NEXT LEVEL QUANTUM INFORMATION PROCESSING FOR SCIENCE AND TECHNOLOGY

DELIVERABLE D5.8 – SECOND NEQST CONFERENCE

Grant Agreement:	101080086
Project Title:	NEXT LEVEL QUANTUM INFORMATION PROCESSING FOR SCIENCE AND TECHNOLOGY
Project Acronym:	NeQST
Project Start Date:	01 November 2022
Deliverable Number and title:	D5.8 – Second NeQST conference
Related Work Package:	WP5 - Management, Dissemination, Communication, and Exploitation
Due Date:	30 April 2024
Submission date:	30 April 2024
Type:	DEC
Dissemination Level:	Public

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the granting authority can be held responsible for them.

Authors

	Name	Beneficiary
Lead Editor	Philipp Hauke	UNITN
Contributors	Sara Rebecchi	UNITN
	Sebastian Schmitt	HRI-EU
	Martin Ringbauer	UIBK
	Antonio Acín	ICFO

History of change

Version	Date	Contributor	Additional information
0.1	06/03/2024	Philipp Hauke, Sara Rebecchi (UNITN)	Set-up of document and content structure
1.0	14/03/2024	Sebastian Schmitt (HRI)	Finalized first draft
1.1	18/03/2024	Martin Ringbauer (UIBK)	Review and minor changes
2.0	15/04/2024	Sebastian Schmitt (HRI)	Updated after workshop
2.1	16/04/2024	Philipp Hauke (UNITN)	Minor revisions
2.2	19/04/2024	Martin Ringbauer (UIBK) Antonio Acín (ICFO)	Minor revisions
3.0	29/04/2024	Sara Rebecchi (UIBK)	Quality check and finalization of the document

Executive Summary

The second NeQST conference took place on 9-11 April 2024 in the premises of the Honda Research Institute Europe (HRI) in Offenbach, Germany. The programme of the conference covered three days, from the early afternoon of Tuesday 9 April until lunchtime of Thursday 11 April. The first and second day of the conference were devoted to the presentation of scientific results presented by researchers of the consortium (talks and posters), and three talks from invited speakers. Additionally, a workshop on IP and exploitation was held in the afternoon session of the second day. The final day of the conference was dedicated to the meetings of the General Assembly and the Steering Board.

The main targets of the NeQST conference were collocated in several areas

(1) Research: To share and discuss the achieved results with all partners, diffuse the accumulated knowledge, and identify the next steps; to this end, the programme included ample time for talks and poster sessions where brainstorming and inspirational discussions took place;
(2) Exploitation: To bring together all partners with experts on exploitation from involved institutions and the consultants of the Horizon Results Booster (HRB) initiative, in order to identify promising routes for exploitation and stimulate involved researchers to actively search for exploitation possibilities; for this goal, the programme included a dedicated workshop on IP and exploitation;
(3) Administration: To align all partners in terms of administration and organization of the project, including upcoming milestones, deliverables, and mid-term report meeting; to this end, the agenda included the meetings of the General Assembly and the Steering Board.

A further, secondary aim was

(4) Dissemination: To disseminate the results also to researchers of the partner institutions not directly involved in the project as well as to a select number of external experts.

The conference was very successful as all above targets were achieved. The researchers of the NeQST project actively exchanged information and ideas, brought each other up to the current state of affairs in each work package, discussed and evaluated future avenues for collaborative research topics, and sharpened their common goals of the NeQST project. The invited scientific guest researches as well as the researchers not in the NeQST project actively participated in the scientific exchange, stimulated discussions of novel ideas, and also got some inspiration for using the results of the NeQST project for their own research. The conference also saw the participation of a significant number of young researchers who did use this chance to practice scientific discourse and took the chance to present and discuss their findings to experienced researchers. Many of the PhD students gave the presentation of their corresponding work package. The workshop on IP and exploitation provided a solid knowledge base and encouraged all researchers who mostly did not have much contact with the topic, to be more attentive to IP and exploitation of their ideas in the future. The NeQST project members revisited and revised the administrative processes, and refined the concrete research plans of each group with the milestones and the overall project goals.

Table of Contents

1. Introduction

The second NeQST conference took place on 9-11 April 2024 on the premises of the Honda Research Institute Europe in Offenbach, Germany. The programme of the conference covered three days, from the early afternoon of Tuesday, 9th of April until lunchtime of Thursday, 11th of April 2024.

The main aims of the NeQST conference can be summarized by the four key targets:

(1) **Research: To inform the partners about the achieved results, diffuse the accumulated knowledge, and identify the next goals.**
To this end, the first day and a significant part of the second day of the conference were devoted to the presentation of scientific results by researchers of the consortium. Moreover, three external experts were invited to speak in order to give new stimuli to the consortium. Participants from the partner institutions (NeQST researchers as well as external to the project) presented their work in two poster sessions (8 posters).

(2) **Exploitation: To provide fundamental knowledge on IP and exploitation to researchers, bring together all partners with experts on exploitation, to identify promising routes for exploitation and stimulate involved researchers to actively search for exploitation possibilities.**
A dedicated IP workshop in the afternoon of the second day was included to achieve this goal. The first part provided the general background on IP and exploitation and was open to all attendees, while the second part was dedicated for NeQST researchers and focussed on concrete strategies for exploitation within the NeQST project. These provided important stimuli to the exploitation strategy of the project and food for thought also for younger participants who had not previously come into contact with questions on IP and exploitation.

(3) **Administration: To align all partners in terms of administration and organization of the project, including upcoming milestones, deliverables, and mid-term report meeting.**
To this end, in particular the final day of the conference was dedicated to the meetings of the General Assembly and the Steering Board.

A further, secondary aim concerned

(4) **Dissemination: To benefit from the opportunity to disseminate the results also to researchers of the partner institutions not directly involved in the project as well as to a select number of external experts.**
While at this stage it was preferred to not publicly announce the conference, in order to provide a sufficiently intimate venue, it was opened to any interested researchers from the partner institutions as well as to a select number of invited external experts. The feedback of these external participants was very positive, and a number of collaboration avenues that may be highly beneficial to the project have already been identified.

2. Structure and execution of the conference

The first target of the conference was to bring all researchers within the NeQST project, as well additional interested researchers from the partner institutions, together and foster fruitful scientific discussions. A major part of the first two days was dedicated to the project members to report on their progress and findings related to work packages from the NeQST project. This formed the basis for intense discussions during and after the talks. Also, in-depth interactions in small groups on concrete achievements took place during the breaks. Several novel ideas and concrete future collaboration targets resulted from these interactions. The poster sessions supported these fruitful exchanges and also encouraged junior researchers to pitch their ideas to experienced researchers and collect valuable feedback on contents and the presentation of results.

The three invited guests actively participated in the discussions and brought some interesting aspects into the discourse. Their scientific talks were inspiring and also provoked the discussion of novel ideas. They also showed interest in the works presented during the workshop and several new collaboration opportunities have emerged.

The second focus of the conference was the evaluation of possibilities for future exploitation of results of the NeQST project. This was done by first conducting an introductory workshop on intellectual property (IP) and exploitation given by the external experts to the whole audience. This was followed up by a deep-dive into the possibilities of exploiting concrete results of the NeQST workshop where only project members were permitted to participate. During the workshop, the discussions between the exploitation expert and the consortium members led to a clearer image on how to re-evaluate the current key exploitable results (KER) and propose exploitation strategies. The concrete discussions with the exploitation expert elucidated several possible routes for exploitation to the project members. In particular, the issues that need clarification and the concrete market-oriented questions to be addressed for evaluating the exploitation possibilities were intensively discussed.

The overall schedule of the workshop is shown on page 11.

2.1 Participants

Participation to the workshop was open to researchers of the NeQST consortium as well as interested researchers from the partner institutions. Three external speakers were also invited to contribute to the content of the scientific part of the programme. Furthermore, external consultants were invited for the development of the IP and Exploitation strategy, identified through the Horizon Results Booster programme. It was decided to not fully open the conference in order to provide an intimate venue for the exchange of ideas and to streamline the scientific content to the needs of the project; moreover, this format permitted for a much more organic and efficient integration of the IP workshop, an integral part of this conference, than a fully open conference would have allowed. In total, there were 27 on-site and 6 online participants, of which 25 are members of the NeQST project team, and 8 are external to the project. Of the 33 participants, 13 were junior scientists (PhD or postdoctoral fellows). The overview on all participants and their roles in the project is shown in Table 1.

Name	Affiliation	Role in NeQST project
Philipp Hauke	UNITN	Coordinator
Elisa Chiarani (online)	UNITN	Administration
Sara Rebecchi	UNITN	Administration
Matteo M. Wauters	UNITN	PostDoc
Edoardo Ballini	UNITN	PhD
Gopal Chandra Santra	UNITN	PhD
Alberto Bottarelli	UNITN	PhD
Luca Spagnoli	UNITN	PhD
Antonio Acin (online)	ICFO	PI
Maciej Lewenstein (online)	ICFO	PI
David Jansen	ICFO	PostDoc
Ignacio Perito	ICFO	PostDoc
Paolo Stornati	ICFO	PostDoc
Pavel Popov	ICFO	PhD
Martin Ringbauer	UIBK	PI
Peter Tirler	UIBK	PhD
Steve Lenk (online)	Fraunhofer IOSB-AST	PI
Daniel Müssig	Fraunhofer IOSB-AST	Researcher
Sebastian Schmitt	HRI	PI
Linus Ekstrøm	HRI	PhD
Makoto Ohtani (online)	HRI	Researcher
Krishna Rajan	HRI	Staff
Robert Wille	TUM	PI
Kevin Mato	TUM	PhD
Remigiusz Augusiak	CFT PAN	PI
Saronath Halder	CFT PAN	PostDoc
Placentino Francesco	HIT	Staff
Elisa Morganti (online)	HIT	Staff
Elio De Tullio	Horizon Results Booster	Consultant (extern)
Paolo De Stefanis	Horizon Results Booster	Consultant (extern)
Mikel Sanz	U Basque Country	Invited speaker (extern)
Richard Küng	U Linz	Invited speaker (extern)
Erez Zohar	U Jerusalem	Invited speaker (extern)

Table 1: Participants of the NeQST qorkshop

Figure 1: Photo of scientific participants.

2.1.1 Invited speakers

Three external speakers were invited to attend the conference and give 40 minute talks on selected aspects of their research. The external speakers were chosen based on two primary considerations: (i) the research of the invited speaker should be interesting for the NeQST project, and the talk and discussion with the invited guests should stimulate novel ideas and new routes to topics on the NeQST project. (ii) The topic and the research conducted within the NeQST project should be brought to the attention of the invited speaker and hopefully stimulate novel ideas for their own research.

The first invited speaker was Richard Küng from the Johannes Kepler University in Linz, Austria. He is a leading expert in the efficient characterization of quantum systems, which is of critical importance for qudit systems with their significantly larger Hilbert space, compared to qubits, and highly relevant to WP1 and WP4 of NeQST. Richard Küng presented on the topic of classical shadows, which is a technique to extract many different quantities form quantum states with much fewer measurements than using a full state tomography. He is currently extending this technique to qudit quantum states, which constitutes an excellent overlap to the topics of the NeQST project and led to an intense exchange with the project team. During the workshop, it was moreover identified that the classical-shadow formalism could find application in increasing the efficiency of the variational algorithms developed within WP2.

On the second day, Erez Zohar from the Racah Institute of Physics and Hebrew University in Jerusalem, Israel, presented some of his recent work on Projected Entangled Pair States (PEPS) for quantum simulation of lattice gauge theories. In recent research, he also has made significant contributions in deriving efficient mappings for lattice gauge theories to quantum-computing and –simulation hardware. With his research experience, Erez Zohar was a very valuable discussion partner during the workshop, in particular regarding WP2 and aspects of the software simulator for WP1.

The third invited speaker was Mikel Sanz from the University of the Basque Country in Bilbao, Spain. His main research topics are applications of quantum optimization, quantum machine learning, and quantum technology in general. He presented some of his works on quantum machine learning

(relevant for WP3), analog-digital quantum computing (relevant for WP1), and benchmarking quantum algorithms on current NISQ quantum hardware (relevant in particular for WP4). He is currently investigating extensions of these three topics to qudit systems. During the workshop it was further found that previous works of his on local symmetries in Kraus channels could find applications in WP2. This various expertise led to a good exchange on topics that are being treated within the consortium and stimulated also novel ideas between members of the NeQST project and Mikel Sanz.

2.2 Venue

The conference venue was determined by the partners to be the premises of the Honda Research Institute Europe (HRI) in Offenbach, Germany. The location of HRI is ideal for this conference due to its proximity to the Frankfurt am Main International Airport. HRI provided full logistics, including registration of participants and catering.
The rooms of HRI were very well suited for conduction of the conference as there is a large hall where the talks and poster sessions took place, with the nearby availability of a larger and two smaller meeting rooms for private discussions and meetings. This layout was ideal for such a type of conference as it allowed for plenary talks to all interested attendees and poster sessions where everybody could freely interact and have many discussions. At the same time, it allowed for break-out sessions with smaller numbers of participants or more private meetings (such as the Steering Board Meeting). Moreover, since the rooms were fully reserved for the conference, there was no need to remove posters or leave the rooms during the workshop.

2.3 Agenda

The agenda of the conference can be seen in Table 2 on page 11.

2.3.1 Scientific talks

This first session was centred around qudit quantum hardware, software and certification, which are the topics of WP1. Talks were given by Peter Tirler (UIBK), Kevin Mato (TUM), Ignacio Perito (IFCO), and Remigiusz Augusiak (CFT). This session was followed by the invited talk by Richard Küng on classical shadows.
The second session was focused on the central topic of WP2, which is quantum simulation for lattice gauge theories. It was opened by the invited speaker Erez Zohar with a talk on projected entangled pair states (PEPS). The following talks were given by Matteo Wauters (UNITN), Paolo Stornati (ICFO), and Pavel Popov (ICFO).

The third and last scientific talk session was on applications of quantum optimization and was opened by the invited guest Mikel Sanz, who presented selected works on analog-digial quantum simulation, quantum machine learning, and quantum benchmarking. This session was concluded by talks from Daniel Müssing (IOSB-AST) and Linus Ekstrøm (HRI).

Figure 2: Impressions from the invited talks

Tuesday, 9th April 2024

11:30 – 12:45	Lunch
12:45 - 13:00	Welcome
13:00 - 13:20	Overview NeQST / UNITN
13:20 - 13:40	Qudit Quantum Hardware (WP1), Peter Tirler / UIBK
13:40 - 14:00	Simulation and Compilation of Mixed-Dimensional Quantum Circuits (WP1), Kevin Mato / TUM
14:00 - 14:20	Certification of qudit systems and their performance(WP4), Ignacio Perito/ ICFO
14:20 - 14:40	Almost device-independent certification of multipartite states with minimal number of measurements (WP4), Remigiusz Augusiak / CFT
14:40 - 15:20	Break
15:20 - 16:00	Invited talk by Richard Küng / Johannes Kepler University Linz
16:00 - 18:00	Poster session, Individual discussions
20:00	Conference Dinner, Alter Bahnhof Heusenstamm

Wednesday, 10th April 2024

9:00 - 9:40	Invited talk by Erez Zohar / Racah Institute of Physics, Hebrew University Jerusalem
9:40 - 10:00	Measurement protection in quantum simulations of lattice gauge theories (WP2), Matteo Wauters / UNITN
10:00 – 10:20	Quantum simulation and thermalization of lattice gauge theories (WP2), Paolo Stornati / ICFO
10:20 - 10:40	Variational quantum simulation of U(1) lattice gauge theories with qudit systems (WP2), Pavel Popov/ ICFO
10:40 - 11:00	Break
11:00 – 11:40	Invited talk by Mikel Sanz / University of the Basque Country
11:40 – 12:00	Quantum Optimization for bi-directional Charging (WP3), Daniel Müssig / IOSB-AST
12:00 – 12:20	Quantum multi-objective optimization (WP3), Linus Ekstrøm / HRI
12:20 – 13:20	Lunch
13:20 – 15:00	Poster session, Individual discussions
15:00 – 16:00	IP management workshop, HIT, De Tullio / HRB, K. Rajan / HRI
16:00 – 18:00	Exploitation workshop, HIT, De Stefanis / HRB, K. Rajan / HRI

Thursday, 11th April 2024

9:00 – 11:20	**General Assembly** • 7 x 10min: project updates: 4 WP leaders + 3 partners (HRI, TUM, CFT) • 15min: coordinator (including WP5) • 20min: discussion & any other business	
11:20 – 11:30	Break	
11:30 – 13:00	Steering Board Meeting (PIs)	Scientific discussions
12:30	Lunch	

open to all attendees
NeQST project internal

Figure 3 Agenda of the workshop

2.3.2 Poster sessions

The poster sessions consisted of 8 posters, which were put up for the complete time of the conference. This allowed everybody to study the contents at any time, and to also gather at a specific poster during a break to continue a discussion started in one of the sessions. The poster session was on the one hand actively used for in-depth discussions between the younger researchers. On the other hand, many senior researchers took the opportunity to interact with younger researchers of the project partners to find out about their current work and also give additional feedback.

Figure 4: Impressions from one poster session

2.3.3 Management updates, General Assembly, and Steering Board meeting

During the general assembly (GA) each project partner gave a concise update on their activities during the first 18 month of the project. The activities and achievements were assessed in relation to the original tasks described in the project proposal. The planned milestones and deliverables were discussed. In summary, all major milestones and deliverables are well on track. Administrative aspects, such as the status of the data management plan and the treatment of potential security issues were discussed. These discussions helped to align the different project partners, in particular also with the aim of informing younger researchers who are not present in the periodic steering board meetings.

The GA was also used to discuss the contact points between project partners for upcoming tasks. Aspects which need increased attention in the near future were identified and concrete collaboration tasks were planned. It was also noted that an amendment will be requested to change the leadership of WP3 from 1 May 2024, due to a change of institution of Steve Lenk (Fraunhofer). Sebastian Schmitt (HRI) will take up the leadership of the work package.

The general assembly was also an opportunity for younger researchers to ask questions and provide feedback.

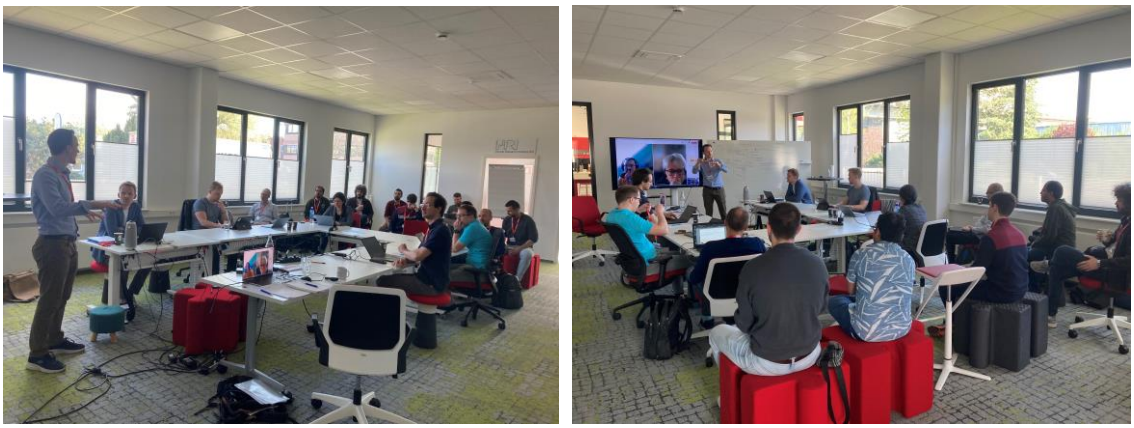

Figure 5: Impressions from the General Assembly

2.3.4 IPR presentation

The external patent attorney Elio De Tullio gave an extensive introduction to the background of intellectual property (IP) rights. After a general motivation of legal aspects, the presentation covered IP aspects such as patents, specifically tailored to the researchers working on fundamental sciences, which usually do not have much interaction with applications and IP issues. The main target, to provide a very concrete introduction and some specific examples in order to lead the researchers to think more in the direction of what and how IP could be identified, was achieved.

2.3.5 Exploitation strategy: workshop

An exploitation workshop was conducted by Paolo de Stefanis and the NeQST project team. It was a very structured discussion where the external consultant guided the team members toward realizing the key aspects of an exploitation plan. Regarding key exploitable results (KERs), there are many different types of results ranging from more theoretic algorithms, to software for control and simulation, to more concrete hardware devices. In the workshop, the key aspects relevant for an exploitation plan for all these different types of KERs were intensively discussed. With the knowledge generated through this workshop, the partners have achieved a much clearer understanding of which aspects need to be further investigated in order to foster exploitation. Also, the partners are now well prepared to improve the existing exploitation plan. The mid-term workshop proved to be the perfect moment for this workshop, as first results and a clear understanding of the project progress have been achieved, while there remains sufficient time to elaborate a targeted strategy for the second half of the project.


Figure 6: Impressions from the Exploitation workshop

3. Conclusions

In summary, the workshop was highly successful. All posed targets for the workshop were achieved: There were many interesting and fruitful discussions that stimulated ideas for further scientific research, and the tasks planned for the remaining project period could be adjusted and consolidated; the achieved results where diffused among all partners and clear next steps were identified; the dedicated IP and exploitation workshop proved highly stimulating and gave important guidance for elaborating a targeted future strategy on exploitation of the project results; the General Assembly and the Steering Board Meeting aligned all partners in terms of administration and project organization, and gave the opportunity for young researchers to get more strongly involved in these matters; the project results were disseminated to researchers of the partner institutions not directly involved in the project as well as to external experts, with whom highly

promising avenues for collaborations on the project topics were identified. All in all, the workshop constitutes a major milestone for achieving the overall project targets.