



Quantum.Amsterdam

innovation hub for software, technology & applications



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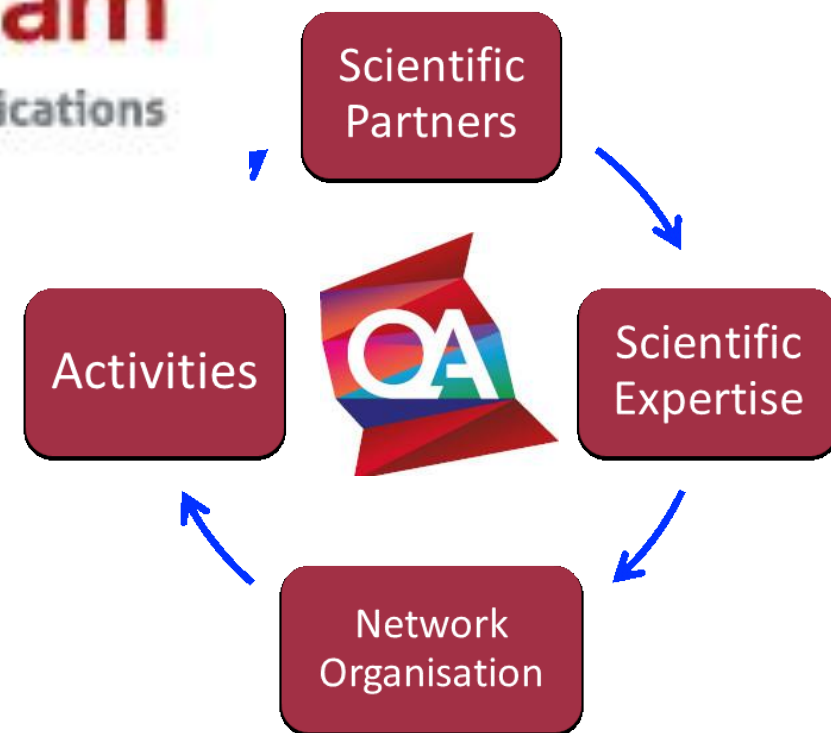
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Visit us at <https://Quantum.Amsterdam>

Partners



National Agenda awarded **€615M**
(2021-2027) for
**Research, Education &
Ecosystem Development**



Running **collaborations &
active network** with key industries



Backed by leading research institutes

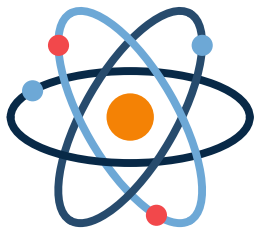


Quantum Algorithms

- Risk modelling (banking, insurance)
- Network analysis (pattern recognition, fraud detection)
- Logistics & Process optimization
- Material Science & Drug Discovery



Quantum.Amsterdam



Quantum Hardware

- Ultracold atoms (Sr) as qubits
- Quantum sensing (mining, navigation)
- Quantum clocks (high precision time stamping, power grid & mobile network optimisation, GPS)



UNIVERSITEIT VAN AMSTERDAM



Quantum Cryptography

- Quantum Key Distribution
- Quantum-safe cryptography



Key use-cases of Quantum Computers

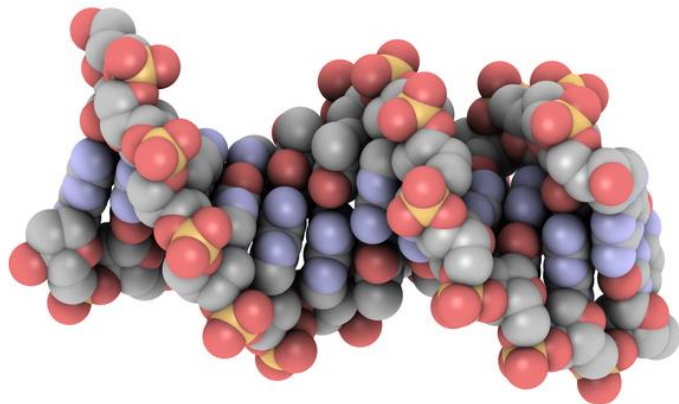
1. Quantum chemistry and material science

Drug design

Batteries

Production of chemicals

Superconductors



2. Cracking cryptography

Type	Algorithm	Key Strength Classic (bits)	Key Strength Quantum (bits)	Quantum Attack
Asymmetric	RSA 2048	112	0	Shor's Algorithm
	RSA 3072	128		
	ECC 256	128		
	ECC 521	256		
Symmetric	AES 128	128	64	Grover's Algorithm
	AES 256	256	128	

Authentication,
Digital signatures,
Key distribution

Plain encryption

Key use-cases of Quantum Computers

3. Optimization and machine learning



10/31/19 | Wolfsburg / Lisbon | Volkswagen Group News | Press Release

Volkswagen optimizes traffic flow with quantum computers



Picking optimal portfolios using Quantum Computing

 Rochisha Agarwal Sep 30, 2020 · 7 min read



 Jirawat Tangpanitanon  · Dec 24, 2020 · 1 min read

Quantum optimization for aircraft's tail assignment problems

Article | [Open Access](#) | [Published: 10 February 2020](#)

Training deep quantum neural networks

[Kerstin Beer](#) , [Dmytro Bondarenko](#), [Terry Farrelly](#), [Tobias J. Osborne](#), [Robert Salzmann](#), [Daniel Scheiermann](#) & [Ramona Wolf](#)

[Nature Communications](#) **11**, Article number: 808 (2020) | [Cite this article](#)

45k Accesses | 63 Citations | 23 Altmetric | [Metrics](#)

Quantum Clocks - opportunities

Network users/applications

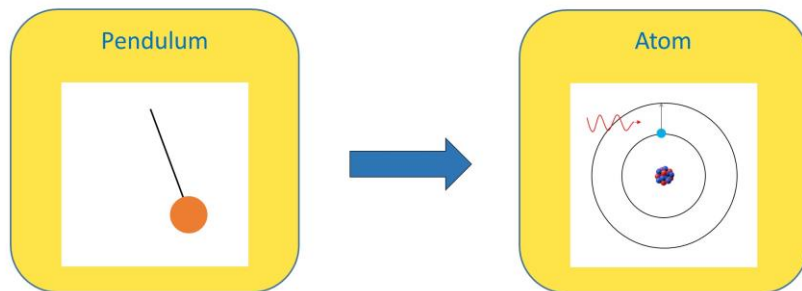
- GPS
 - Time/frequency reference for (local) NTP and PTP networks
 - Electrical grid monitoring
 - Mobile networks
- NTP
 - General-purpose synchronization of datacenters, servers, computers
- PTP
 - Systems for electronic financial transactions and trading
 - Electrical grid monitoring
 - Synchronization of robots in industrial plants
 - Mobile networks



Quantum Clocks & Time Distribution

Classical vs. quantum clock

Task: build the best clock in the world







Highest accuracy

High transition frequency	→	optical transitions
Narrow transition	→	mHz linewidth
Large signal	→	use many atoms
Undisturbed by other atoms	→	use gas of atoms
No Doppler shift	→	cool atoms to standstill

Easy access

Reference Sr optical clock and time+frequency distribution system

 Long-term operation of National Sr Optical Clock
 Fibre network
 Time and frequency distribution equipment
 Jeroen Koelemeij; time and frequency distribution research

Time and frequency as a service

Support application development

- Terrestrial navigation
- Security
- Neutral atom quantum computing
- Fundamental research



European network (Paris)

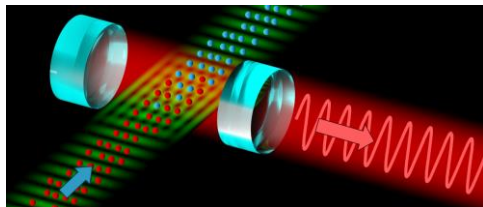
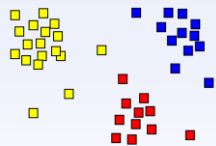
Quantum.Amsterdam activities

World-renowned R&D



Dedicated Quantum Software research center since 2015

Discovering clustering algorithms with ABN AMRO



Building world's most accurate quantum clock

Education programs in Amsterdam



UNIVERSITEIT VAN AMSTERDAM

Unique MSc Course "Quantum in Business and Society"

Workforce training "General Awareness Quantum Computing"



Active outreach and meetup programme

... And much more! Visit us at <https://Quantum.Amsterdam>