presented an excellent opportunity to obtain first-hand experience with this platform.

Session 2.1—Experimental Qudit Control

MR (UIBK) presented the Innsbruck approach to qudit-based quantum information processing with trapped ions. He highlighted how to perform the full set of operations from initialization to manipulation to readout, and discussed the current limitations and potential opportunities.

This presentation had highest relevance for WP1, but also to all others, as a tight collaboration between theory and experiment will be critical for the development of theoretical algorithms and certification strategies that can eventually be implemented on UIBK qudit hardware.

Session 2.2—Open discussion (non PIs, in parallel to GA and SB meeting)

The open discussion mostly focused on establishing common ground for research groups working on the same WPs. Overviews on what was done already were discussed between the various groups.

Session 2.3—Qudit Design and User Interface

RW and SH (TUM) presented methods and software tools for the design of quantum algorithms, circuits, and systems, with special focus on a qudit-based approach. They also showed how the use of decision diagrams to save classical memory will allow for simulating quantum systems in an efficient way.

The contents of this presentation were in particular relevant for WP1, but also for all other WPs, as the software developed by TUM will be used by all other partners as interface in implementations

of the developed algorithms and certification strategies, as well as for classical benchmark simulations.

Session 2.4—Quantum Simulation of Gauge Theories

PH (UNITN) presented strategies of quantum simulating lattice gauge theories, with the aim of studying high energy physics at ultra-cold temperatures. Challenges of comparable classical computations as well as of state-of-art quantum simulations were highlighted, and an outline was given how these could be overcome through implementations of LGTs in a qudit approach, for Abelian and non-Abelian theories. AR (UNITN) presented strategies for improved quantum error correction using constraints given by gauge symmetries.

The contents were of most relevance for WP2, though connections to other WPs, in particular WP1 (qudit requirements for LGTs), WP3 (formulation of constraints), and WP4 (development of error-resilient methods) were highlighted.

Session 2.5—Quantum Optimization for Industry-relevant Applications

SS (HRI) presented the EV charging problem as an example to introduce the goals and deliverables of WP3. Multi-Objective constrained quantum optimization was introduced, along with a discussion on the relevance of finding a Pareto-Dominant solution of the problem and some ideas on how to tackle it using the qudit based architecture. Ideas for a minimal instance were discussed. Connections in particular to WP2 were discussed.

Session 2.6—Quantum Optimization for Energy Management

SL (IOSB-AST) described optimization of energy distribution on a grid. The focus was set on the typical constraints of the problem, which are highly relevant also to WP2. First results were shown regarding the study of the energy landscape of the quantum system representing the original problem. Ideas on how to implement inequality constraints were presented. The contents of this presentation were of primary relevance for WP3, with connections to WP2.

Session 2.7—Certification of Quantum Systems

AA presented how to certificate quantum devices performance in a device-independent way, solely by extracting statistics from them. The certification of energy spectra and the dimensionality of constituents were discussed. The possibilities to validate future devices and/or protocols developed by other groups of the consortium were discussed.

The contents of this presentation were of primary relevance for WP4, but with repercussions on all WPs as the techniques developed will be used to certify the experimental machine (WP1) and to benchmark the algorithms designed within WPs 2 and 3.

Session 2.8—Lab Tours & Open Discussion

The lab tour was focused on presenting the already existing architecture of qubit based quantum computers of the UIBK laboratory. Further explanations of both one and two dimensional ion traps were provided, along with a presentation of the problems of upgrading from a quBit to a quDit architecture. This first-hand experience will be of significant use for all groups in their development of software interfaces, quantum computational algorithms, and certification strategies (all WPs).

Table 1: Agenda of NeQST kickoff meeting

Thursday, November 17	
10:00 – 10:15	Welcome | UIBK
10:15 – 10:30	Project Presentation | UNITN
10:30 – 11:20	Presentation of partners | PIs of nodes
11:20 – 12:20	Presentation of Work packages 1-4 | WP leaders
12:20 – 13:30	Lunch
13:30 – 14:30	WP5, Management, Dissemination, Exploitation | UNITN, HIT
14:30 – 15:30	Open Discussion
15:30 – 16:00	Coffee Break
16:00 – 16:45	Experimental Qudit Control | UIBK
16:45 – 18:30	Steering Board Meeting
19:00	Workshop Dinner

Friday, November 18	
9:00 – 9:45	Qudit Design and User Interface | TUM
9:45 – 10:30	Quantum Simulation of Gauge Theories | UNITN
10:30 – 11:00	Coffee Break
11:00 – 11:45	Quantum Optimization for Industry-relevant Applications | HRI
11:30 – 12:30	Quantum Optimization for Energy Management | IOSB-AST
12:30 – 14:00	Lunch
14:00 – 14:45	Certification of Quantum Systems | ICFO
14:45	Lab Tours & Open Discussion