

EQIP: Engineering for Quantum Information Processors

Anthony Leverrier (COSMIQ)

19 November 2021

Kickoff meeting of Inria challenge EQIP

Program of the meeting

- ▶ 10:00 - 10:15: welcome
- ▶ 10:15 - 11h45: presentation of EQIP & quantum@Inria
 - ▶ challenge EQIP: Anthony Leverrier + Mazyar Mirrahimi , Simon Perdrix
 - ▶ Quantum@Inria, PEPR: Harold Olivier
- ▶ 11:45-12:00: short break
- ▶ 12:00 - 13:30: scientific talks
 - ▶ Simon Martiel (Atos)
 - ▶ Pablo Arrighi (QUACS)
 - ▶ Olivier Aumage (STORM)
 - ▶ Phong Nguyen (CASCADE)
 - ▶ Christophe Vuillot (MOCQUA)
- ▶ 13:30 - 15:00: lunch
- ▶ 15:00 - 16:30: scientific talks
 - ▶ Antoine Tilloy (QUANTIC)
 - ▶ Masaaki Tokieda (MATERIALS)
 - ▶ Augustin VanrietVelde (QUACS)
 - ▶ Alastair Abbott (QINFO)
 - ▶ Mischa Woods (QINFO)
- ▶ 16:30 - 17:00: discussion and conclusion

Challenge EQIP

- ▶ duration: 4 years → October 2020 - September 2024
- ▶ coordinator: Anthony Leverrier
- ▶ main objectives:
 - ▶ foster discussion/collaboration between teams with different expertise
 - ▶ help non expert researchers to learn about the main challenges in quantum computing
- ▶ resources: ~ 5 PhD + ~ 10 years of postdoc

Partners

- ▶ CAGE (Paris): Mario Sigalotti
 - ▶ CASCADE (Paris): Phong Nguyen
 - ▶ COSMIQ (Paris): Anthony Leverrier
 - ▶ DEDUCTEAM (Saclay): Pablo Arrighi
 - ▶ GRACE (Saclay): Alain Couvreur
 - ▶ HiePACS (Bordeaux): Emmanuel Agullo
 - ▶ MATHERIALS (Paris): Claude Le Bris
 - ▶ MOCQUA (Nancy): Simon Perdrix
 - ▶ PACAP (Rennes): Caroline Collange
 - ▶ *QINFO (Lyon): Omar Fawzi*
 - ▶ *QUACS (Saclay): Pablo Arrighi*
 - ▶ QUANTIC (Paris): Mazyar Mirrahimi
 - ▶ STORM (Bordeaux): Denis Barthou
- + External partner: Atos Quantum: Cyril Allouche

“Observers”: CAMBIUM (Paris), McTAO (Sophia), TONUS (Nancy)

Expertise

- ▶ *superconducting qubits*: QUANTIC
- ▶ *simulation of quantum systems*: CAGE, QUANTIC
- ▶ *numerical methods*: MATHERIALS, McTAO, TONUS
- ▶ *control theory*: CAGE, McTAO, QUANTIC
- ▶ *programming languages and formal methods*: CAMBIUM, MOCQUA, QUACS
- ▶ *compilation*: PACAP, QUACS, Atos Quantum
- ▶ *quantum error correction*: COSMIQ, MOCQUA, QINFO, QUANTIC
- ▶ *quantum emulation*: Atos Quantum
- ▶ *cryptography and cryptanalysis*: CASCADE, COSMIQ, QINFO
- ▶ *quantum algorithms*: COSMIQ, MOCQUA, Atos Quantum, QINFO
- ▶ *high-performance computing*: HiePACS, STORM

Objectives (as written in the letter of intent)

- ▶ Demonstration of error correction, as well as some protected gates, for cat qubits
- ▶ Mathematical/numerical model reduction methods for open quantum systems
- ▶ A versatile and well-founded high-level quantum language
- ▶ A public domain library of quantum routines for high-performance scientific computing
- ▶ An emulation platform for testing algorithms
- ▶ Methods and tools for optimizing fault-tolerant quantum computation
- ▶ Quantum cryptanalysis of symmetric and public-key cryptography
- ▶ NISQ compatible algorithms

Most of these objectives are also relevant for the 3 projects of the French national initiative (PEPR) involving Inria.

Scientific approach: 3 workpackages

- ▶ *WP1: Building a quantum processor.*
 - ▶ questions at the interface between physics and applied mathematics
 - ▶ goal: to design and understand systems that can process quantum information
- ▶ *WP2: Operating quantum computers.*
 - ▶ how to encode quantum information so as to process it efficiently?
 - ▶ how to program quantum computers?
- ▶ *WP3: Overtaking classical computers.*
 - ▶ quantum algorithms, e.g. for cryptanalysis
 - ▶ computing with NISQ devices
 - ▶ integration between HPC and quantum computing

Organisation *(as written in the letter of intent)*

- ▶ *Scientific meetings each semester* – We plan a scientific meeting every six months, where partners will present informally their work and where joint decisions (if any) will be addressed.
- ▶ *Workshops* – We plan to organize 2-3 focussed workshops during the project.
- ▶ *Meetings within the WP* – We also plan to hold regular meetings within the different work packages. These meetings which could take the form of (possibly online) seminars, reading groups or more general discussions will be essential to create a community and encourage collaborations between the different teams.

⇒ we can discuss this at the end of the day

WP3: *Overtaking classical computers*

- ▶ *Goal*: exploiting the capabilities of quantum machines to go beyond classical computing
- ▶ *Tasks*:
 - ▶ Quantum cryptanalysis (2 ERC grants on this topic): CASCADE (talk Phong NGuyen), COSMIQ
 - ▶ NISQ algorithms: COSMIQ, MOCQUA, QUANTIC, ...
 - ▶ Integration with HPC (a European project on this topic): HiePACS, STORM (talk Olivier Aumage)