Stichting NIOC en de NIOC kennisbank

Stichting NIOC (www.nioc.nl) stelt zich conform zijn statuten tot doel: het realiseren van congressen over informatica onderwijs en voorts al hetgeen met een en ander rechtstreeks of zijdelings verband houdt of daartoe bevorderlijk kan zijn, alles in de ruimste zin des woords.

De stichting NIOC neemt de archivering van de resultaten van de congressen voor zijn rekening. De website www.nioc.nl ontsluit onder "Eerdere congressen" de gearchiveerde websites van eerdere congressen. De vele afzonderlijke congresbijdragen zijn opgenomen in een kennisbank die via dezelfde website onder "NIOC kennisbank" ontsloten wordt.

Op dit moment bevat de NIOC kennisbank alle bijdragen, incl. die van het laatste congres (NIOC2023, gehouden op donderdag 30 maart 2023 jl. en georganiseerd door NHL Stenden Hogeschool). Bij elkaar bijna 1500 bijdragen!

We roepen je op, na het lezen van het document dat door jou is gedownload, de auteur(s) feedback te geven. Dit kan door je te registreren als gebruiker van de NIOC kennisbank. Na registratie krijg je bericht hoe in te loggen op de NIOC kennisbank.

Het eerstvolgende NIOC vindt plaats op donderdag 27 maart 2025 in Zwolle en wordt dan georganiseerd door Hogeschool Windesheim. Kijk op www.nioc2025.nl voor meer informatie.

Wil je op de hoogte blijven van de ontwikkeling rond Stichting NIOC en de NIOC kennisbank, schrijf je dan in op de nieuwsbrief via

www.nioc.nl/nioc-kennisbank/aanmelden nieuwsbrief

Reacties over de NIOC kennisbank en de inhoud daarvan kun je richten aan de beheerder:

R. Smedinga kennisbank@nioc.nl.

Vermeld bij reacties jouw naam en telefoonnummer voor nader contact.

Quantum Technology

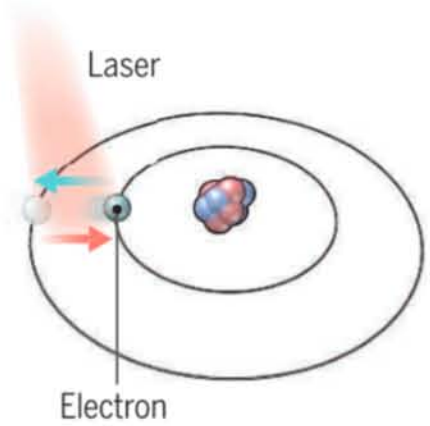
NIOC Emmen
30th March 2023

Marten Teitsma

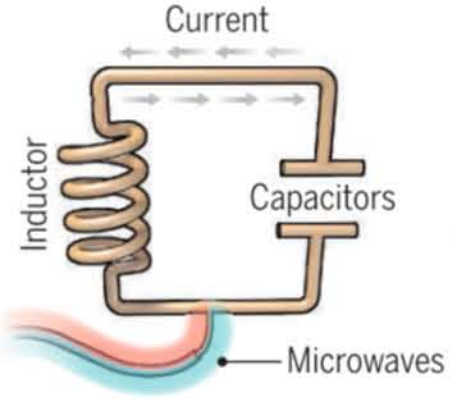
Quantum Technology

Quantum Computing
Quantum Communication
Quantum Sensing

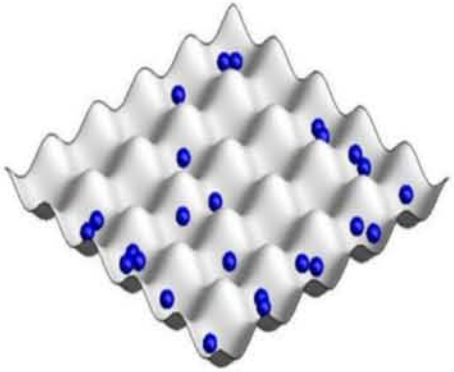
Alternative hardware platforms



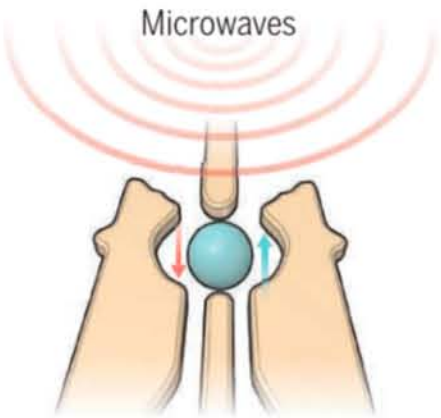
Trapped ions



Superconducting loops



Ultracold atoms



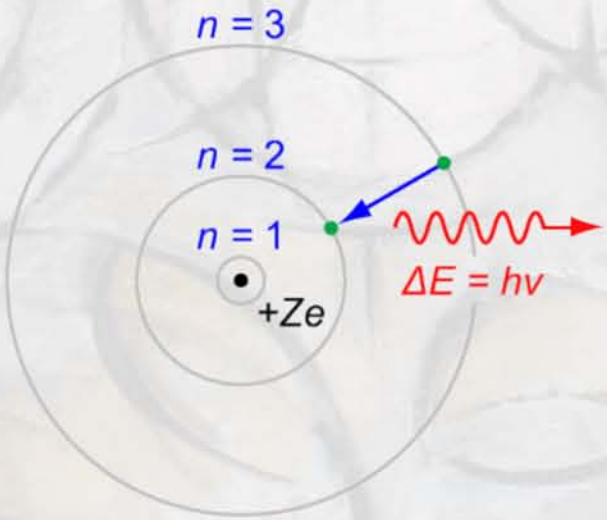
Silicon quantum dots

Divincenzo criteria

- A scalable physical system with well-characterized qubit
- The ability to initialize the state of the qubits to a simple fiducial state
- Long relevant decoherence times
- A "universal" set of quantum gates
- A qubit-specific measurement capability

DiVincenzo, David P. ,The Physical Implementation of Quantum Computation, Fortschritte der Physik, 2000

Superposition

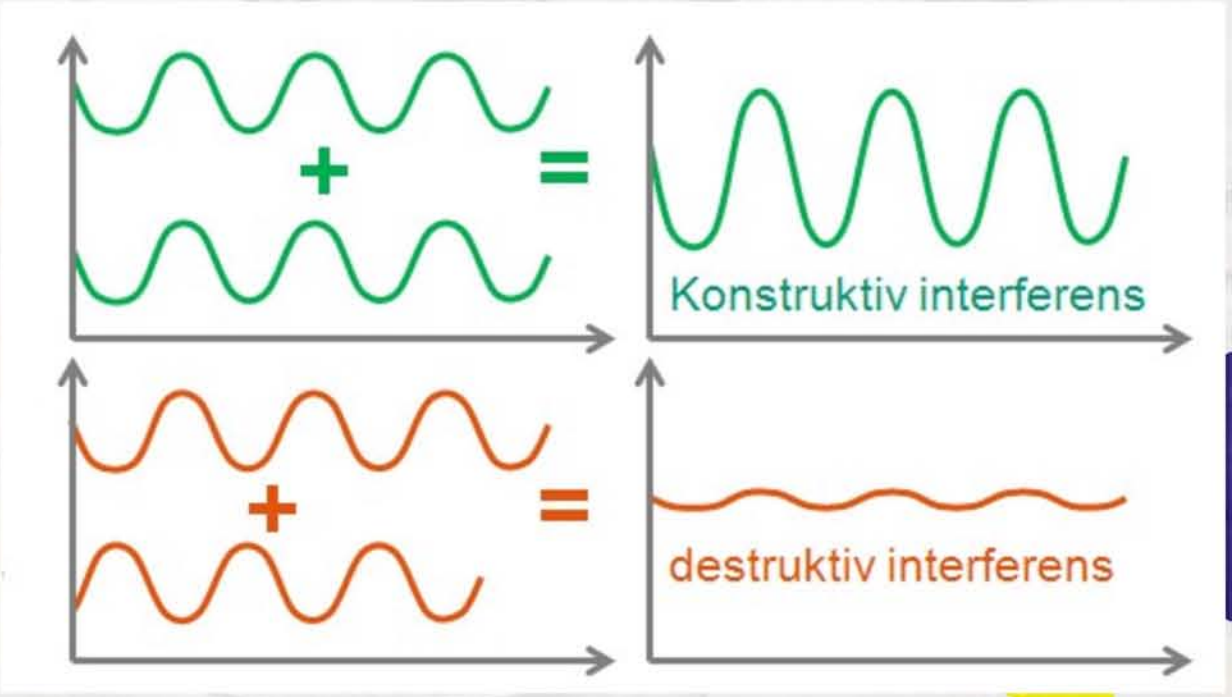


Two states at the same time: $|\phi\rangle = \alpha|0\rangle + \beta|1\rangle$

Born's rule: $|\alpha|^2 + |\beta|^2 = 1$

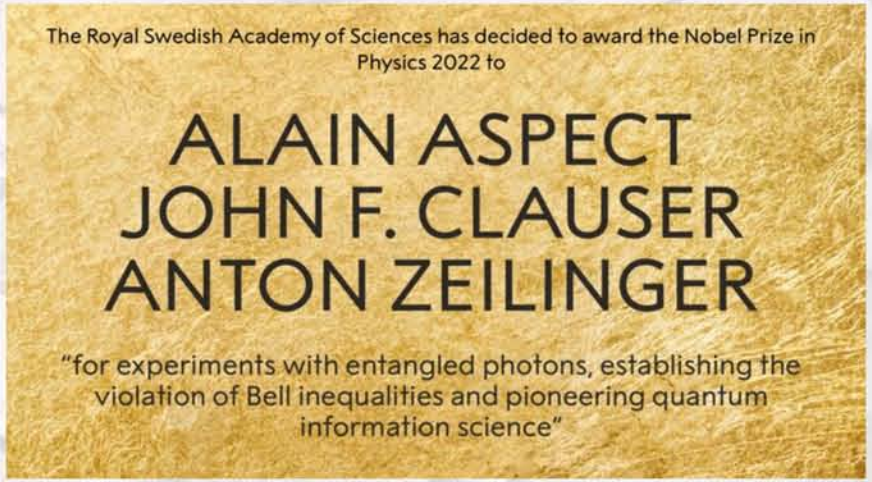
Using the Hadamard gate we can push the qubit, more or less right, in between the two states $|\phi\rangle$: $1/\sqrt{2}\ |0\rangle + 1/\sqrt{2}\ |1\rangle$

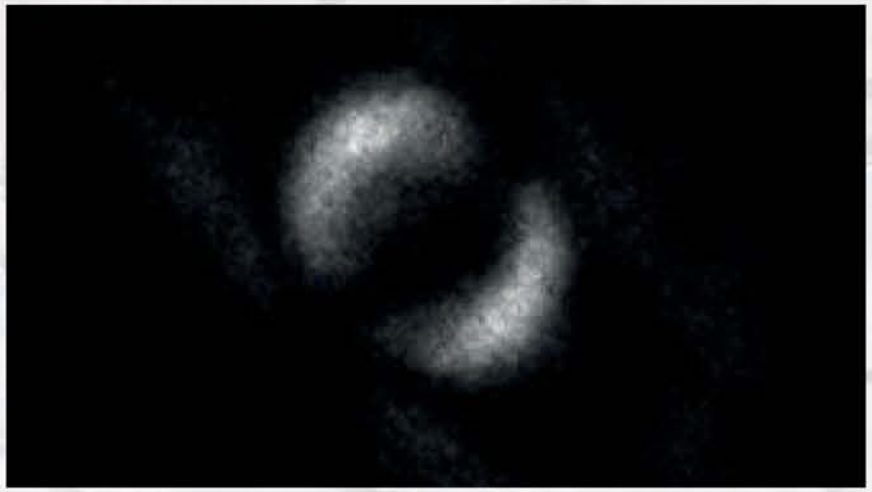
Interference



By using interference one can compute with qubits.

Entanglement





$$|\phi\rangle_1: \frac{|00\rangle + |11\rangle}{\sqrt{2}}$$

$$|\phi\rangle_2: \frac{|00\rangle - |11\rangle}{\sqrt{2}}$$

$$|\phi\rangle_3: \frac{|01\rangle + |10\rangle}{\sqrt{2}}$$

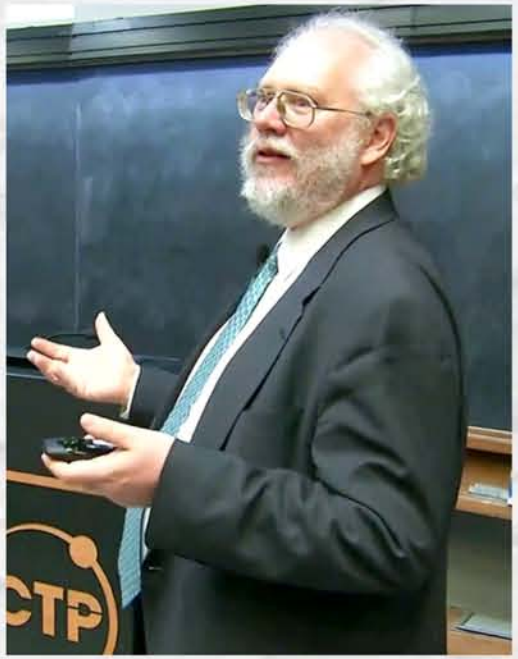
$$|\phi\rangle_4: \frac{|01\rangle - |10\rangle}{\sqrt{2}}$$

Measurement

Parallellism

1. Quantum computer containing 50 qubits: $250 \approx 11^{15}$complex amplitudes → 32×10^{15}bytes ≈ 32.000*TB*
2. Quantum computer containing 51 qubits: $251 \approx 22^{15}$complex amplitudes → 72×10^{15}bytes
3. Quantum computer containing 500 qubits: $2500 \approx 32^{150}$complex amplitudes → 72×10^{151}bytes ≈ 32×10^{30}*TB*

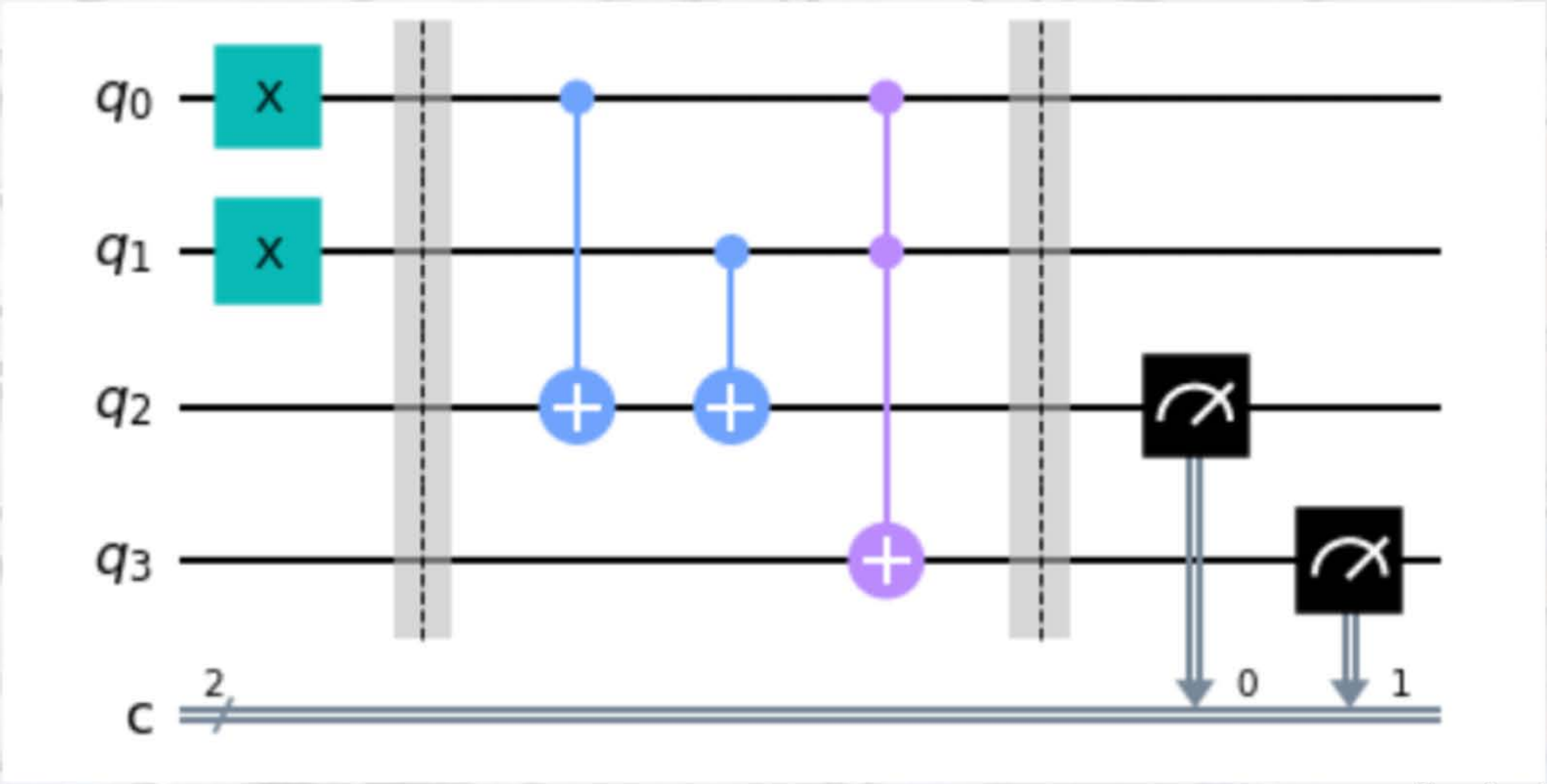
Faster algorithms



Possibility of finding prime factors in theory. Exponentially faster than known classical algorithms (1994).

Unstructured search which offers a quadratic speed-up (1996).

Gates



Envisioned use cases I

	Chemical simulation
Chemical and petroleum industry	• Chemical product design • Surfactants, Catalysts
Distribution and Logistics	
Health & Life Science	• Drug discovery • Protein structure predictions
Financial Services	
Manufacturing	• Material discovery • Quantum chemistry

Envisioned use cases II

	Scenario simulation
Chemical and petroleum industry	
Distribution and Logistics	• Disruption management
Health & Life Science	• Disease / pandemic prediction
Financial Services	• Pricing • Risk analysis
Manufacturing	

Envisioned use cases III

	Optimisation
Chemical and petroleum industry	• Feedstock to Product (i.e. refining processes) • Shipping / trucking logistics
Distribution and Logistics	• Network optimization • Vehicle Routing
Health & Life Science	• Supply chain optimization • Process planning
Financial Services	• Stock portfolio management
Manufacturing	• Fabrication optimisation

Envisioned use cases IV

	Artificial Intelligence
Chemical and petroleum industry	• Drilling locations • Seismic imaging
Distribution and Logistics	• Freight forecasting • Detecting irregularities
Health & Life Science	• Genome analysis • Computer-aided diagnosis
Financial Services	• Credit / asset scoring • Fraud detection
Manufacturing	• Quality control • Structural design and Fluid dynamics

The hype

- Over-promises in advertisement campaigns
- A lot is uncertain, and concepts are not clear
- Market predictions are sky high
- Venture capital is floating around and looking for a place to prosper
- The hype changes the way research is being done

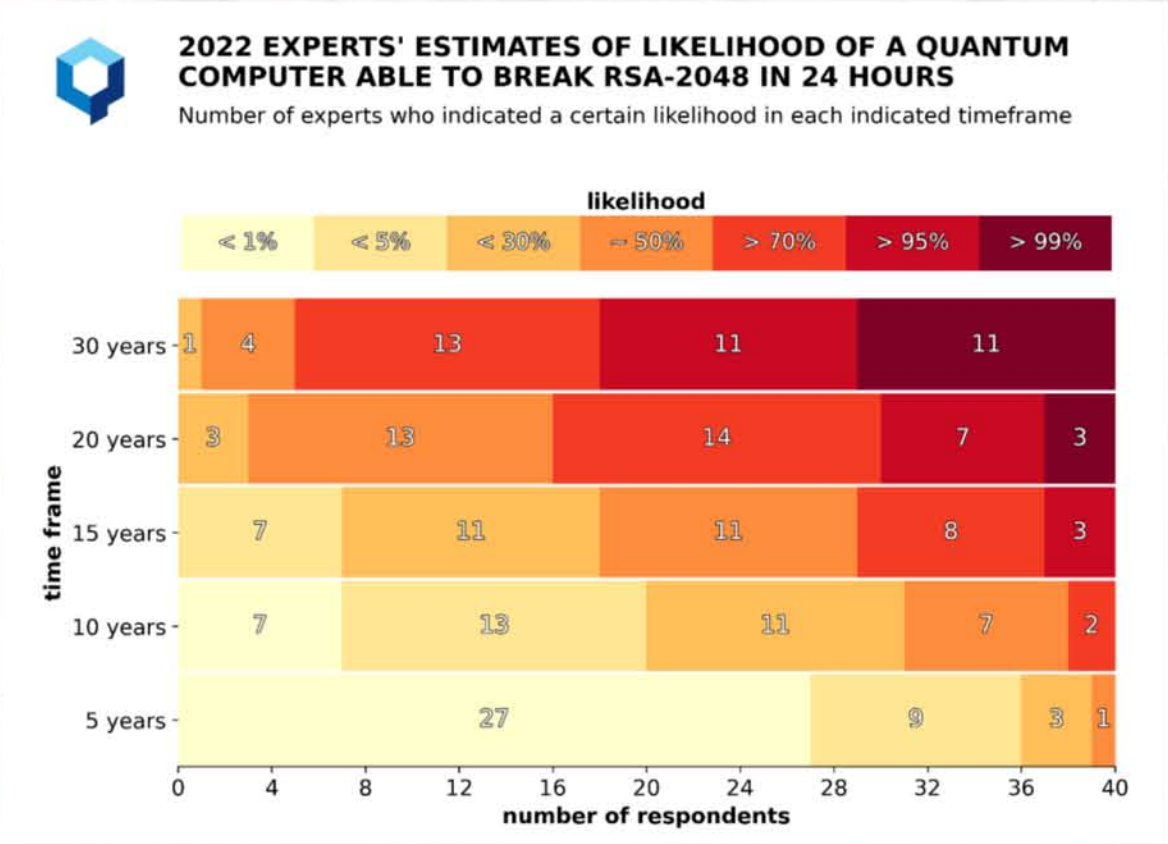
The Quantum hype

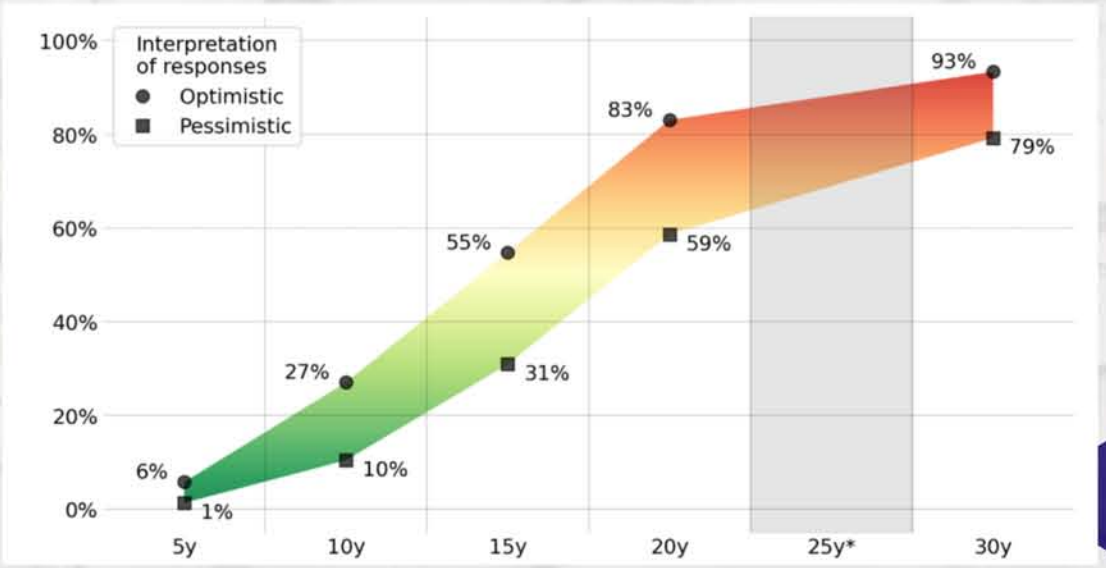
- There is a lot of scientific and technical uncertainty.
- Quantum Technology research is more than most other disciplines reproducible.
- Hardware implementation diverges
- Skepticism is still around
- It is difficult to check whether what is being said is correct
- Quantum Computer will be an accelerator
- Technological sovereignty increases the hype

Challenges

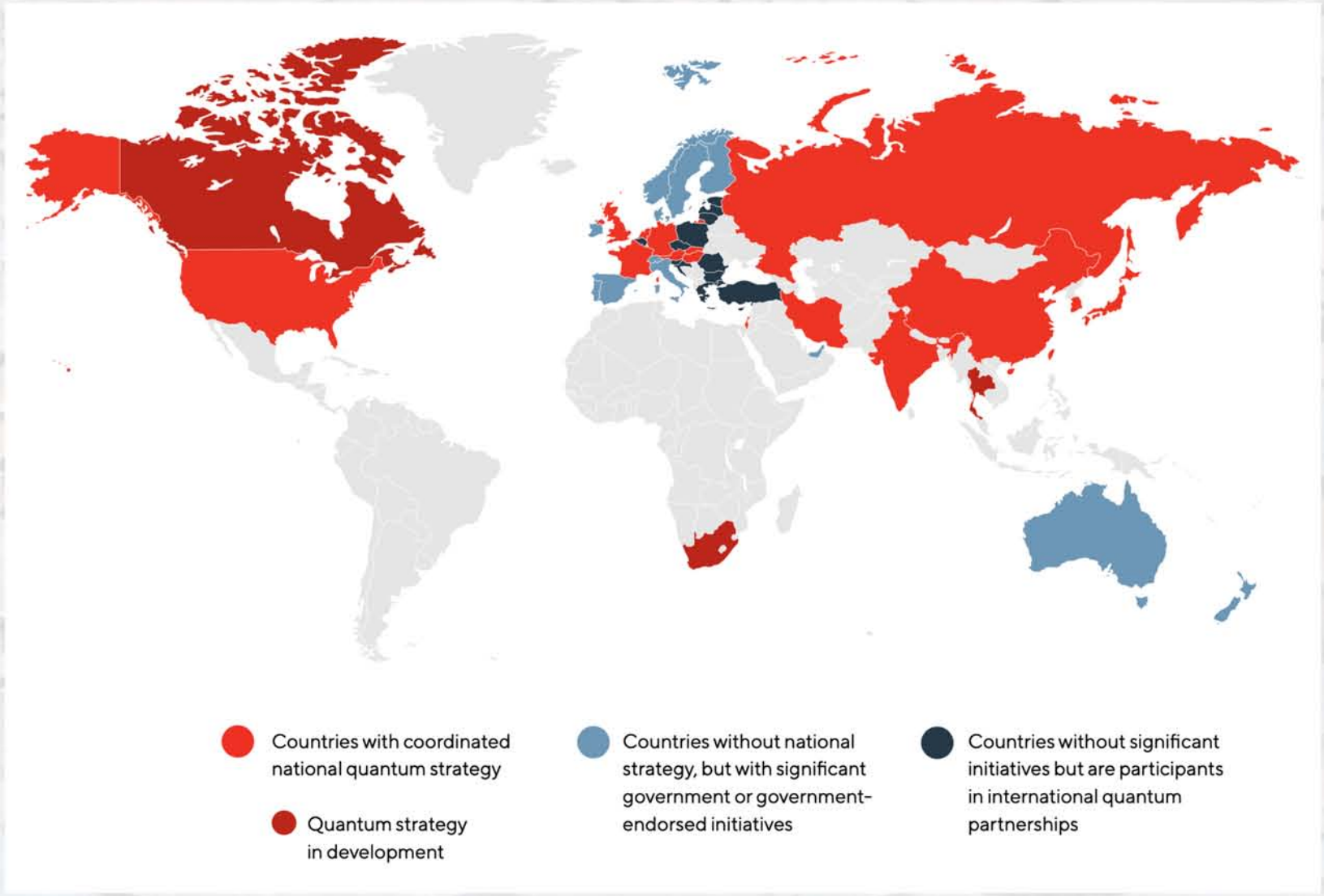
1. More Coherent Qubits vs Error Correction
2. Scalability
3. Hardware Development
4. Software Development
5. Classical Computer Interfaces
6. Standards and Protocols
7. Trained Talent

Expectations

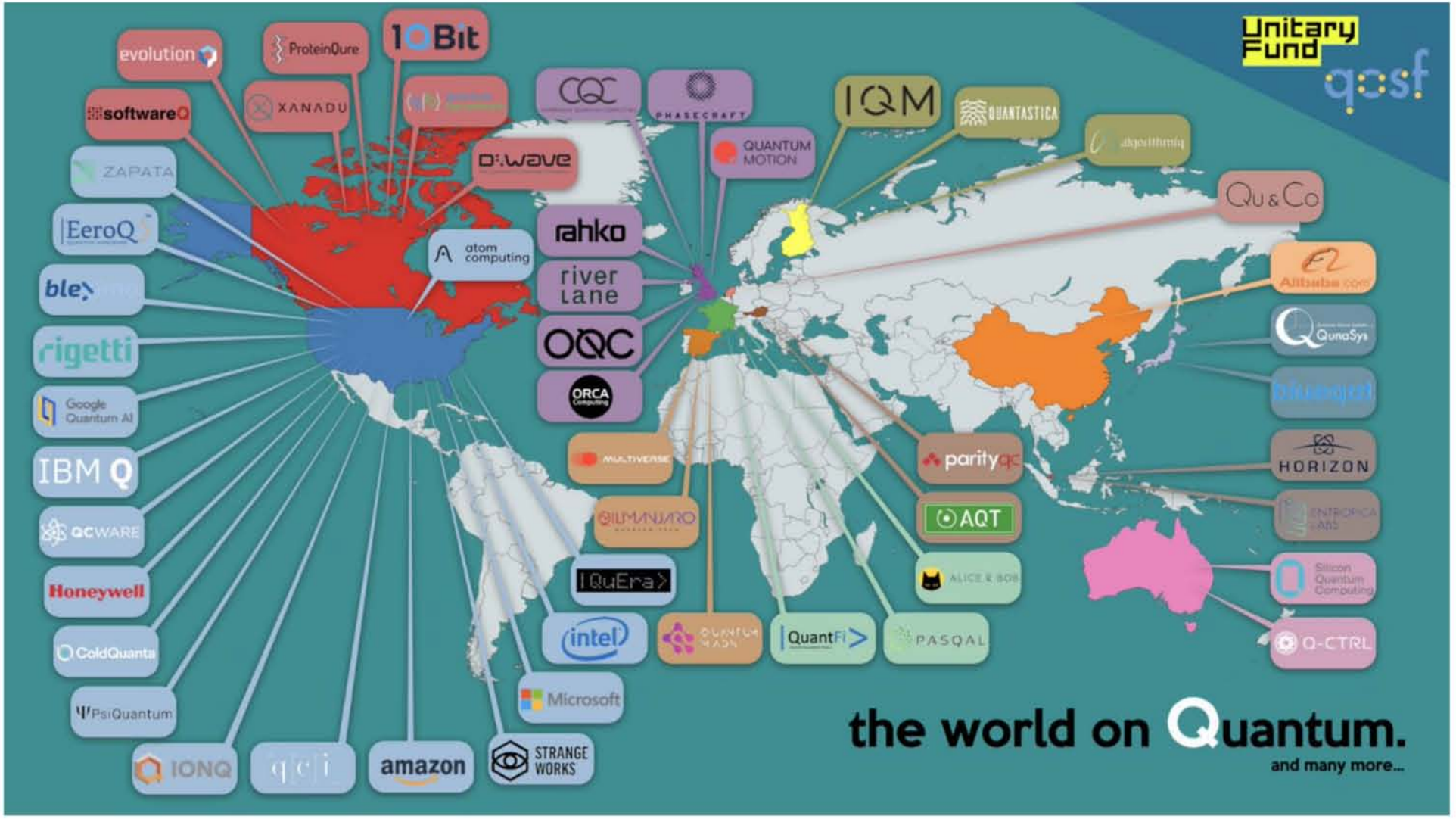




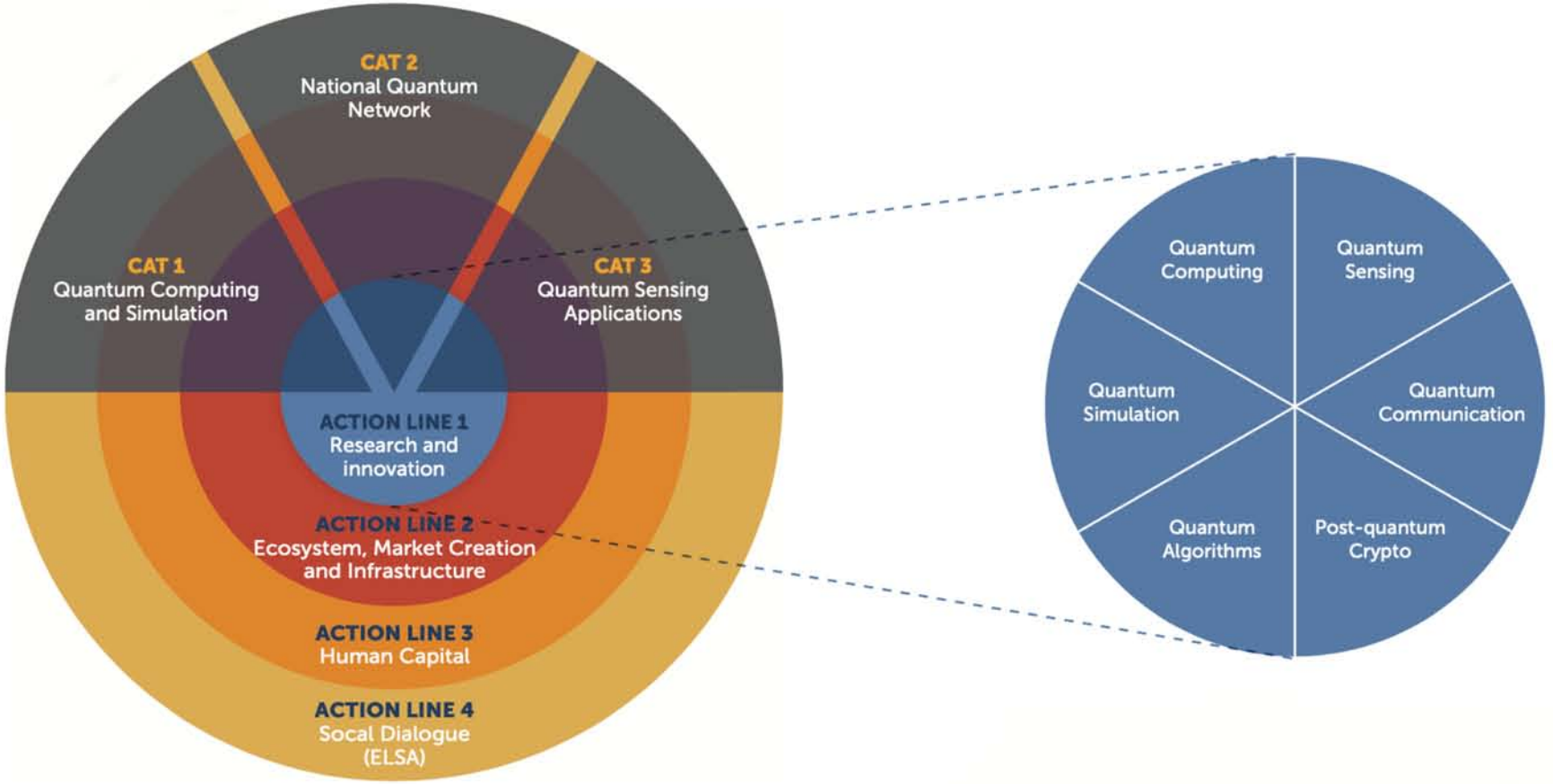
World wide investment



Companies worldwide



Dutch ecosystem



Dutch educational initiatives

- Professional Master Applied Quantum Technology (Fontys, Saxion, HHS, AUAS): Sept. 2024
- Thematic semester Quantum Sensing (AUAS): Sept. 2024
- Minor Applied Quantum Computing (2020)
- Internship mediation
- Course Quantum Sensing for HAVO
- And lots more

Nice websites

- Quantum Flagship
- Quantum Delta Nederland
- Quantum. Amsterdam
- Shtetl-Optimized
- Quantum computing for the very curious
- Quantum computing report
- Inside Quantum Technology

Taking a leap into the future

The Netherlands is ready for the quantum decade