

Growing
ideas
through
networks

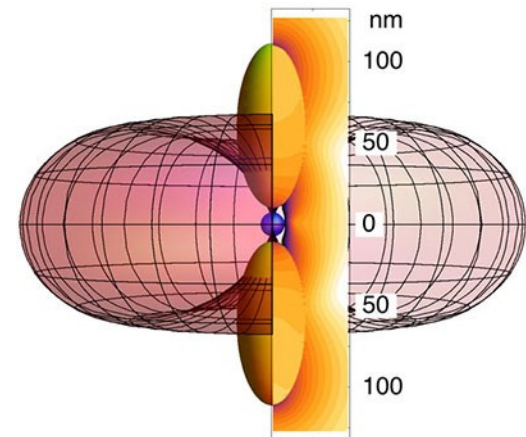
Nanoscale Quantum Optics

COST Action MP1403

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Funded by the Horizon 2020 Framework Programme
of the European Union



Focus and Aims

- The investigation of **quantum phenomena in nanophotonics systems** may lead to new scales of quantum complexity and constitutes the starting point for developing **photonic technologies that deliver quantum-enhanced performances** in real-world situations
- The aim of the COST Action Nanoscale Quantum Optics (NQO) is to support and coordinate research activities in nanoscale quantum optics, explore innovative approaches by identifying, establishing and exploiting cross-links between **quantum science & technology, nanoscale optics & photonics and materials science**, and facilitate the early-involvement of end-users

Key Data

- Start 2.12.2014 - End 1.12.2018
- 28 COST Countries (12 Inclusiveness Target Countries)
- 3 COST Near-Neighbor Countries, 9 COST International Partner Countries, ESA
- 52 MC members, 16 Core Group members
- **579 members organized in 4 Working Groups**
- 18% female, 38% early-career investigators
- **~ 450 attended COST events**
- 462 000 EUR spent (~ 1000 EUR per person)
- Topical events (~ 25), publications & patents, short-term scientific missions (~ 60), conference grants (~ 10), startups (~ 10), several invited speakers & lecturers from US

Core Group

- WG1 Leader: Christophe Couteau (FR) and Félix Bussières (CH)
- WG2 Leader: Walter Pfeiffer (DE)
- WG3 Leader: Thomas Durt (FR) and Branko Kolaric (BE)
- WG4 Leader: Peter Rabl (AT) and Dimitris Angelakis (GR)
- Industry Advisor: Félix Bussières (CH) and Valérian Giesz (FR)
- Gender Balance Advisor: Ruth Oulton (UK)
- ESR Advisor: Humeyra Caglayan (FI) and André Xuereb (MT)
- Education Advisor: Darrick Chang (ES) and Dario Gerace (IT)
- STSM Manager: Concita Sibia (IT)
- Chair and Vice Chair: Mario Agio (DE) and Irene D'Amico (UK)

Scientific Focus

- Explorative scientific scope of NQO, but also addressing three major application areas that already exhibit clear evidence that the combination of quantum optics with nanophotonics is technologically valuable:
 - Information & communication technology (ICT)
 - Sensing & metrology
 - Energy efficiency
- The roadmap towards compact and efficient NQO devices still requires a substantial basic research approach

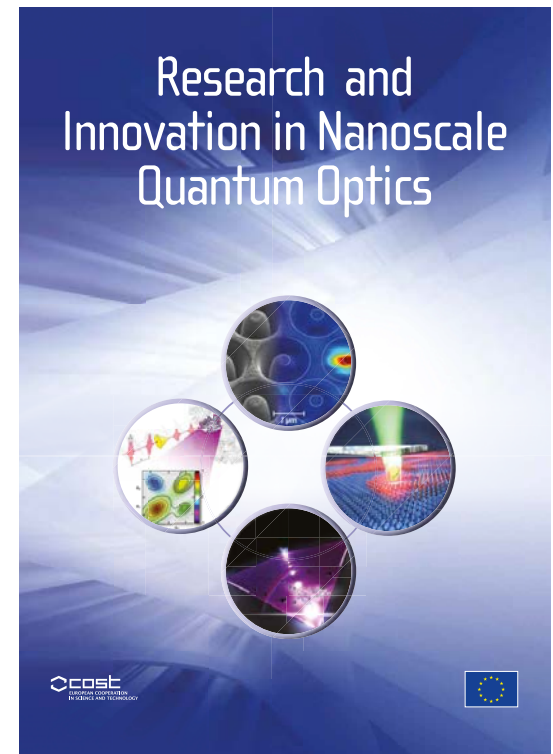


Research Priorities

- Generation, detection, manipulation & storage of quantum states of light at the nanoscale
- Nonlinearities and ultrafast processes in nanostructured media
- Nanoscale quantum coherence
- Cooperative effects, correlations and many-body physics tailored by strongly confined optical fields

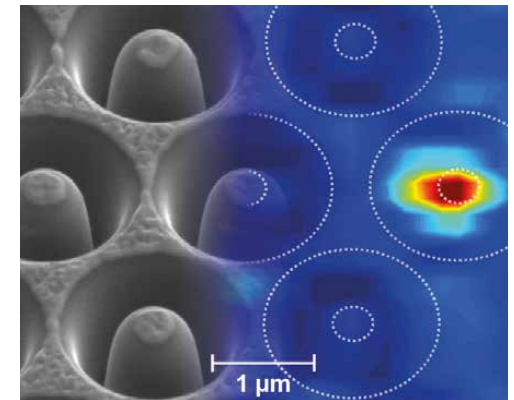
NQO Roadmap (2017)

- Outlines research and innovation in NQO addressing researchers and policy makers, especially for FP9 and QT Flagship
- Shaped during Action's meetings and other networking events: it reflects the Action's scientific focus and work plan
- Structure of the NQO Roadmap:
 - Executive summary
 - Presentation of the COST Action NQO
 - 4 Working-Group Scientific Areas
 - Topics
 - Concept / Theory / Models
 - Materials / Systems / Experiments
 - Challenges / Performances / Goals
 - References
 - Technological outlook



WG1: Generation, detection, manipulation & storage of quantum states of light at the nanoscale

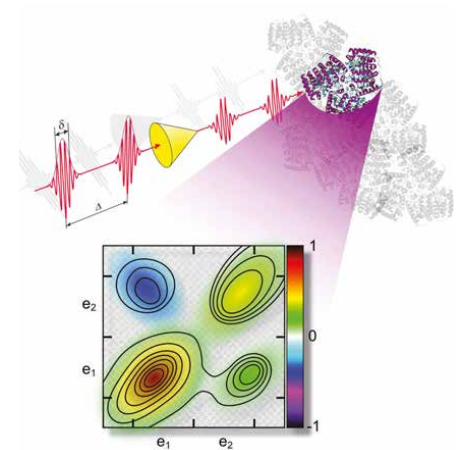
- Single-photon sources
- Superconducting single-photon detectors
- Manipulation and storage of single photons
- Application areas: basic research, ITC, sensing & metrology, energy efficiency



Courtesy of the Quantum Optics Group, Saarland University (www.uni-saarland.de/fak7/becher)

WG2: Nonlinearities and ultrafast processes in nanostructured media

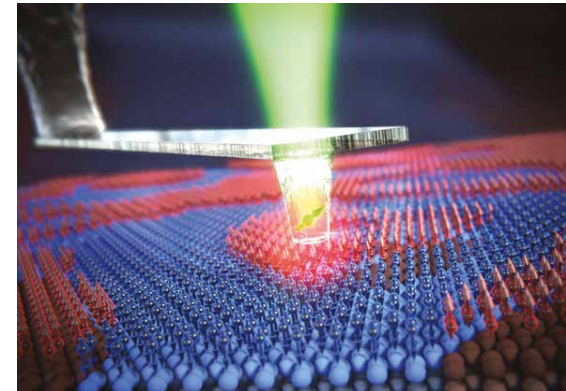
- Coherent control at the nanoscale
- Coherent spectroscopy on the nanoscale
- Strong-field phenomena in nano systems
- Application areas: basic research, ITC, sensing & metrology, energy efficiency



Courtesy of the Laboratory of Nano-Optics, University of Siegen (nano-optics.physik.uni-siegen.de)

WG3: Nanoscale quantum coherence

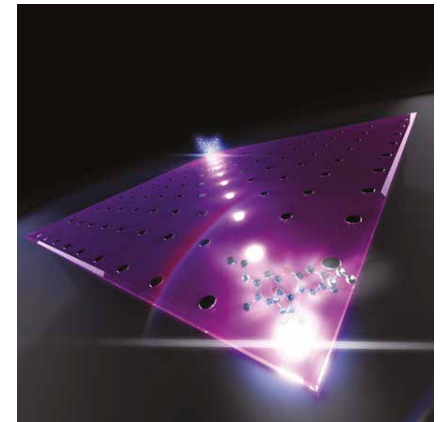
- Quantum coherence and dephasing as a sensing tool
- Fundamental aspects of quantum coherence at the nanoscale
- Strong light-matter interaction at ambient conditions
- Application areas: basic research, sensing & metrology, energy efficiency



Courtesy of the Quantum-Sensing Lab, University of Basel
(www.quantum-sensing.ch)

WG4: Cooperative effects, correlations and many-body physics tailored by strongly confined optical fields

- Photonic quantum simulators
- Quantum plasmonics
- Nano-optomechanics
- Application areas: basic research, ITC, sensing & metrology, energy efficiency



Courtesy of the Quantum Dynamics Group, Aalto University
(physics.aalto.fi/en/groups/qd)

Technological Outlook

- **Several companies have emerged** or have expanded their activities in the field of NQO, see for example the COST Action NQO industry partners at www.cost-nqo.eu/industry
- **Spotlight on companies**, e.g. www.cost-nqo.eu/industry/spotlight-on-qnami/
- **Industry sessions**, e.g. at SPSS Workshop
- Single-photon sources
- Single-photon detectors
- Photonic integration
- Single-spin sensing
- Numerical modeling
- Enabling technologies:
 - Lasers
 - High-speed electronics
 - Cryogenics

TOSHIBA
Leading Innovation >>>

VLC
PHOTONICS

Qnami

IDQ
FROM VISION TO TECHNOLOGY

SINGLE QUANTUM
Excellence in photon detection

cost
EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

TOPTICA
PHOTONICS

QUANDELA

Sparrow
Quantum

Market Research Study in NQO (ongoing)

- Present the innovation potential of the field in a quantitative manner
- Short-term: **5 years** with insights for long-term market
- Tematys, a photonics market research company
- Cooperation between industry members of the COST Action NQO, other relevant industry in the value chain, stakeholders, and Tematys
- The MRS will focus on:
 - **Quantum Sensing, Imaging and Measurement Systems**
 - **Quantum Communications**
- The MRS will be an **open access** document for decision makers in the private and public sectors
- MRS Workshop in Frankfurt Airport on June 5.

Gender Balance

- The numbers of women in Nanoscale Quantum Optics is low (~18%)
- There is substantial evidence that **women face disadvantages in their scientific careers** (see poster presented at ICWIP)
- How much do scientists themselves know about these issues? To answer we did two things:
 - Ran a survey of attitudes towards gender equality in science
 - Ran discussion sessions with the whole COST NQO community at our meetings. Topics (usually thought-provoking and controversial) include: parenthood and academia, sexual harassment, affirmative action/positive discrimination...
- We plan to run a second survey at the end of the COST Action to monitor whether attitudes in our community have changed

Interaction with QT Flagship

- Feedback on QT Roadmap and Flagship Governance
- Informal discussions and participation at meetings
- NQO Roadmap
- Irene D'Amico and Ruth Oulton involved in the CSA for gender balance
- Market Research Study
- Submitted proposals to Quanterra and H2020 calls

Upcoming

- Market Research Study Workshop, Frankfurt, Germany
- ESOF (panel session on gender balance in QT), Toulouse, France
- Focus Issue in NQO (New J. Phys., open access)
- “E. Fermi” International Physics School, Lake of Como, Italy
- Proceedings Book and Lecture Notes
- ESR Workshop, Braga, Portugal
- Short-Term Scientific Missions
- Conference Grants
- Planned (TBC):
 - Market Research Study Workshop, Paris, France
 - Final Dissemination, Brussels, Belgium

References

- www.cost-nqo.eu/support/research-database/
- www.cost-nqo.eu/support/opportunities/
- www.cost-nqo.eu/support/documents/
 - Memorandum of Understanding
 - Quantum Nanophotonics (EC open consultation)
 - Roadmap for quantum information on a chip (NSF and EU scientists)
 - QT Flagship open consultation
 - Gender Survey
 - NQO Brochure
 - NQO Roadmap