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Matching photon sources with the quest for quantum technology

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'Strahlenlinien' – V. Kandinsky (1927)

On the menu:

- Introduction to Quantum Technology
- Qubit platforms and Quantum Computing
- Investments in Quantum Technology
- Photon science for Quantum Technology
- LEAPS and Quantum Technology: reflections and suggestions for a strategy agenda.



Quantum technology – what's in a name?



Source: EU Quantum Flagship

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Expectations of Quantum Technology



Source: Quantum Delta Nederland (2021)

From bit to qubit



Source: World Economic Forum (2022)

Different qubit platforms



J.N. Eckstein and Jeremy Levy MRS Bulletin 38, 783 (Oct. 2013)

N.P. de Leon et al., Science 372, eabb2823 (2021)





The Quantum 'Layer Cake'



Source: Quantum Delta Nederland (2021)

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Hype(r)reality?



FIRST 100-QUBIT Quantum computer ERS CROWDED RACE

But IBM's latest quantum chip and its competitors face a long path towards making the machines useful.

The Sycamore chip is composed of 54 qubits, each made of superconducting loops.



The company says that its quantum computer is the first to perform a calculation that would be practically impossible for a classical machine.

COMPUTING Silicon gains ground in quantum-computing race

Slow-starter seeks to catch up with rival techniques.



Trapped-ion technologies are gaining momentum in the quest to make a commercial quantum computer.



BEFORE THE QUANTUM WITH DECADES STILL TO GO UNTIL THE FIRST GENERAL-PURPOSE QUANTUR

COMPUTERS, THE RACE IS ON TO MAKE TODAY'S SYSTEMS USEFUL

Source: diverse articles in Nature and Science (2019-2021)

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The

quantum gold rush

The science is immature and a

multi-purpose quantum computer doesn' yet exist. But that isn't stopping investors

pouring cash into quantum start-u

Quantum Computing: scale



Source: World Economic Forum (2022)

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Quantum Computing: speed



Source: World Economic Forum (2022)

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Quantum Computing: quality



Source: World Economic Forum (2022)

Worldwide investments in Quantum Technology



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Source: World Economic Forum (2022)

Worldwide investments in Quantum Technology



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Source: World Economic Forum (2022)

Key challenges – opportunities for LEAPS

Understand microscopic mechanisms for noise, loss and decoherence!

- Energy scales
- Noise sources
- Decoherence processes
- Quantum states



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V. Lordi and J.M. Nichol, MRS Bulletin 46, 589 (2021)

Noise and losses in SC qubits



Example: characterization of SC layer



A. Premkumar et al., Communications Materials 2, 72 (2021)



A.P.M. Place et al., Nature Communications 12, 1779 (2021)

SC qubits: coherence lifetime



Microscopic insight in loss mechanisms is paying off!

I. Siddiqi, Nature Reviews Materials 6, 891 (2021)

Noise and losses in spin qubits



N.P. de Leon et al., Science 372, eabb2823 (2021)

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Example: strain imposed by electrodes













A. Pateras et al., J. Materials Research 34, 1291 (2019)

Noise and losses in color center qubits





N.P. de Leon et al., Science 372, eabb2823 (2021)

Noise and losses in color center qubits



S. Sangtawesin et al., Phys. Rev. X 9, 031052 (2019)



NV-centers in diamond used in diamond anvil cell.

M. Lesik, L. Toraille et al., Science **366**, 1359 (2019)

LEAPS and Quantum Technology: a match made in heaven....



LEAPS and Quantum Technology: a match made in heaven, but....



Different languages are spoken! Major effort is needed (task force!) to bridge the gap! Approach QT community in a topic-oriented way (instead of technique-oriented). Provide showcases of successful interactions.

LEAPS and Quantum Technology: a match made in heaven when....



Re-think modes of access to RI's (shorter but more frequent access). Dedicated calls for experiments in Quantum Technology. Operate RIs as partners of research groups rather than users@facility interaction. Further develop in-house research lines on quantum technology. Co-ordinated approach! (LEAPS is one of the leading examples)!

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Picture sources: ESRF (2022, left) and SOLEIL (2020, right)

LEAPS and Quantum Technology: a match made in heaven when....

Keep on contributing to the **dialogue with** the broad field of **stakeholders**! Contribute to the EU **missions**! Reach out to the **public** at large!

Picture sources: Helmholtz Association (2022, left); Quantum Delta Nederland (2021, middle) and SOLEIL (2020, right)

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Master programs in Quantum Technology

Actively approach master programs to include photon/RI-based techniques! Develop and offer modules of (online) learning. Offer internships and master thesis topics to master study programs. Crucial: trained workforce!

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Source: World Economic Forum (2022)

Actively engage QT private sector

THE EUROPEAN QUANTUM COMPUTING STARTUP LANDSCAPE

Many **spin-offs** and **start-up** companies. Looking for **profiles with a (strong) background** in quantum technology. Eager to use **state-of-the-art techniques**. Difficult issues: speed of **access** and **IP**.

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Source: Unternehmertum Venture Capital (2020)

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Thank you for your attention!