putting quantum into nanotechnology

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what will be the driving technology

in the 21st century?

revolutions: a historical perspective

1780

$$dS \geqslant \frac{\delta Q}{T}$$

industrial

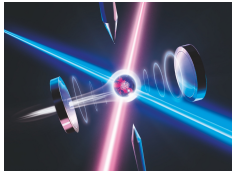
1865

$$\begin{aligned} \nabla \cdot E &= \rho \\ \nabla \cdot B &= 0 \\ \nabla \times E &= -\partial_t B \\ \nabla \times B &= J + \partial_t E \end{aligned}$$

electromagnetic

1925

$$i\hbar \frac{\partial |\psi\rangle}{\partial t} = \mathcal{H} |\psi\rangle$$



quantum

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two lessons

lesson #1: science drives technology

new science $\Rightarrow$ new technologies

lesson #2: it's all about resources

harnessing resources is key

generate, transport, control, transform, use

quantum nanotech

driving technology in 21st century

the art of manipulating & controlling

individual quantum systems

to perform useful tasks

quantum resources

superposition, entanglement, nonlocality, duality

quantum features:

1. cannot be explained classically
2. essential for quantum technologies

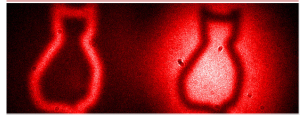
quantum technologies: disruptive

Quantum communication

the future **quantum internet** will use quantum superposition and entanglement to achieve **super-secure communication**

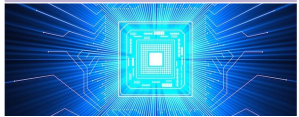
Quantum sensing/imaging

novel quantum devices – **quantum microscope**, **quantum radar**, **quantum telescope** – will revolutionise sensing and imaging



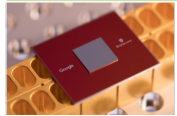
Quantum simulation

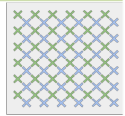
efficient simulation of designer molecules will lead to **advanced materials**, **new drugs**, **higly-efficient batteries**



Quantum computation

quantum computers will solve important problems (optimization, code breaking) exponentially faster than classical computers





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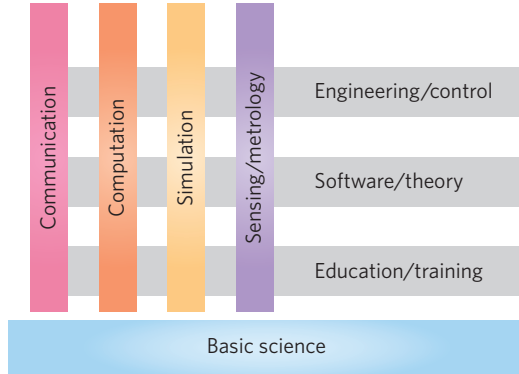
QUANTUM FLAGSHIP

- launched May 2017
- € 1 Billion
- www.qt.eu



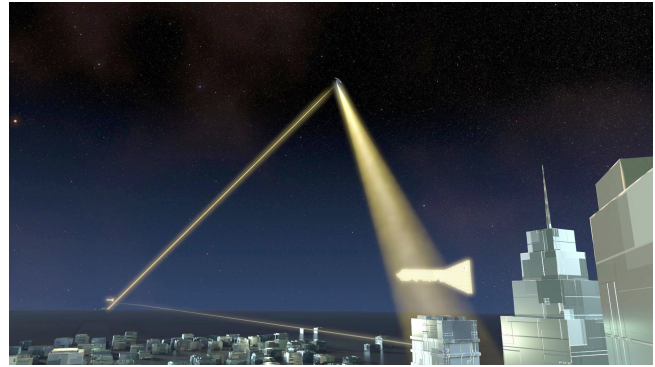
EU + ESA

European Quantum Communication Infrastructure (QCI)

SAGA (Security And cryptoGrAphic mission)

QCI

1. ground segment: fiber
   - trusted nodes
   - quantum repeaters
2. space segment: free space



QCI will use both

λ= 1550nm (fiber) and λ= 810nm (free space)

quantum + nanotech

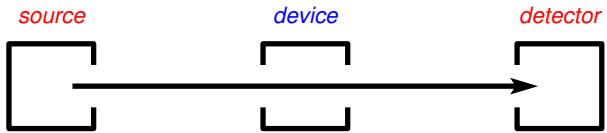
nanotech

- technology platform for the 2nd q.revolution
- tools for building mobile quantum devices
  small, integrated, room-T
- Moore's law for quantum

quantum

- q.simulation: methods for designing new materials
- q.imaging: revolutionary ways for nanotech imaging

nanotech for quantum



sources	devices	detectors
single-photon	beam-splitters	single-photon
entangled photons	phase shifters	photon-# discriminating
high purity	PBS	high efficiency
deterministic/on-demand	quantum memories	low dark-count rates

chip integrated, ambient (T, p)

quantum @RO

Romanian Quantum Network

www.roqnet.ro

roqnet

Vision

quantum: the driving technology in 21st century

Mission

develop quantum technologies in Romania

Strategic objectives

1. *research*
2. *education*
3. *dissemination*

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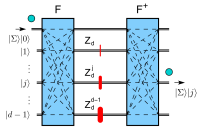
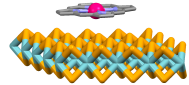
QUTECH-RO

- €1.14 Mil
- 5 partners, 5 projects
- grant: UEFISCDI

P1: Q-INFO	P2: Q-CHIP	P3: Q-VORTEX
IFIN-HH	INFLPR	IMT
quantum information quantum simulation quantum protocols	integrated quantum photonics 3D laser *fabrication*	optical vortices lithography



P4: Q-LAB	P5: Q-FERMI
UPB	ITIM-Cluj
Applied quantum optics Lab IBM-Q Lab quantum source	quantum computation with Majorana Fermions



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research areas

- quantum information: theory, protocols, imaging
- integrated quantum photonics
- optical vortices: q.communication & imaging
- q.memories, Majorana fermions

full process chain

THEORY

gates, algorithms, protocols

⇓

DESIGN & SIMULATION

inverse design, DBS, OptiFTD, MEEP

⇓

FABRICATION

3D printing, lithography

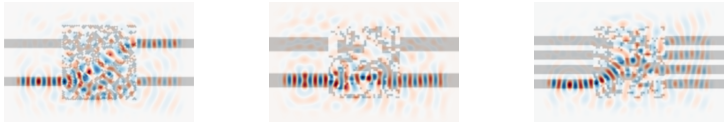
⇓

TESTING

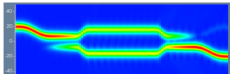
tomography, state estimation, certification

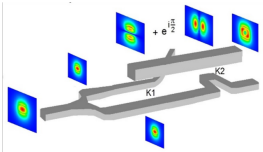
design & simulation

quantum gates:

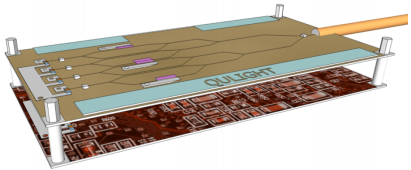


devices:





full integration:



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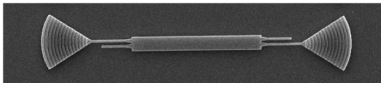
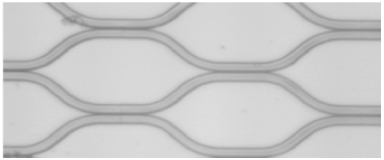
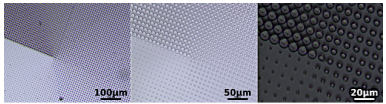
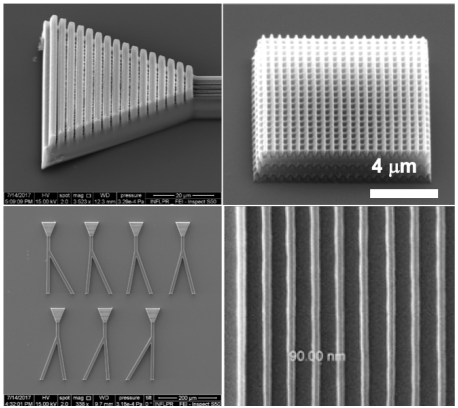
fabrication

3D laser writing + lithography









message

- quantum + nanotech: driving tech in 21st century
- synergies: beneficial for both
- q.communication, q.imaging, q.sensing: paradigm changing
- q-Moore's law: smaller, cheaper, faster q.devices

acknowledgements

team: IFIN-HH, INFLPR, IMT, UPB, ITIM-Cluj ($\sim$ 50 people)

grant: UEFISCDI, 79PCCDI/2018

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thank you!