QSS53 - Helmut Katzgraber - Questions & Answers

Helmut Katzgraber

You've had experiences both as a professor at Texas A&M and now in industry at Microsoft and Amazon Web Services. What similarities and differences do you find between working in academia and working in industry in this field?

HELMUT: Similar: We do science. Differences:

- Slightly less academic freedom — you have to pair research with an outcome that matters.
- Unlimited funding in industry, no grant writing
- Much better salaries
- No teaching and service
- You can get fired any time in industry
- You have more free time on evenings and weekends in industry.

We've had some questions and comments asking about the hype surrounding quantum computing from various people. You spoke about swapping out the classical optimisation backend for scalable quantum hardware tomorrow - What do you see as the most likely near-term applications of quantum hardware, and when is "tomorrow"?

HELMUT: Chemistry of strongly correlated systems (catalytic). Compute energy differences for active spaces using a QC backend, instead of quantum chemistry (e.g., DMRG FCI, …).

Can you clarify the distinction between NISQ digital and analogue devices - aren't all non-error corrected NISQ machines analogue in principle?

HELMUT: In principle, yes. But NISQ machines are designed to be programmed (like a laptop) with high-level programming languages (Cirq, Q#, Qiskit, …). Analog annealers can only optimize binary optimization problems which are **encoded** (and not programmed) into the hardware.

What are the requirements for your algorithms in terms of qubit quality (fidelities, connectivity, etc.)? At the beginning of your talk, you discussed a variety of platforms - what can you say about the comparative quality of the qubits and what it means for applications?

HELMUT: These data are hard to get because some providers disclose this and others do not. See https://quantumcomputingreport.com

You mentioned quantum RAM: how do you see its role? Is this not simply qubits with very good lifetimes? How long would qubits need to live to make this interesting? For example, atoms and ions have the potential for coherence times of the order of many seconds (or up to an hour with spin echo for ions) - does that help?

HELMUT: Indeed, you need long-lifetime qubits. Google has developed a scheme that might be able to accommodate that. Atoms are an option, too. But how many can you store in a trap?

You've shown that there is a lot you can do with physics-inspired classical algorithms beating quantum annealing. Does that change if we do annealing completely coherently - e.g., heading towards coherent annealing?

HELMUT: Good question. I doubt it, because we can simulate coherent annealing — albeit with a lot of effort — and we did not see much advantages.

How do you see the development of hybrid compute environments, i.e. a combination of classic computing (CC or HPC) combined with QC?

HELMUT: These are extremely important. Think chemistry: Usually you start with determining an active space and do several quantum chemistry simulations on HPC, the quantum device is only called for one single step of the process. Then it goes back to HPC and so forth. This is the same for many other workloads. For example, google purchased a brand new hybrid data center that houses both HPC and QC right next to each other — their focus is chemistry.

Are there ways to extend your hybrid machine-learning and physics-inspired algorithms towards quantum hardware? And at which point could they help to generate a quantum advantage?

HELMUT: There was a paper last night on just that with John Preskill (AWS) as a co-author.