World of PHOTONICS Talk No. 1 Quantum Computing
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Q&As

"From Photons, via Lasers, to Quantum Computing"

Dr. Thomas Monz

Question 1: The surrounding infrastructure seems to be complex, require high accuracy, not small and expensive (vacuum chamber, ion traps, EM field and lasers). How do you see this being shrunk to a small, robust and inexpensive system?

Answer 1: There is actually no problem to do so - just no demand. The vacuum chambers could be the size of a smart phone, the ion traps produced based on semiconductor fabrication and the size of a thumbnail. We have lasers in CD/DVD systems and in telecom etc. Our device is already operated in a normal office without AC.

Question 2: If the lifetime of the optical transition defined the state of the Qubit, could this time dependency make the computation very time expensive?

Answer 2: The lifetime of the excited state has nothing to do with the speed of the calculation. Ion gates can be as fast as a few tens of ns (as realized, e.g., in Stockholm). The lifetime can be made (essentially) infinite by a different encoding in the ground states.

Question 3: Do you plan to include integrated photonics in your systems? If yes, what are the most important parameters here?

Answer 3: Yes - the main challenge is that most integrated photonics have been developed for telecom wavelengths. Ions would need the same technology, but to support wavelengths down to about 400 nm.

Question 4: What are, in your view, the other most promising platforms besides Trapped Ions and Superconductive Qubits?

Answer 4: That depends on what you value: If you want to focus on the number of qubits, cold atoms have shown capabilities of loading more than 100 atoms.

Question 5: What are the main limitations to gate fidelities when controlling ions with laser pulses? Are there limitations from the optical setup?

Answer 5: Only partially. Recent work on optical Raman gates has shown that non-technical limits should be on at error rates as low as a few 10^-5 - which would be about one to two factors of magnitude better than what is currently realized.

Question 6: Are miniaturized thin film filters (example 25x25µm) interesting for routing the laser light?

Answer: Could be, but it depends on the details. Please reach out to me.

Question 7: Are there any propositions of two-qubit gates that do not rely on single photon transition? I understand that single photon coupling in optical setups can only achieve mediocre fidelities.

Answer 7: The highest fidelities reached so far have been direct coupling between transitions with a single laser. Yes, there are gates based on Raman gates which promise similar and/or better performance.

Question 8: What is your view on scalability associated with modular designs and associated photonic component level costs that scale with large qubit requirements? This could be considered for both Trapped Ion QC or Photonic QC.

Answer 8: It's something we are working on. If you have ideas or can provide fabrication capabilities, please reach out to me.

Question 9: Is there any main challenge(s) or single change/solution/tech which would be a breakthrough in commercializing a quantum computer?

Answer 9: Sadly, no. The eco system is currently facing challenges such as number of qubits being small; gate error being high; very few algorithms that both outperform and are applicable to classical challenges; and then - most importantly, very little market pull (partially based on the existing market push).

Question 10: What are the requirements for P&P fiber-fiber couplings?

Answer 10: SM/PM, ideally not more than 10% loss; suitable for a particular wavelength in the range of 400 nm upwards.

"Quantum Computing with Superconducting Qubits"

Prof. Dr. Stefan Filipp

Question 1: What are the main challenges that this platform will need to face in the next 3-5 years?

Answer 1: The main challenges are the continued improvement of materials and interfaces to overcome decoherence, along with the accurate control of many superconducting qubits on a chip without quantum and classical crosstalk. Clearly, the control of thousands and more qubits will require different technologies on the control electronics side as well.

Question 2: Do you see a possibility for Germany and Europe to take the lead in developing a Quantum Computer based on Superconductive Qubits? If yes, what is a realistic timeline for catching up with IBM and other leaders in the field?

Answer 2: With a focused and well-structured German and European effort, I believe that we can catch up with the leaders in the field within the next 3-5 years and build a competitive quantum ecosystem, a quantum community, in Europe.

Question 3: Is there a way to build a microwave to optical link by using frequency combs or optical cavities with free-spectral range in the 5-10 GHz?

Answer 3: Microwave to optical interfaces is a hot research topic at the moment and I am certain that we will see further improvements that will lead to quantum communication interfaces between distant qc units in future.