What Next

Fisica Fondamentale

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Roma, Angelicum, 17 Feb 2016

Topics to discuss

- Quantum Metrology and Quantum Imaging
- Quantum Opto-Mechanics
- Quantum Communication
- Photonics
- Quantum Simulations

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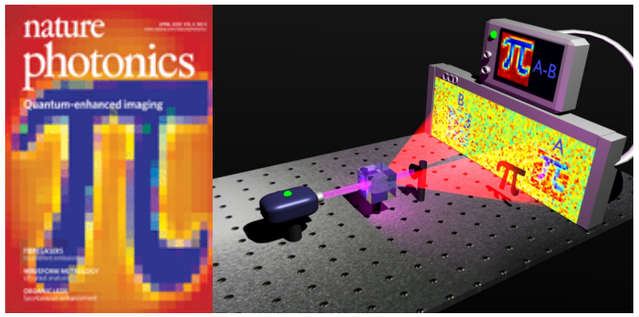
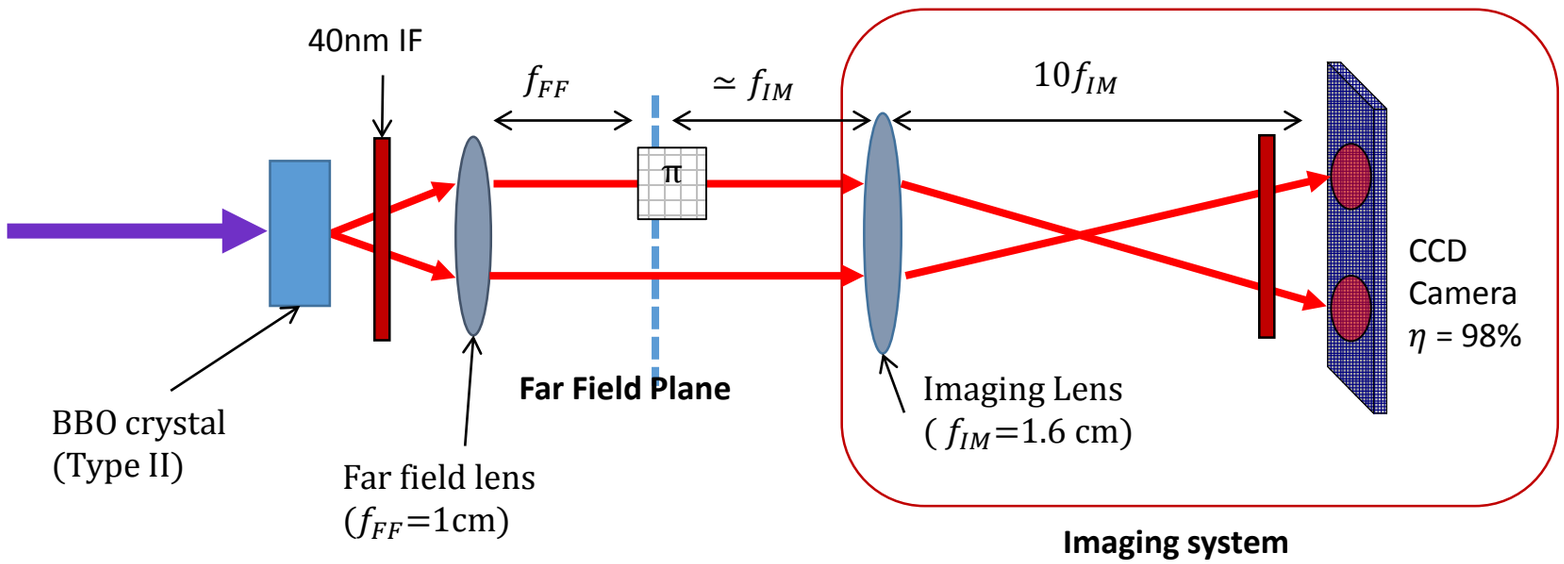
Criteria
(following and interpreting the guidelines of WN)
Incremental
Promising
Scope and Vision (within INFN)

- Quantum Metrology and Quantum Imaging

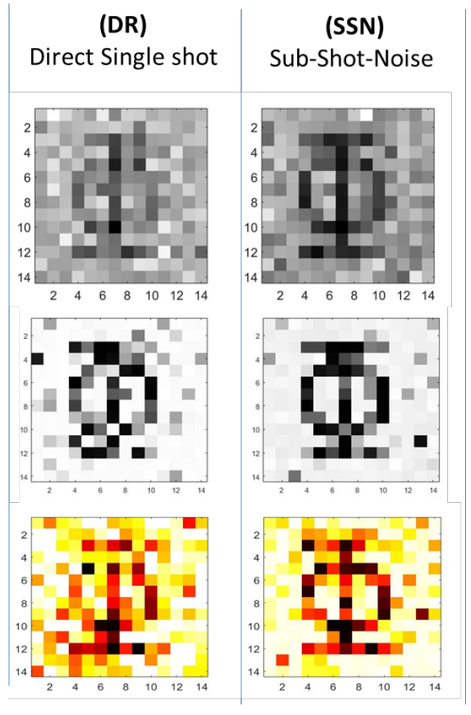
2013-4



2015-6

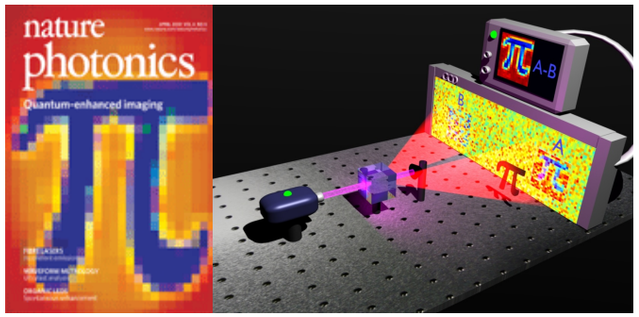


Imaging system

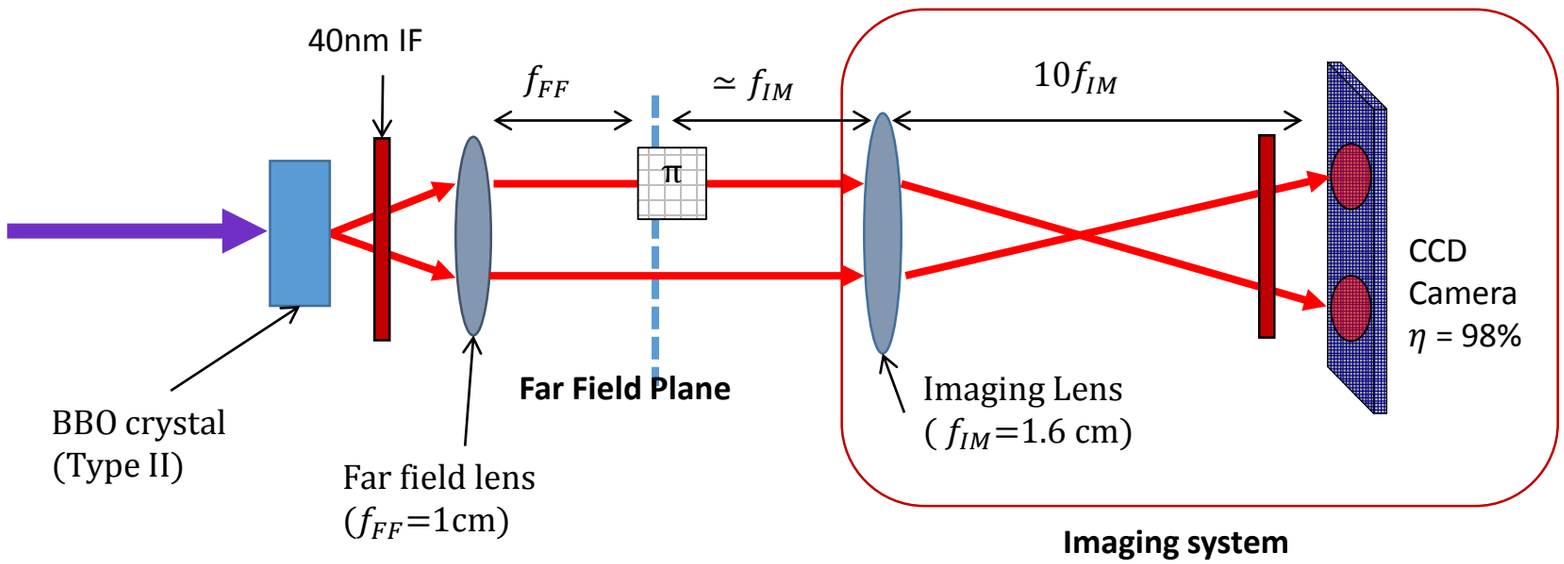


- # Quantum Metrology and Quantum Imaging

2013-4



2015-6



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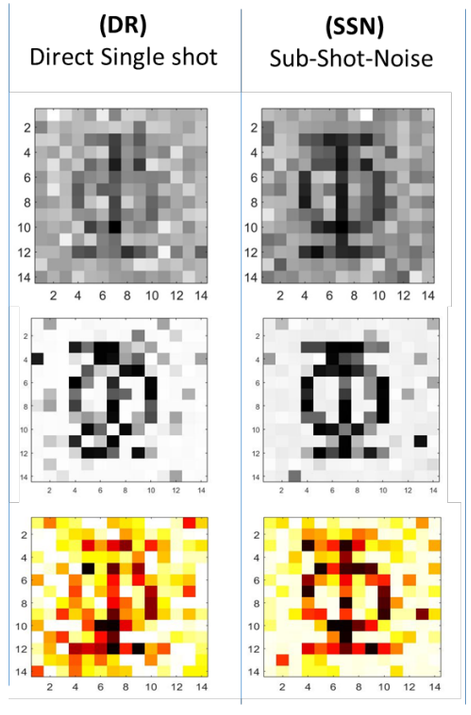

Quantum metrology and sensing will represent a fundamental tool for enhancing measurement performance in the near future: from interferometry to sensing at sub-shot noise level.

Future: from gravitational waves
in interferometers to quantum gravity noise
in quantum interferometers

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- Quantum Opto-Mechanics

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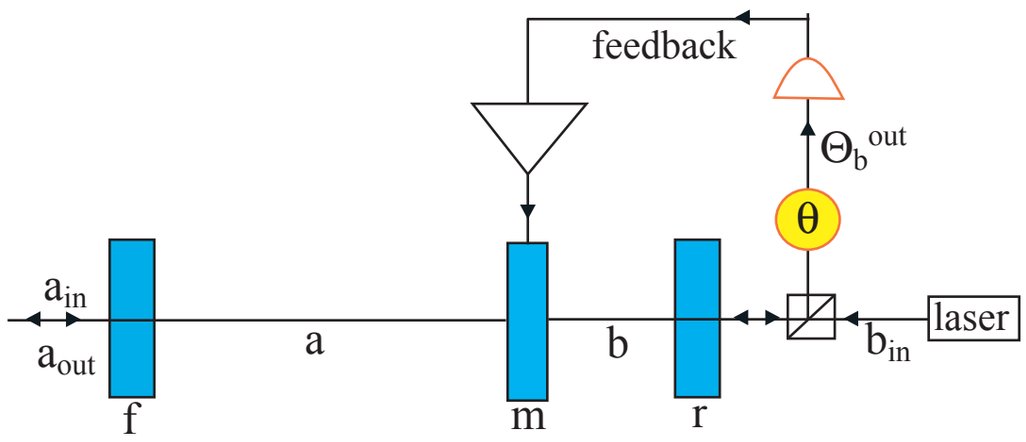
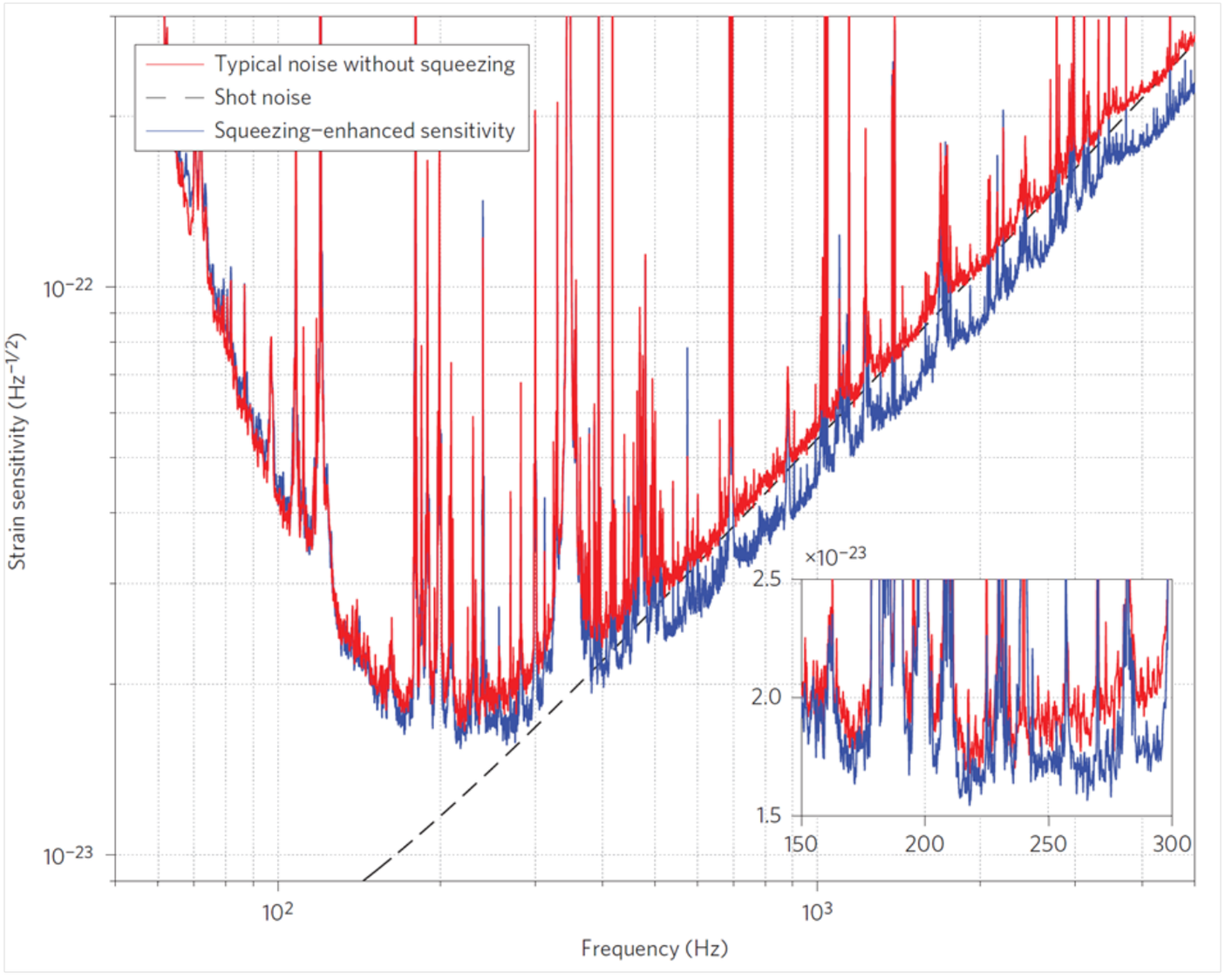
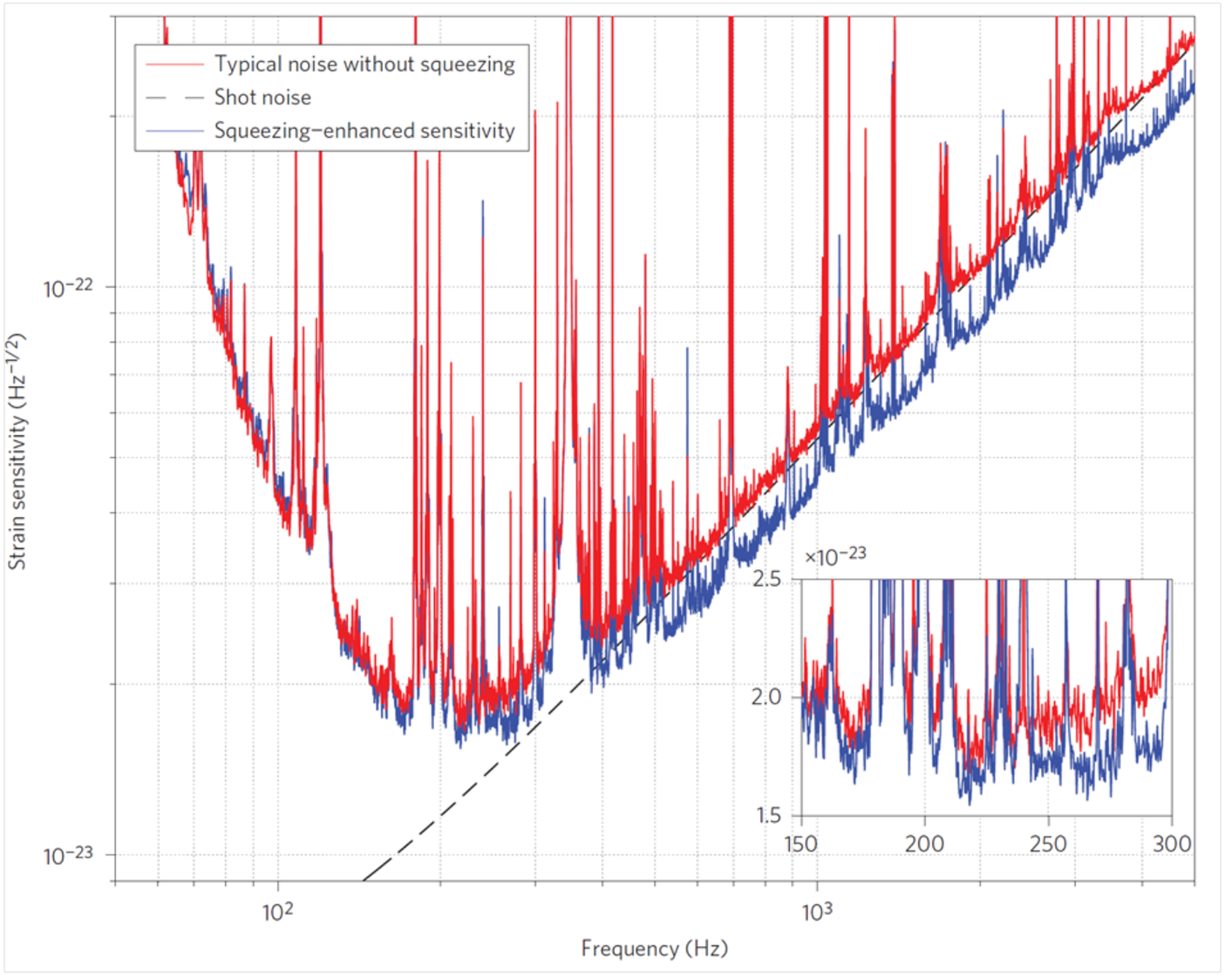
Idea (2004): Noise reduction in gravitational wave using feedback





Advanced GW detectors operate at the quantum noise limit imposed by Heisenberg uncertainty: **injection of squeezed vacuum light enables one to go beyond the standard quantum limit (LIGO collaboration, Nat. Photon. July 2013)**



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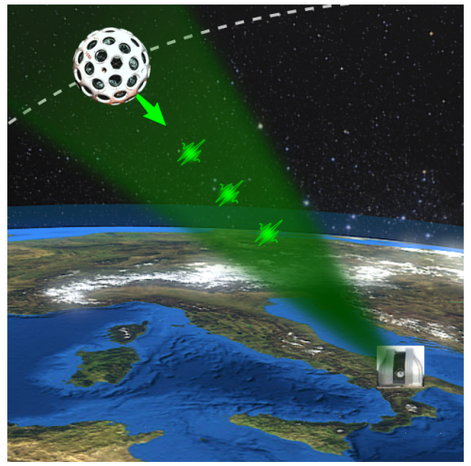
Nano-opto-mechanical systems are and will be a unique platform for testing fundamental physics, especially when quantum mechanics and gravity meet

- # Quantum Communication (in space)

UNIPD

Steps forward in Quantum Communication from orbiting sources (@ Matera Laser Ranging Observatory - MLRO, Italian Space Agency)

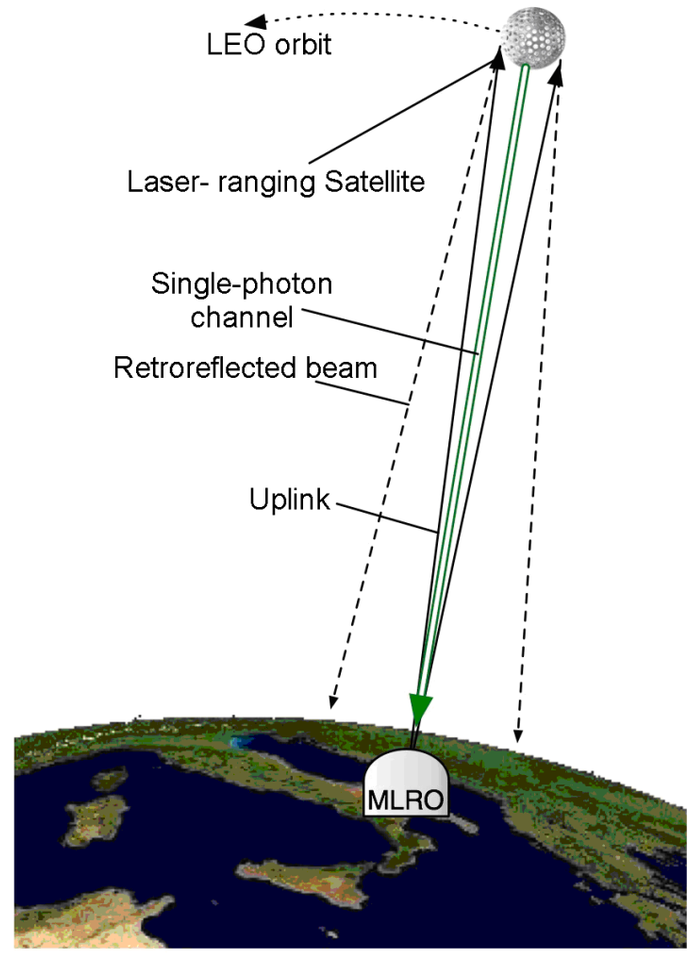


- Space Quantum Communications: exchange of photonic quantum states with transmitter or receiver in Space. Correlations between terminals.

- Quantum Teleportation, Quantum Key distribution

- Tests on the effects of Gravitation in Quantum Mechanical measurements.

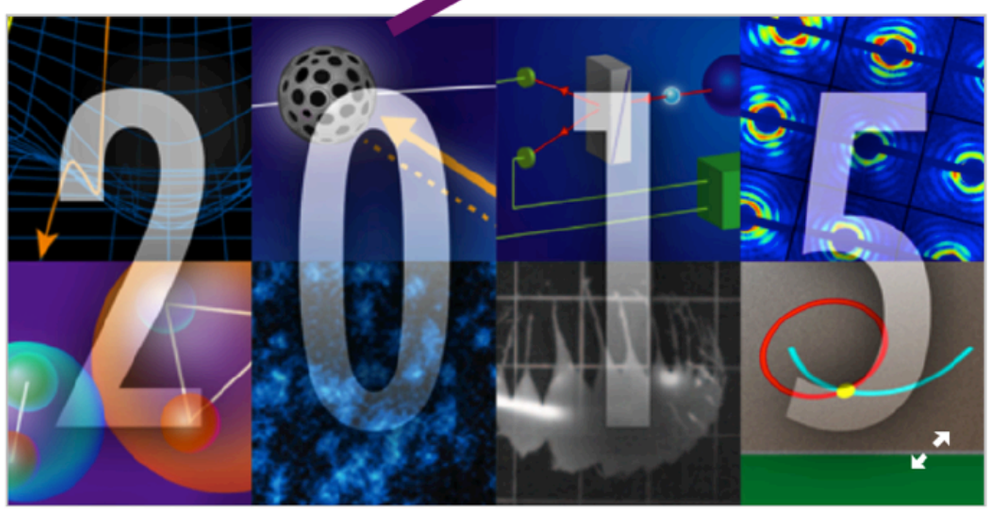
- Polarization and temporal modes. Integrated photonic quantum circuits in the transmitter in orbit will simplify the payloads and allows for more complex protocols as in teleportation.



Highlights of the Year

December 18, 2015 • *Physics* 8, 126

Physics picks its favorite stories from 2015.



Qubits in Space

Photons have been used to securely transmit quantum encryption keys over more than 300 kilometers of optical fiber. Ultimately, light attenuation limits how far a fiber can transmit a signal without degrading its quantum properties. But satellite-to-Earth links might soon open new frontiers for quantum communication. Researchers from the University of Padua and the Matera Laser Ranging Observatory, both in Italy, demonstrated that qubits encoded in photons can preserve their fragile quantum properties even after a round trip to satellites located more than one thousand kilometers away from Earth (see Viewpoint: **Sending Quantum Messages Through Space**). The authors encoded qubits in the photons' polarization and sent them to five satellites that bounced the light back to Earth. After the long journey, different qubit states could be distinguished reliably enough for viable quantum protocols.

As 2015 draws to a close, we look back on the research covered in *Physics* that really made waves in and beyond the physics community

Wishing everyone an excellent 2016.

–The Editors

- Photonics

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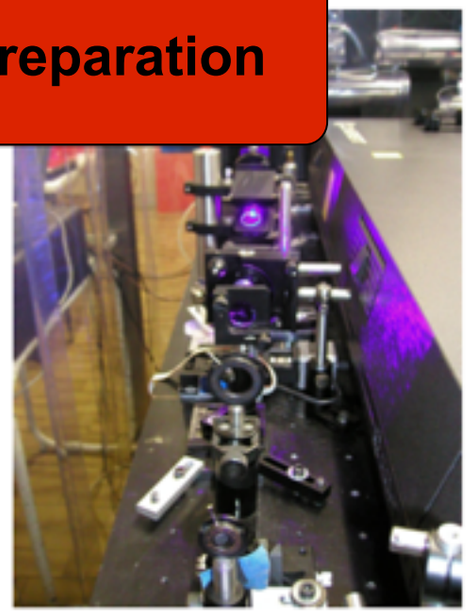
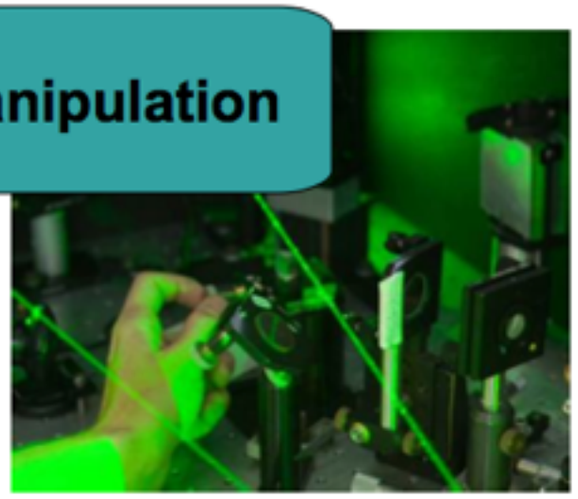
Integrated quantum photonics

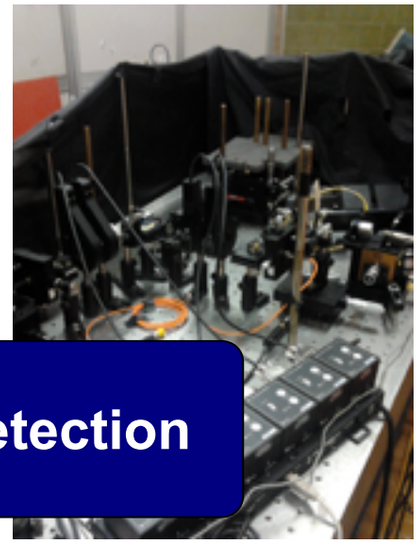
Preparation



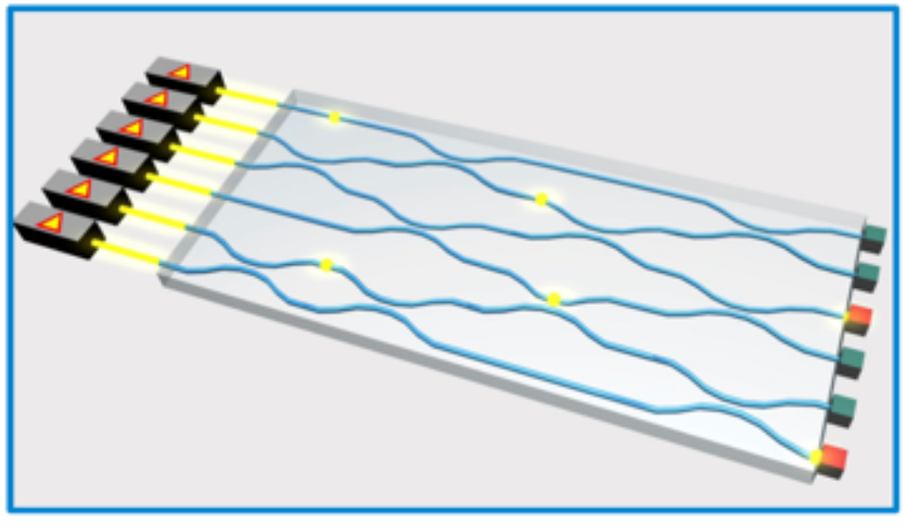
Manipulation



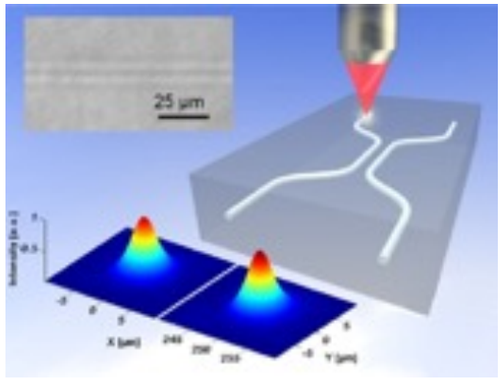
Detection

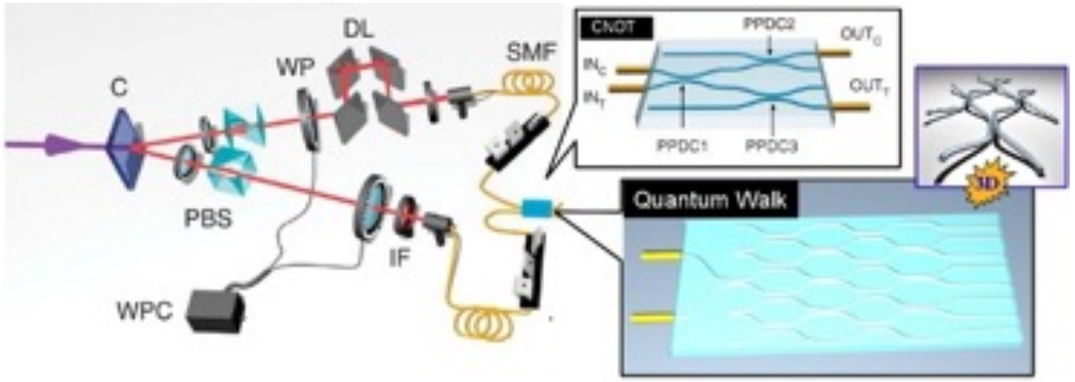


- Single photon sources
- Manipulation
- Single photon detectors
ON THE SAME CHIP

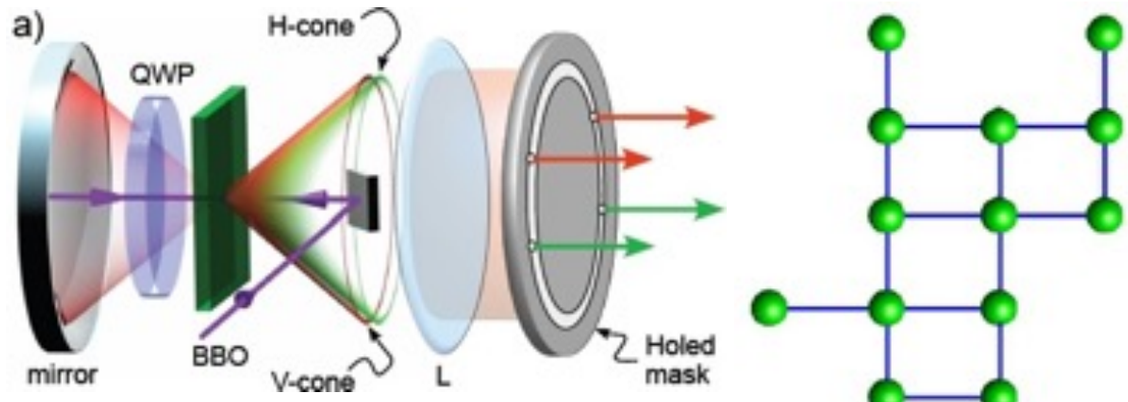


Integrated quantum optics

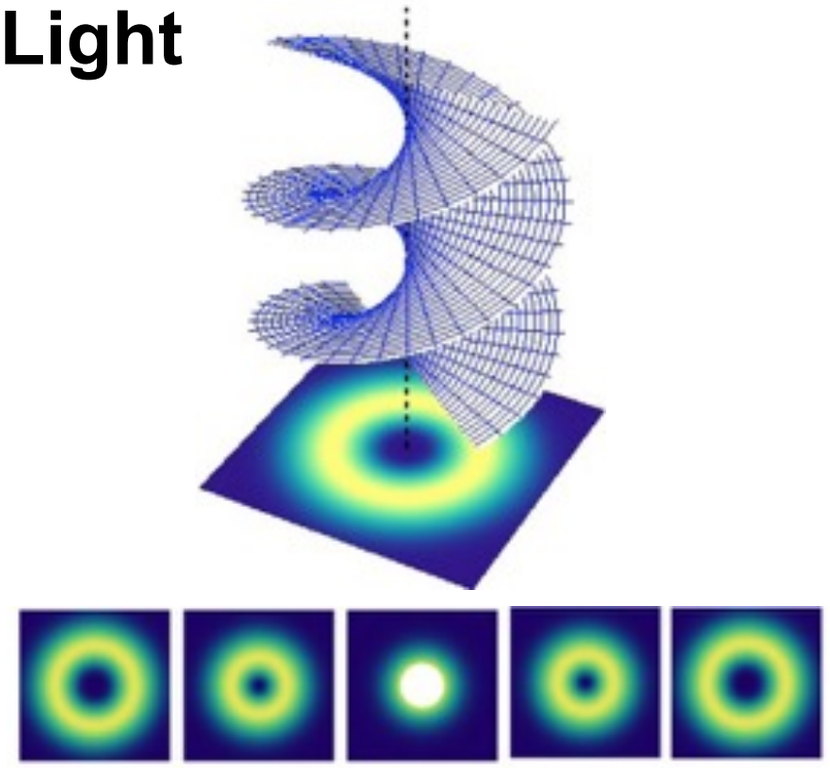




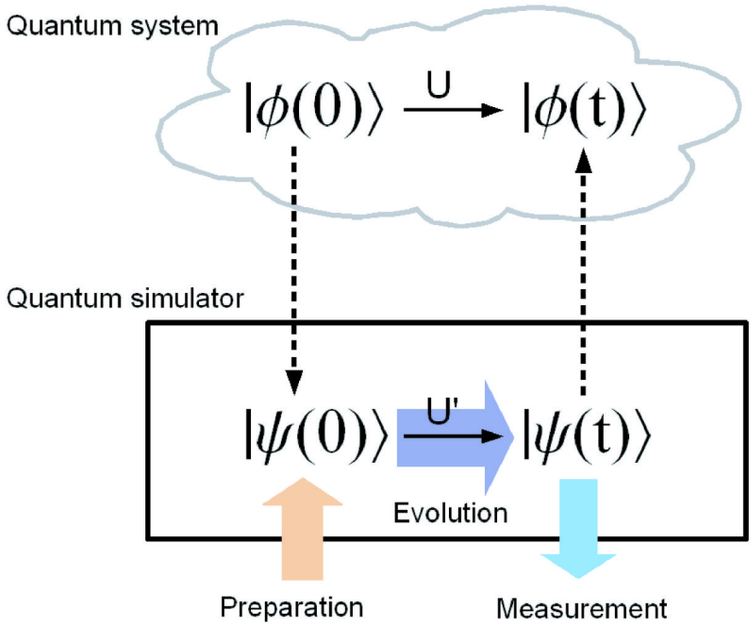
Multi degrees of freedom of light for quantum information processing



Orbital Angular Momentum of Light

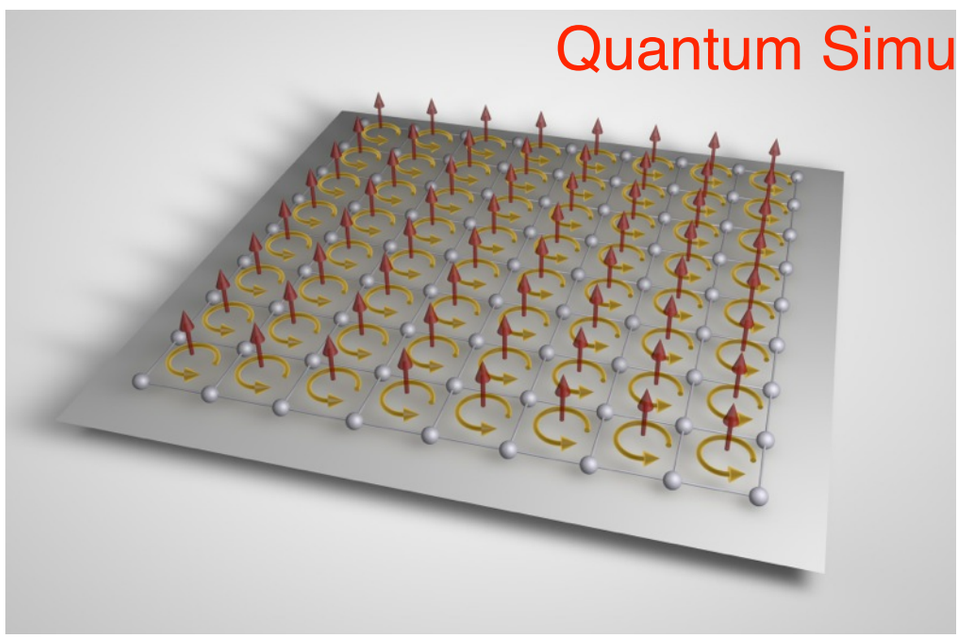


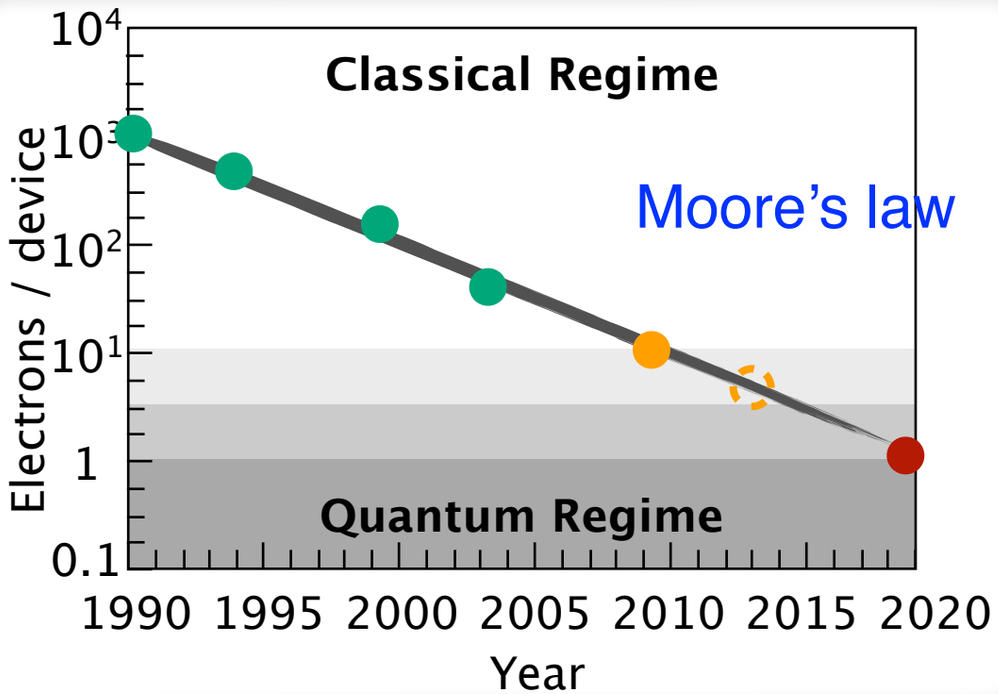
• Quantum Simulations

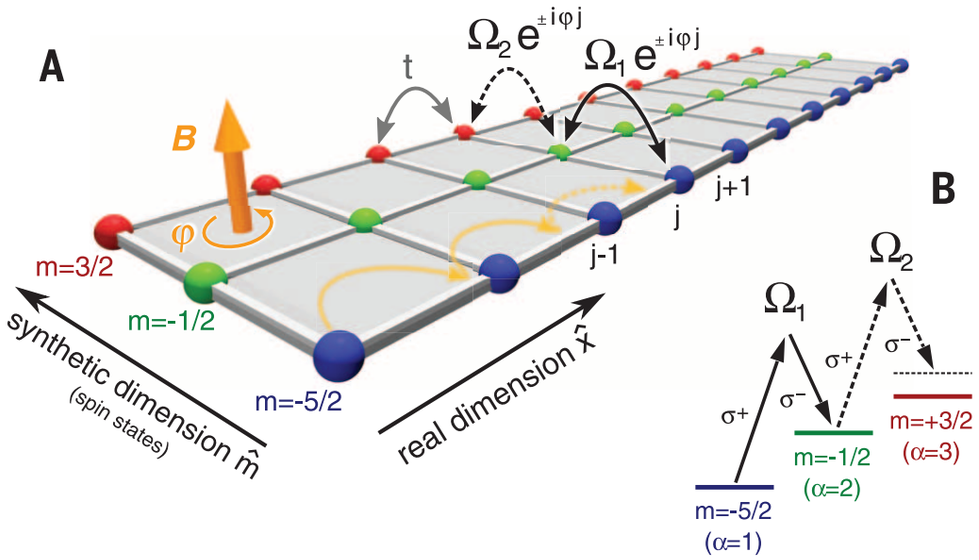


- Lattice Gauge Theories
- Quantum Technologies
- Role of European and Italian collaborations

Quantum Simulator

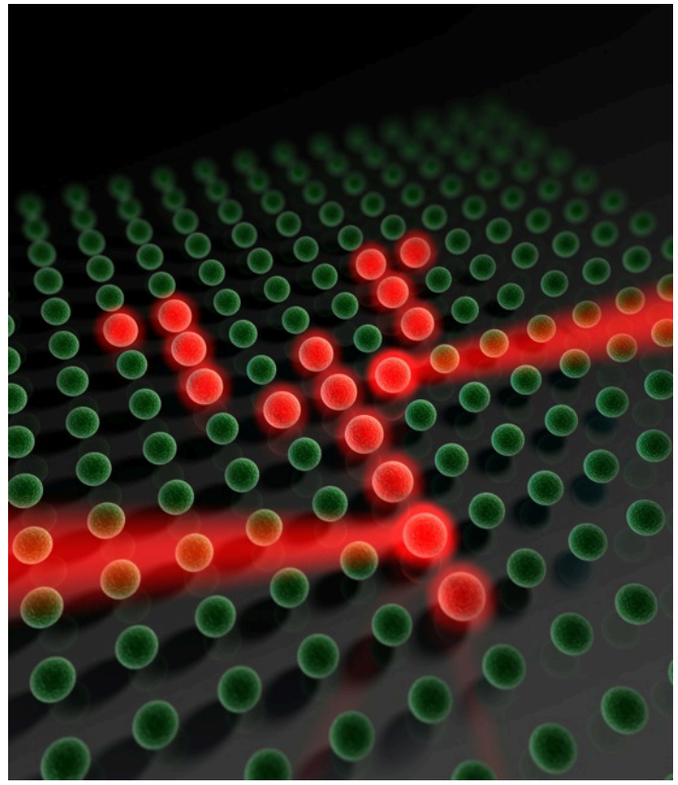


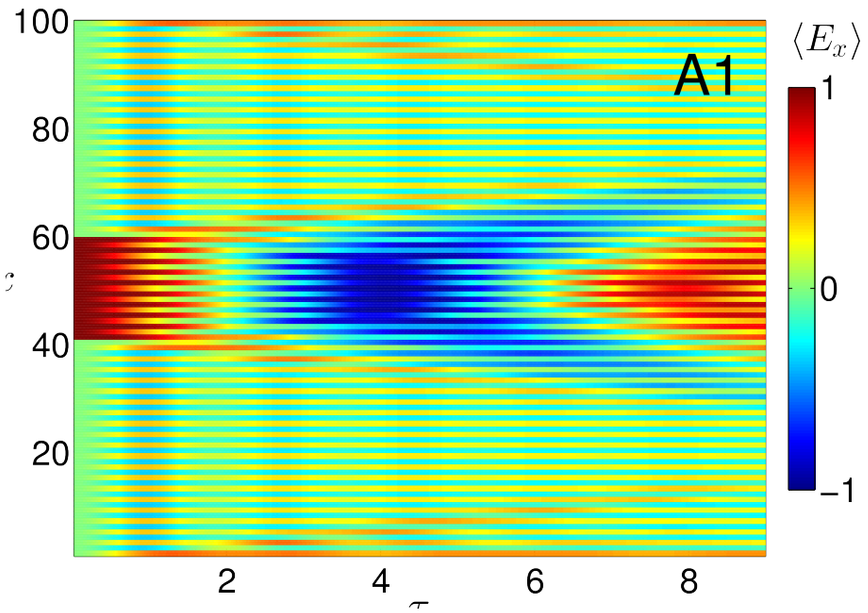




LENS: synthetic gauge field in a synthetic dimension

UNIBO-UNINA:
phase diagram QED (1+1)





UNIV. ULM:
real time dynamics QED (1+1)
string breaking and pair creation