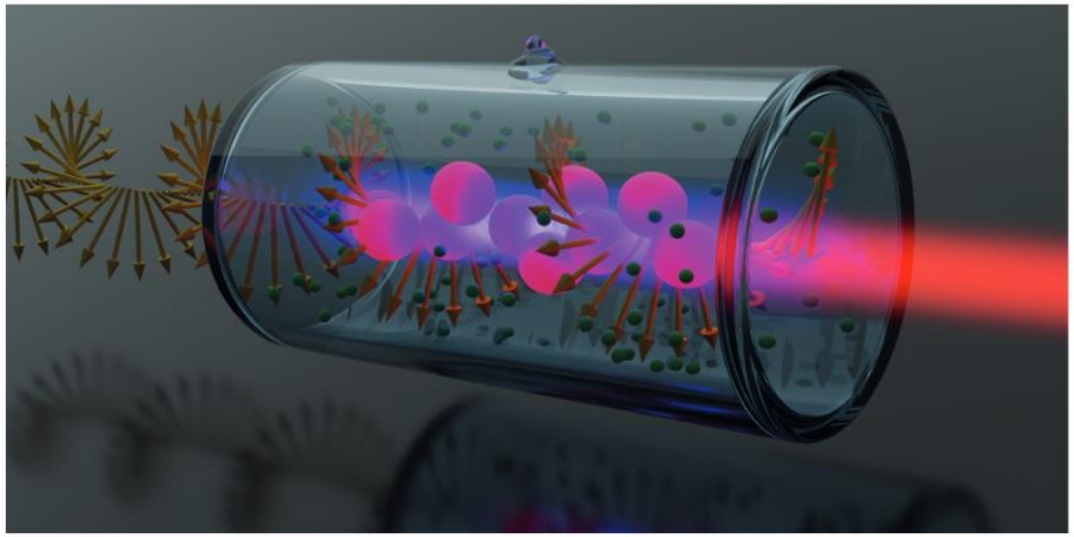
CENTRE FOR QUANTUM OPTICAL TECHNOLOGIES

UNIVERSITY OF WARSAW

QUANTUM OPTICAL TECHNOLOGIES

APPLICATIONS IN SENSING, IMAGING, AND COMMUNICATIONS



European Funds Smart Growth

Republic of Poland

FNP Foundation for Polish Science

European Union European Regional Development Fund

UNIVERSITY OF WARSAW

QOT CENTRE FOR QUANTUM OPTICAL TECHNOLOGIES

UNIVERSITY OF OXFORD

Quantum Technologies Laboratory
led by prof. Konrad Banaszek
QOT Director

QT LAB

Quantum Memories Laboratory
led by dr hab. Wojciech Wasilewski, Prof. UW

QM LAB

Quantum Information and Inference Laboratory
led by dr Jan Kołodyński

QI² LAB

Quantum Resources and Information Laboratory
led by dr hab. Alexander Streltsov

QR+I LAB

Quantum Optical Devices Laboratory
led by dr hab. Michał Parniak-Niedojadło

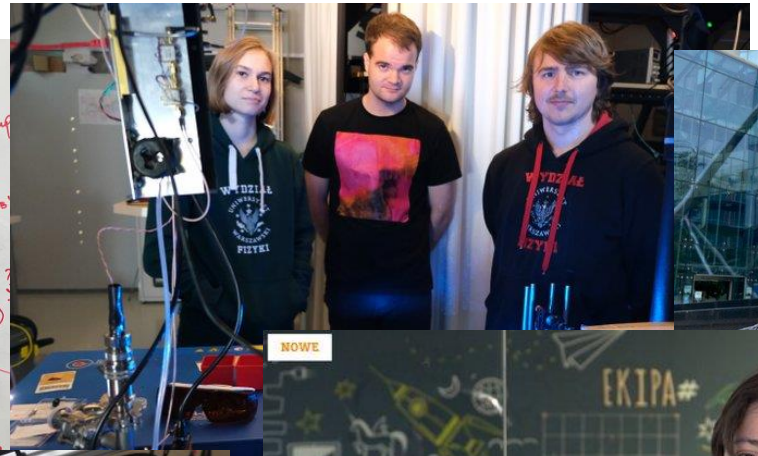
QOD LAB

+ administrative and technical support team led by the **Director for Scientific Affairs, Dr Lidia Tańska**

- >40 members of which ~15% are women, ~ 25% are foreigners and ~ 2/3 are young researchers

www.qot.uw.edu.pl


QML & QODL

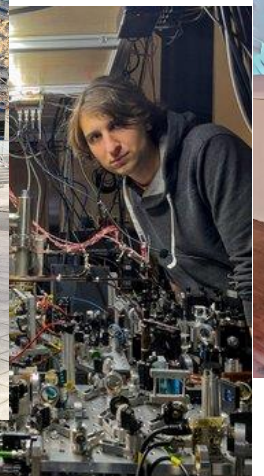


KCIK



NOWE
EKIPA#

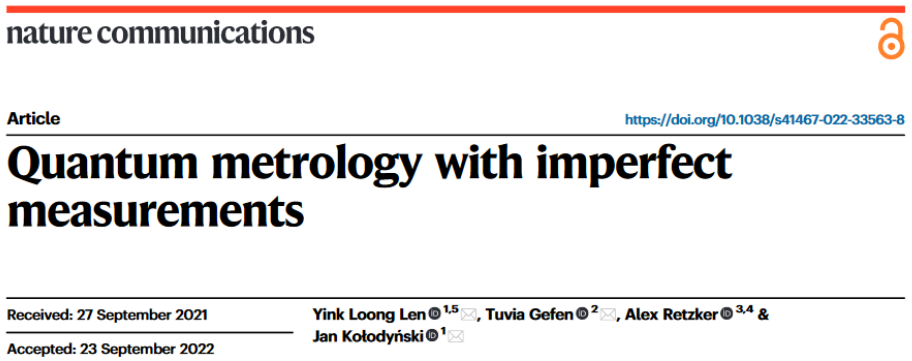




esa


Practical quantum technologies @QOT

Quantum metrology and sensing



nature communications

Article

https://doi.org/10.1038/s41467-022-33563-8

Quantum metrology with imperfect measurements

Received: 27 September 2021

Accepted: 23 September 2022

Yink Loong Len[1,5], Tuvia Gefen[2], Alex Retzker[3,4] & Jan Kołodyński[1]

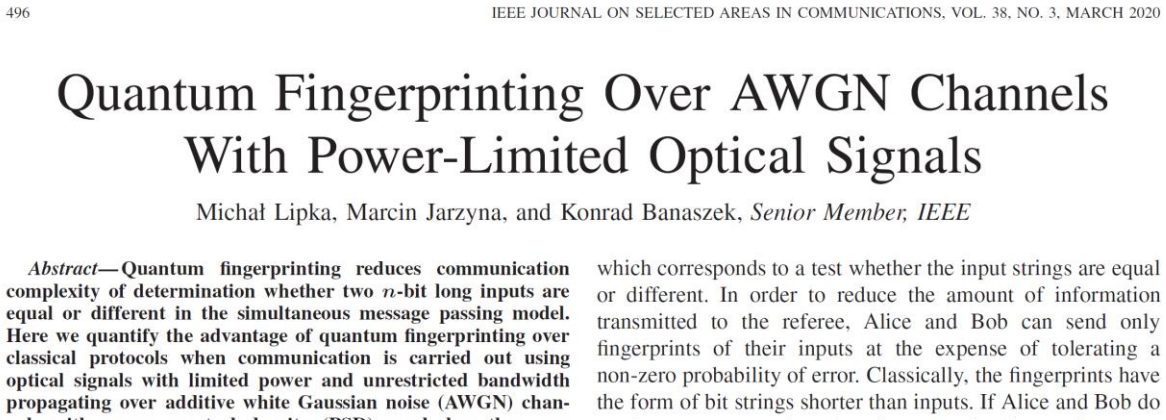
Quantum imaging

optica

Temporal imaging for ultra-narrowband few-photon states of light

Mateusz Mazelanik,[1,2,*,†] Adam Leszczyński,[1,2,†] Michał Lipka,[1,2] Michał Parniak,[1,3] and Wojciech Wasilewski[1]

Quantum and optical communications



Quantum Fingerprinting Over AWGN Channels With Power-Limited Optical Signals

Michał Lipka, Marcin Jarzyna, and Konrad Banaszek, *Senior Member, IEEE*

***Abstract*— Quantum fingerprinting reduces communication complexity of determination whether two n-bit long inputs are equal or different in the simultaneous message passing model. Here we quantify the advantage of quantum fingerprinting over classical protocols when communication is carried out using optical signals with limited power and unrestricted bandwidth propagating over additive white Gaussian noise (AWGN) chan-**

which corresponds to a test whether the input strings are equal or different. In order to reduce the amount of information transmitted to the referee, Alice and Bob can send only fingerprints of their inputs at the expense of tolerating a non-zero probability of error. Classically, the fingerprints have the form of bit strings shorter than inputs. If Alice and Bob do

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European Patent Register

EP About this file: EP3692657

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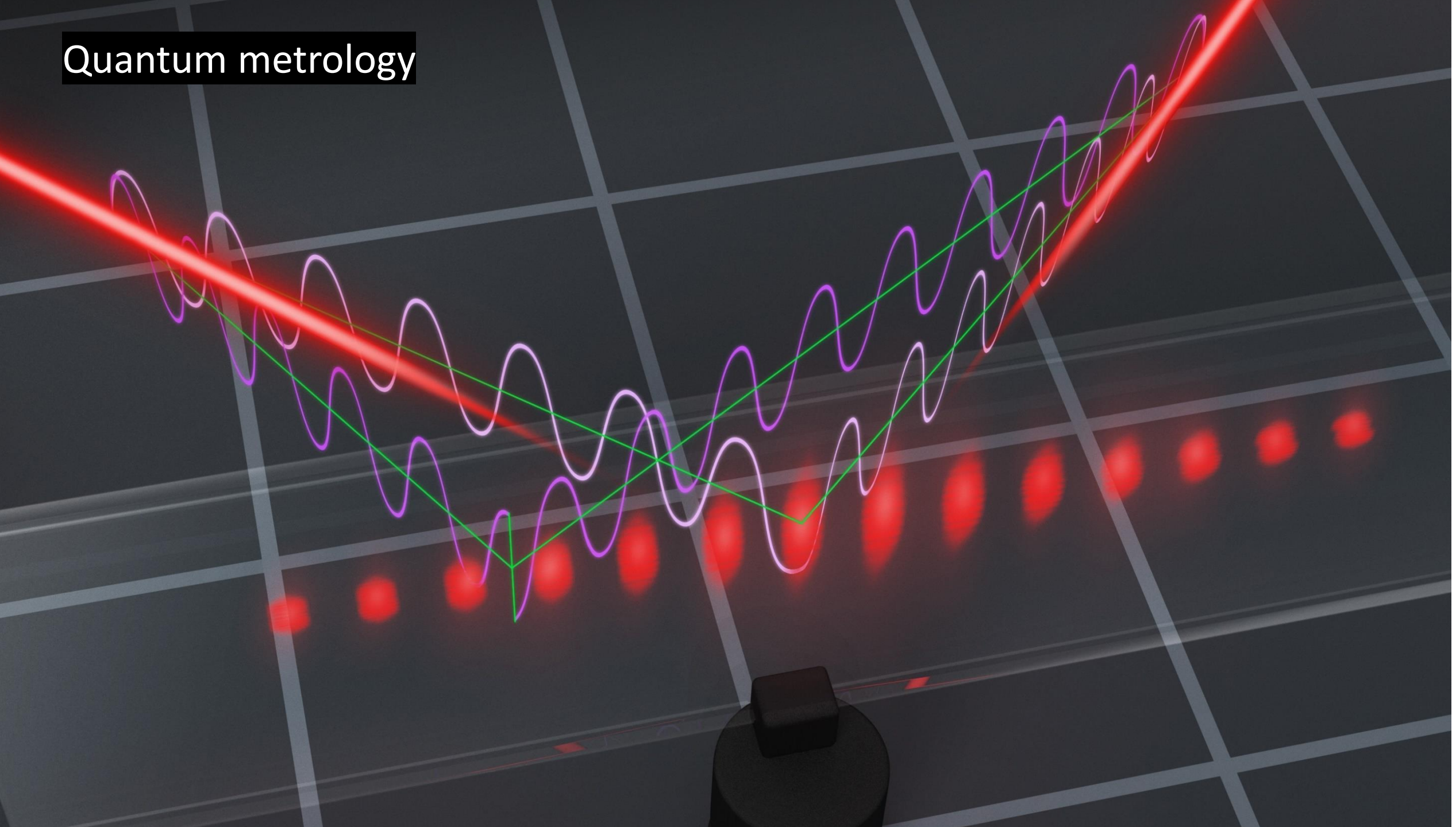
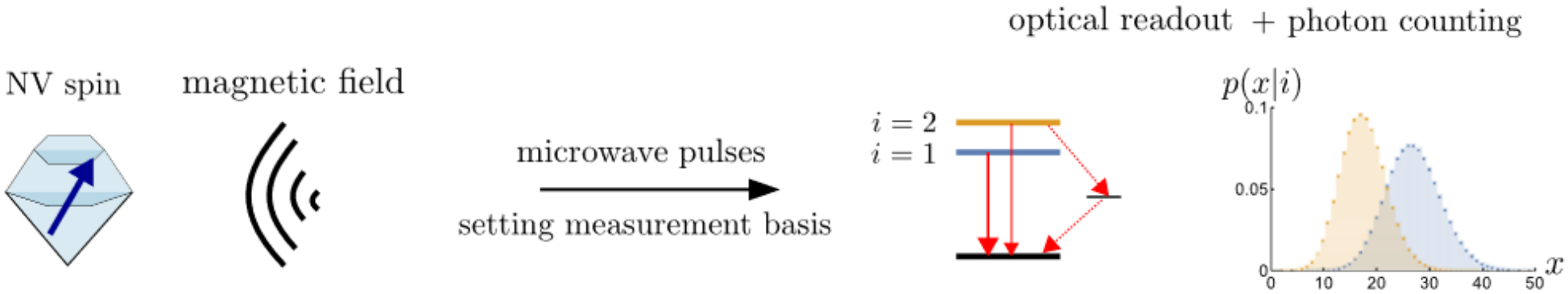
EP3692657 - A RECEIVER FOR RECEIVING INFORMATION TRANSMITTED USING VERY WEAK LIGHT PULSES, A SYSTEM FOR TRANSMITTING INFORMATION COMPRISING SUCH A RECEIVER AND A METHOD FOR TRANSMITTING INFORMATION USING VERY WEAK LIGHT PULSES [Right-click to bookmark this link]

Quantum metrology



Quantum metrology with photon counting



nature communications

Article

https://doi.org/10.1038/s41467-022-33563-8

Quantum metrology with imperfect measurements

Received: 27 September 2021

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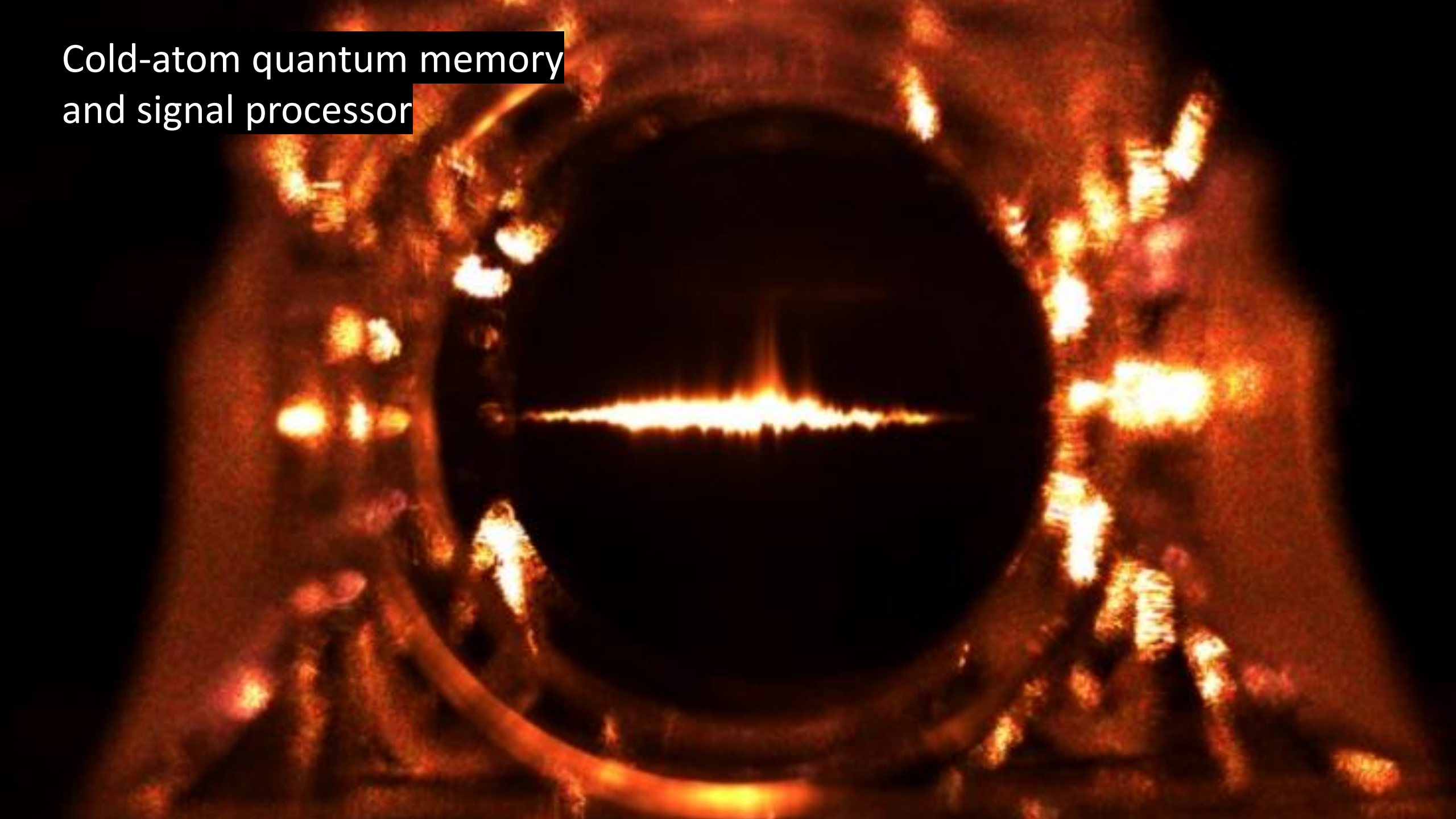
Yink Loong Len [1,5], Tuvia Gefen [2], Alex Retzker [3,4] & Jan Kołodyński [1]

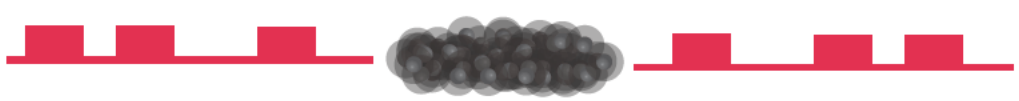
Also supported by QUANTERA

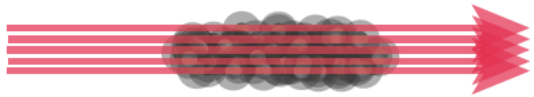

Cold-atom quantum memory
and signal processor

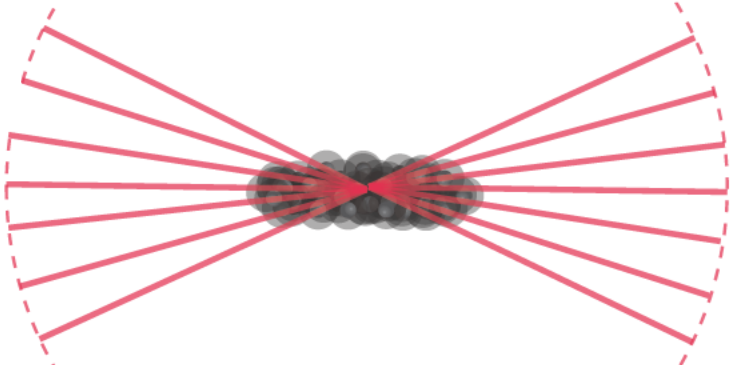
Many functionalities of light-atom interface

Storing photons in spin waves
Storing qubits or qudits
Photon generation
Interference of stored photons

Quantum signal repeaters
Entanglement distillation
Quantum gates
Nonlinear conversion
Optimal sensing via transduction
Quantum imaging







Europäisches Patentamt
European Patent Office
Office européen des brevets

European Patent Register

EP About this file: EP4035302

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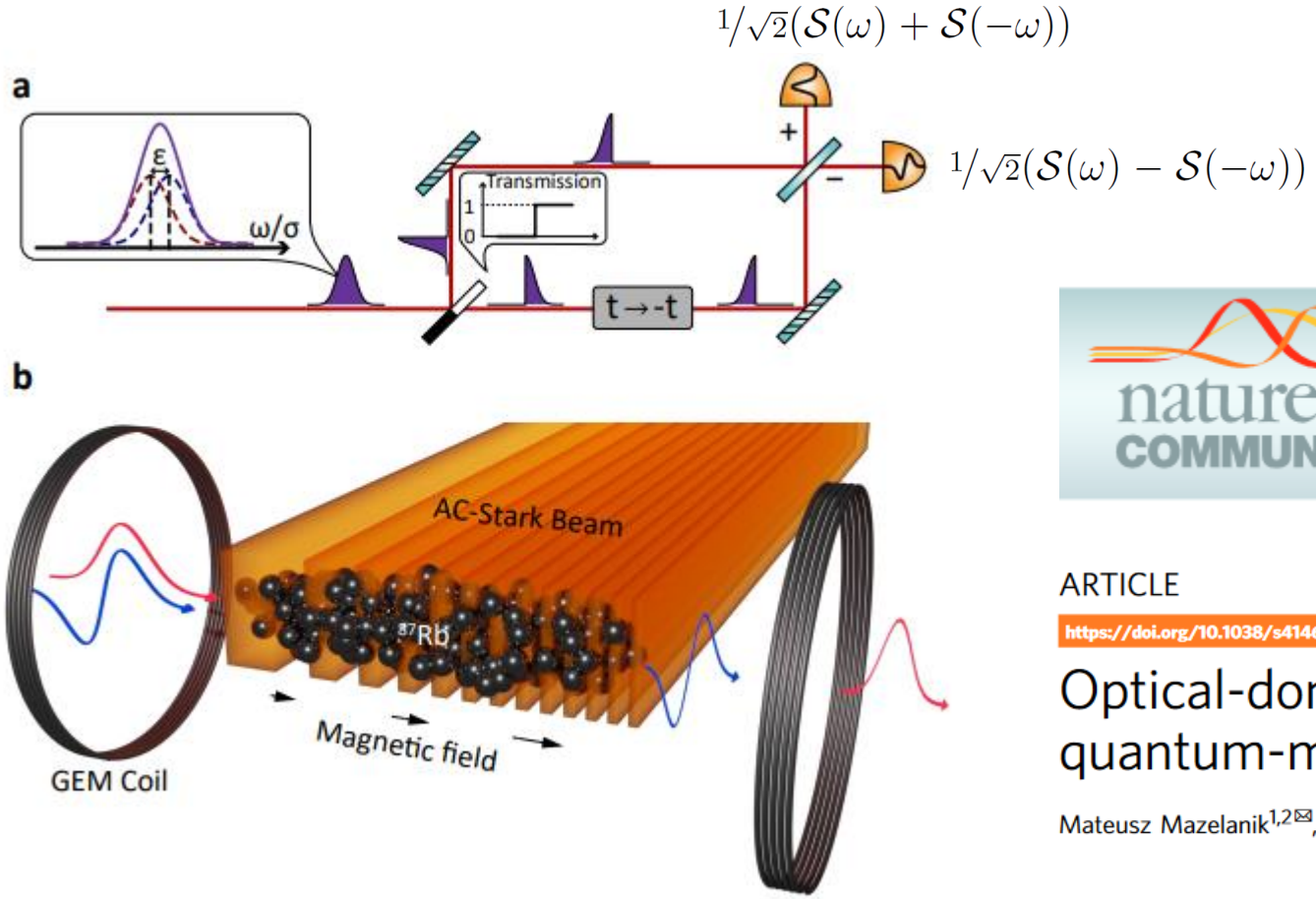
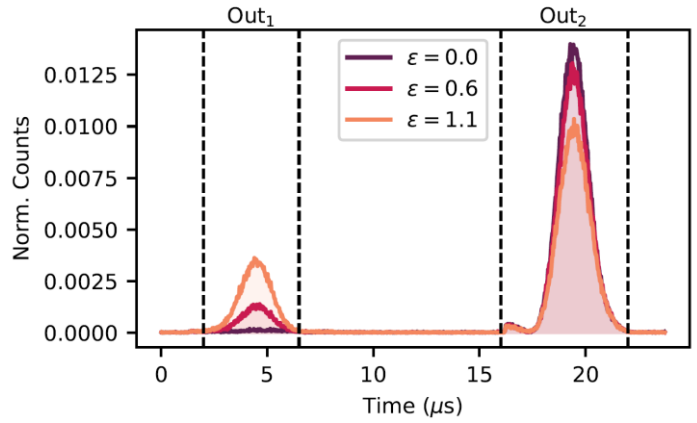
EP4035302 - A SYSTEM FOR GENERATING POLARISATION-ENTANGLED PHOTON PAIRS FOR REPEATING A QUANTUM SIGNAL OVER A DISTANCE AND A METHOD FOR GENERATING POLARISATION-ENTANGLED PHOTON PAIRS IN A MULTI-MODE QUANTUM MEMORY FOR REPEATING A QUANTUM SIGNAL OVER A DISTANCE [Right-click to bookmark this link]

Pulse-division time-axis-inversion interferometer





nature COMMUNICATIONS

ARTICLE

https://doi.org/10.1038/s41467-022-28066-5 OPEN

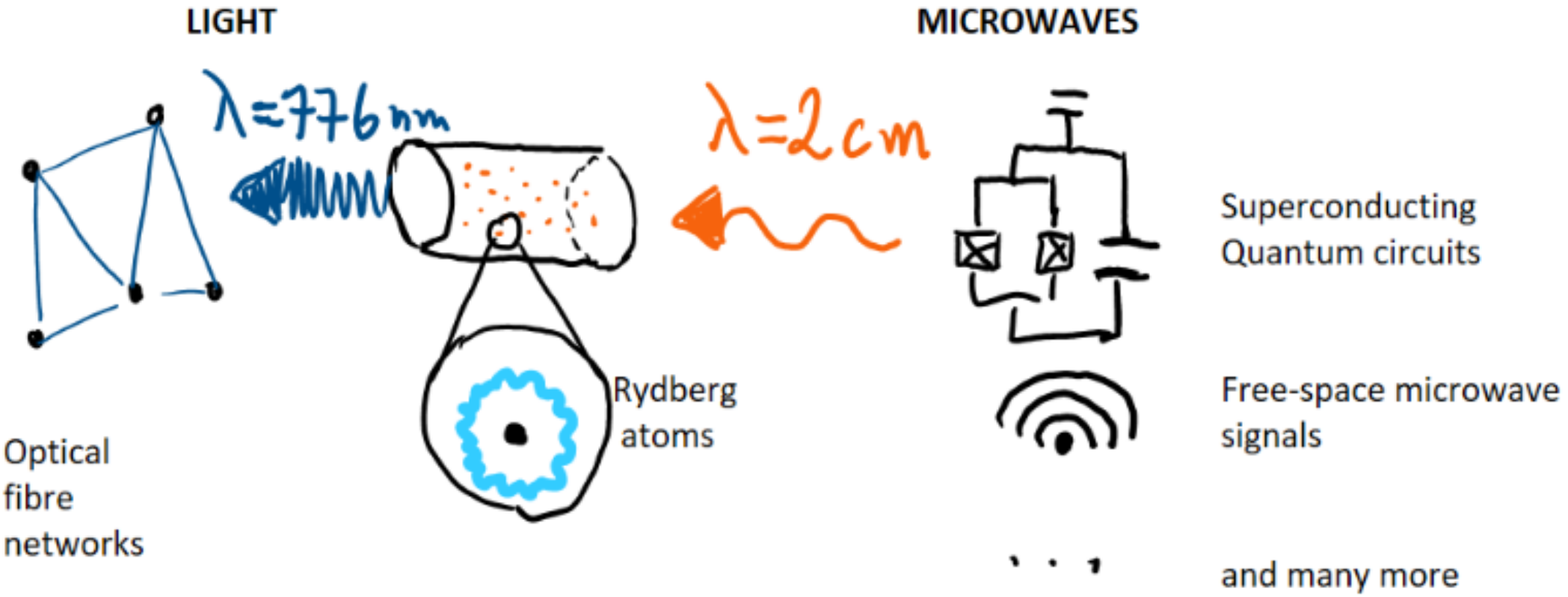
Check for updates

Optical-domain spectral super-resolution via a quantum-memory-based time-frequency processor

Mateusz Mazelanik[1,2]✉, Adam Leszczyński[1,2] & Michał Parniak[1,3]✉

Rydberg atoms

End goal: quantum networking with quantum transduction



Article

https://doi.org/10.1038/s41566-023-01295-w

Continuous wideband microwave-to-optical converter based on room-temperature Rydberg atoms

Received: 28 February 2023

Accepted: 21 August 2023

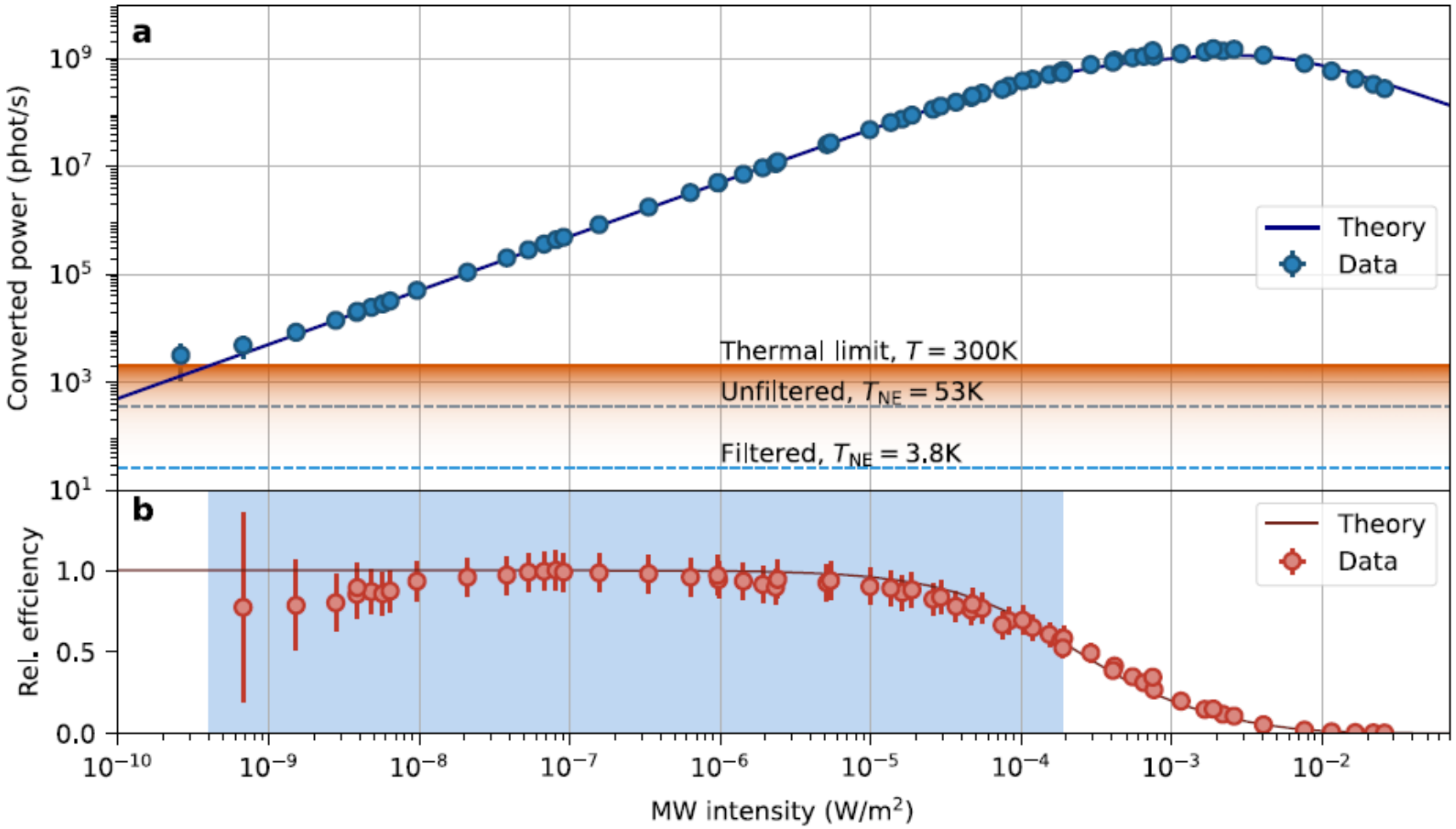
Published online: 05 October 2023

Check for updates

Sebastian Borówka[1,2], Uliana Pylypenko[1,2], Mateusz Mazelanik[1,2] & Michał Parniak[1,3]

The coupling of microwave and optical systems presents an immense challenge due to the natural incompatibility of energies, but potential applications range from optical interconnects for quantum computers to next-generation quantum microwave sensors, detectors and coherent imagers. Several of the engineered platforms that have emerged are constrained by specific conditions, such as cryogenic environments, impulse protocols or narrowband fields. Here we employ Rydberg atoms that allow the wideband coupling of optical and microwave photons at room temperature with the use of a modest set-up. We present continuous-wave conversion of a 13.9 GHz field to a near-infrared optical signal using an ensemble of Rydberg atoms via a free-space six-wave mixing process designed to minimize noise interference from any nearby

Photon counting and efficiency



Saturation due to Autler-Townes splitting

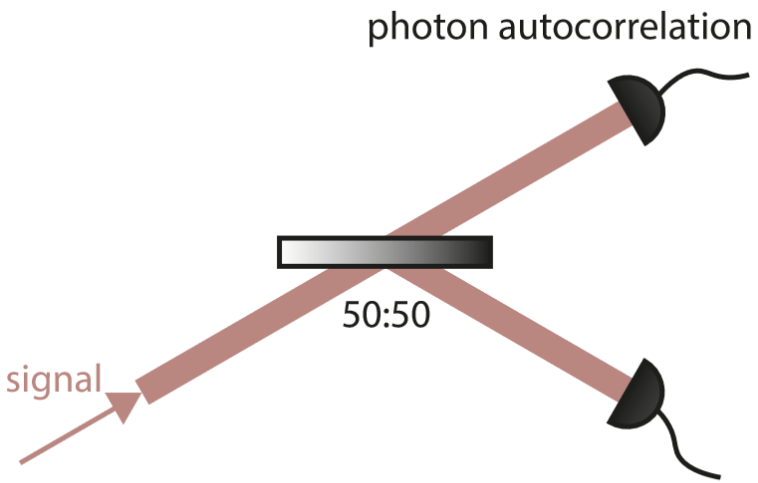
A-T splitting also provides fundamental reference for electric field
(cf. Nature Physics 8, 819–824 (2012))

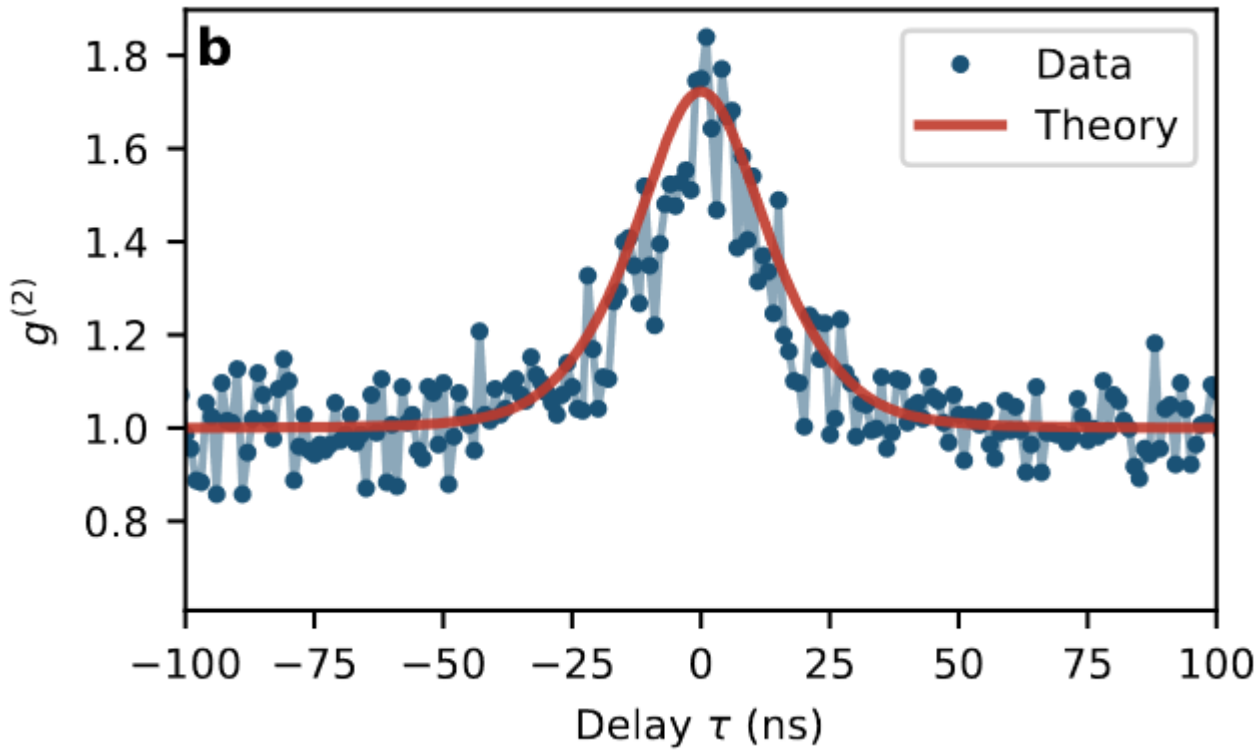
$1.59\ \text{nV cm}^{-1}\,(\text{rad/s})^{-1/2}$ Measured
$1.64\ \text{nV cm}^{-1}\,(\text{rad/s})^{-1/2}$ Calculated

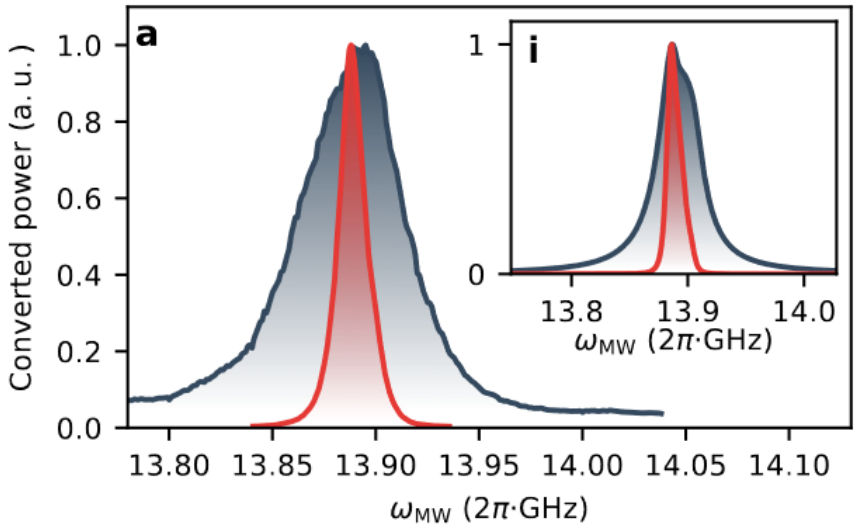
Intrinsic noise (dark background almost 100 times lower than thermal radiation)

S. Borówka *et al.*,
Nature Photonics (2023),
arXiv:2302.08380

Photon statistics and tunability





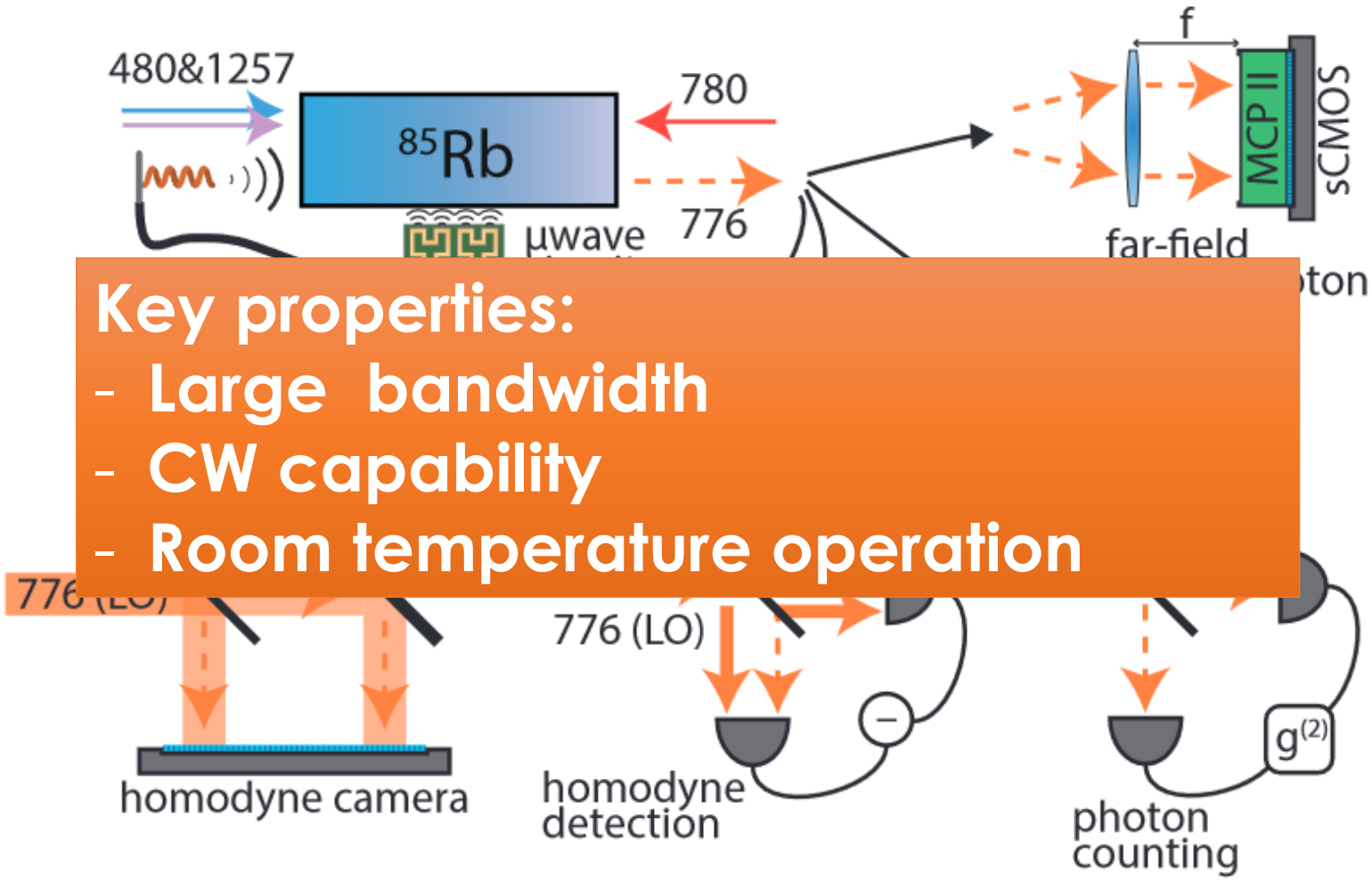


Tunable bandwidth (single laser)

Instantenous bandwidth

S. Borówka *et al.*,
Nature Photonics (2023),
arXiv:2302.08380

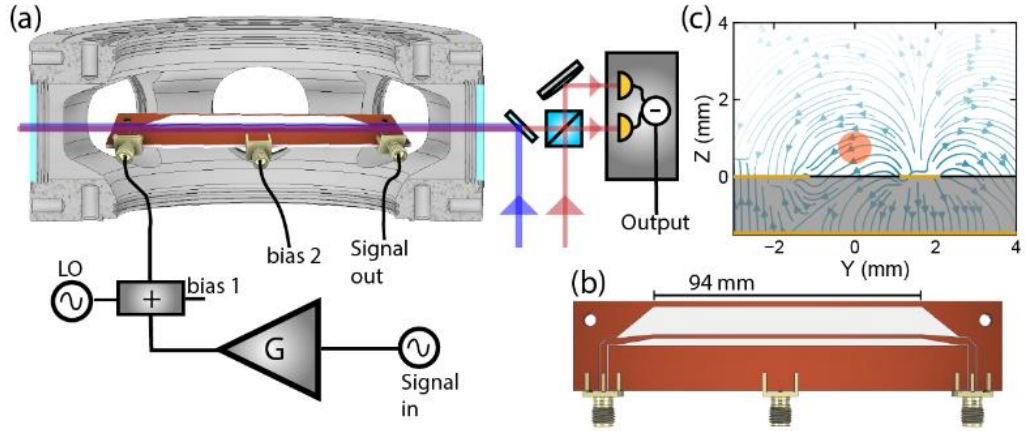
Next applications of our quantum transducer



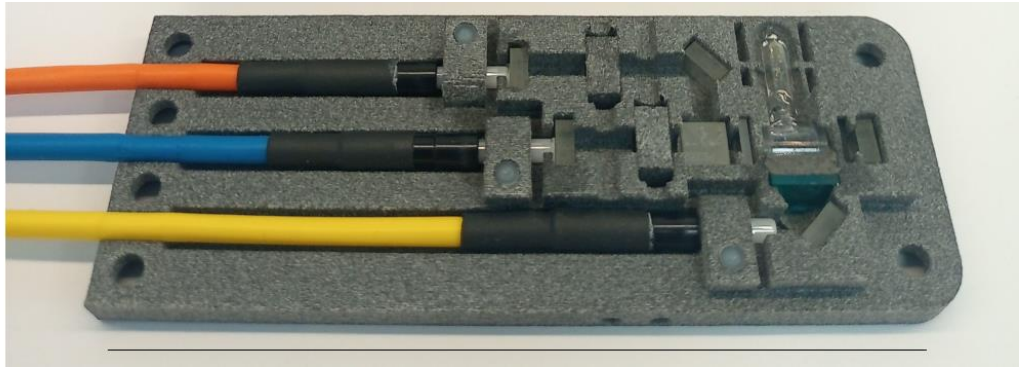
Key properties:

- **Large bandwidth**
- **CW capability**
- **Room temperature operation**

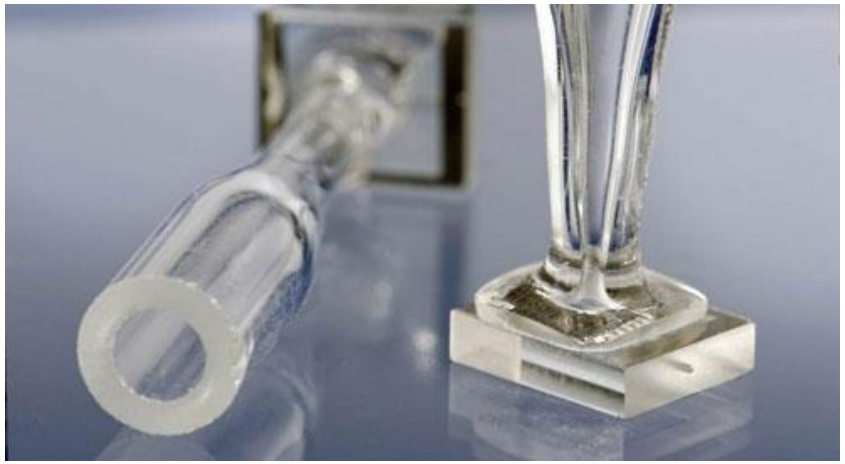
Towards practical devices: cells and waveguides



Waveguided device

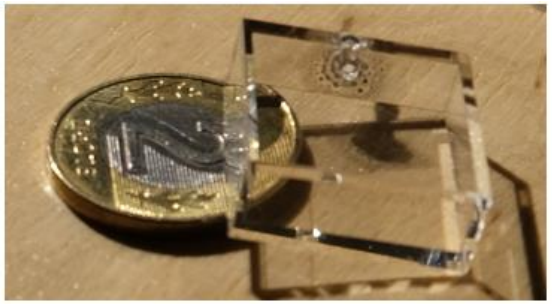


Future: all-fiber laser system?



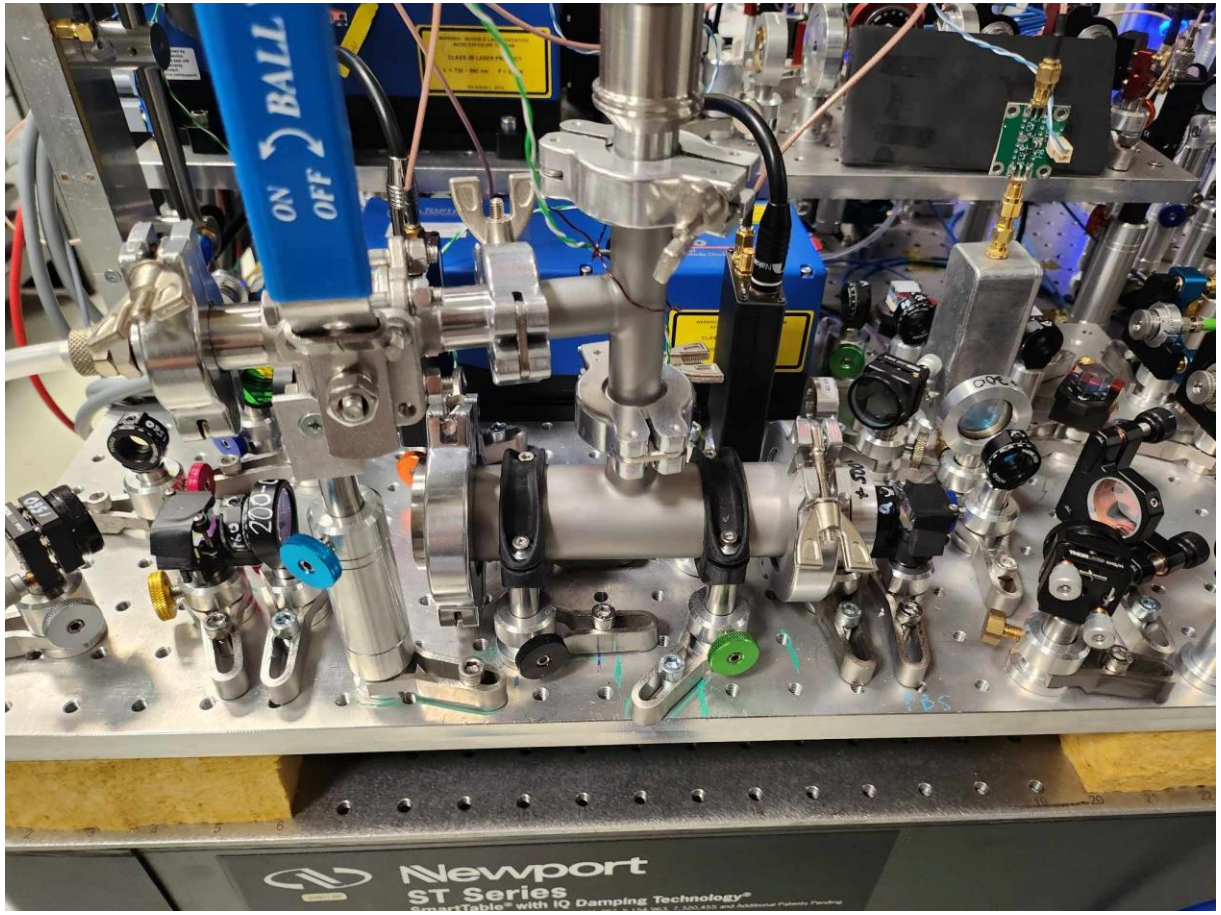
Soon: smaller cel

Future: miniaturized assembly



Potential: all-glass/fiber/plastic microwave receiver, insensitive to EMI

Towards practical devices: laser locking



Patent pending locking scheme, EP23461571.4

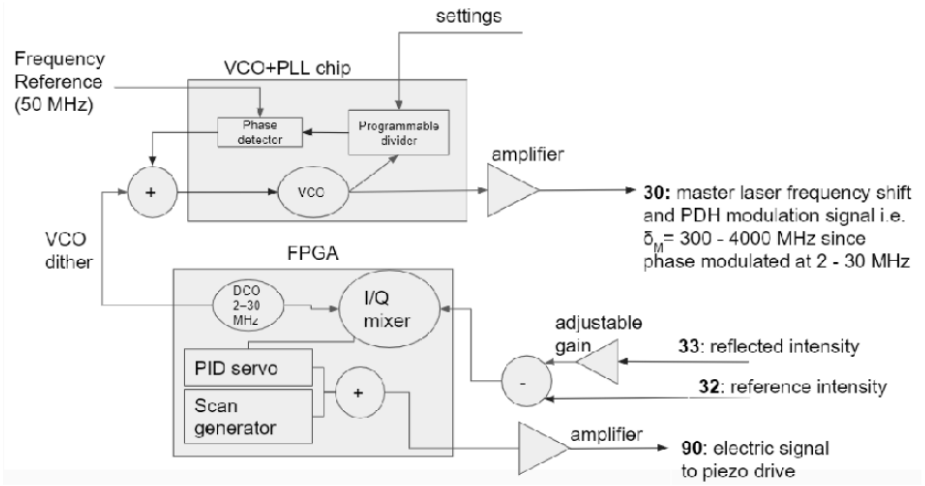


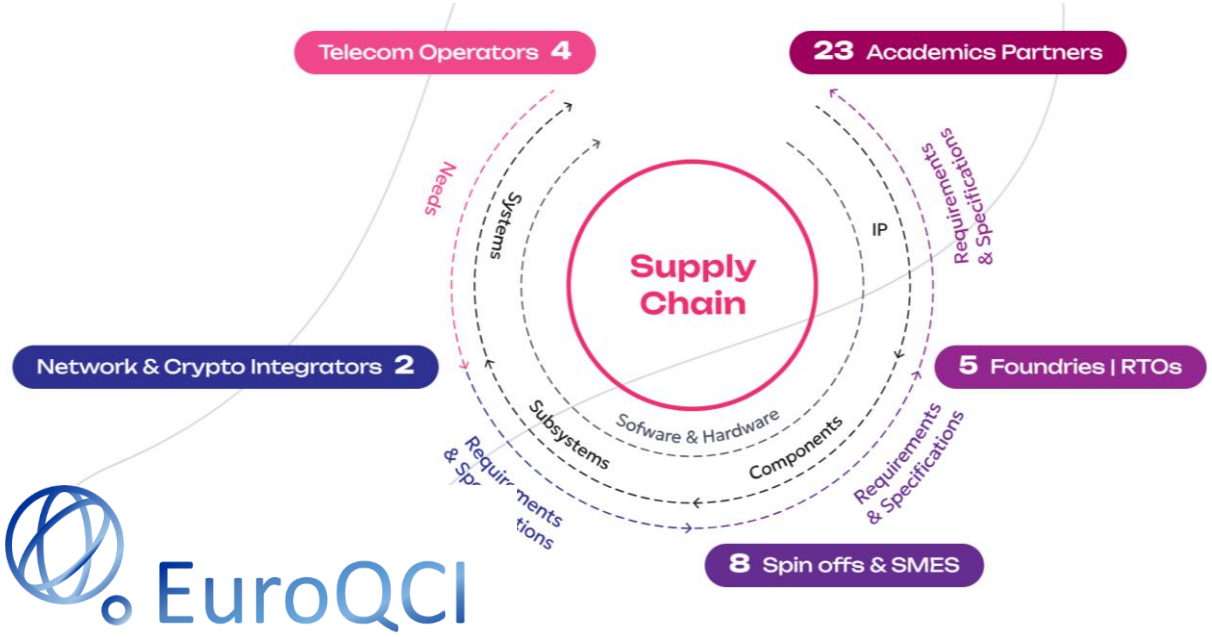
Fig. 3

CENTRE FOR QUANTUM OPTICAL TECHNOLOGIES

Quantum Secure Networks Partnership

QSN PARTNERSHIP

QUANTUM FLAGSHIP



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QUANTUM BLOCKCHAINS

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Thank you!

The "Quantum Optical Technologies" project (Project No. MAB/2018/4) is carried out within the International Research Agendas programme of the Foundation for Polish Science co-financed by the European Union under the European Regional Development Fund.

European Funds Smart Growth

Republic of Poland

FNP Foundation for Polish Science

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