SP1
Quantum Memories
&
Interfaces

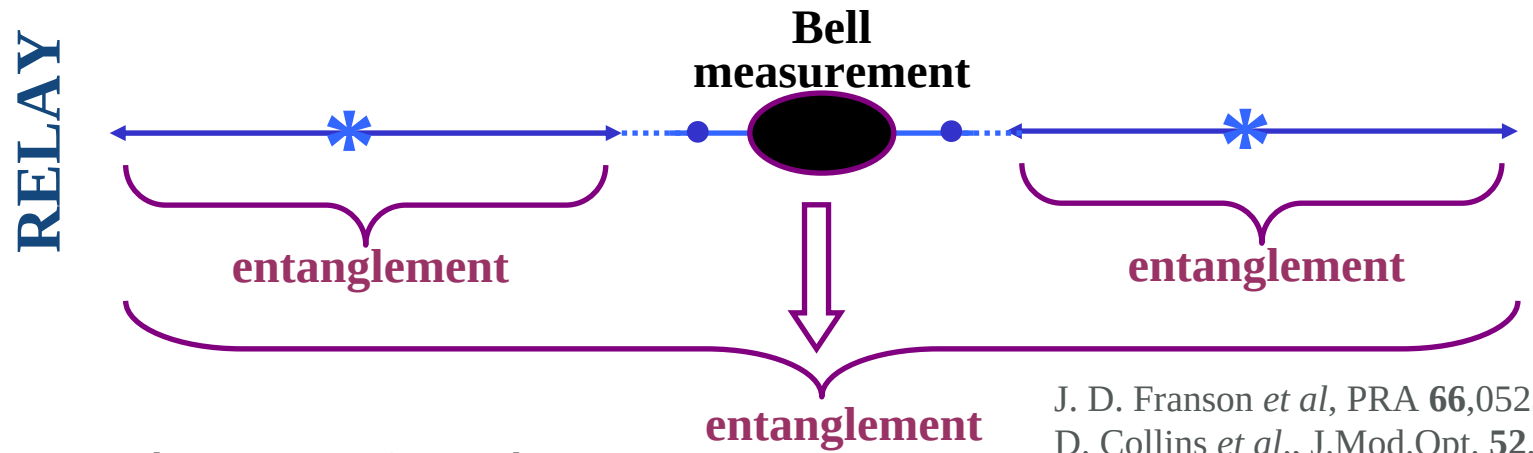
QAP KICK-OFF

Paris 12.02.2006

Quantum Memories & Interfaces

- Quantum communication / networks / processors will depend on quantum memories and interfaces
- Map non-classical photon states onto electronic excitations in atoms and solids, and to store and recall them with high fidelity
- Understanding / characterising interaction between different carriers
- Diverse range of architectures

Q repeaters & relays



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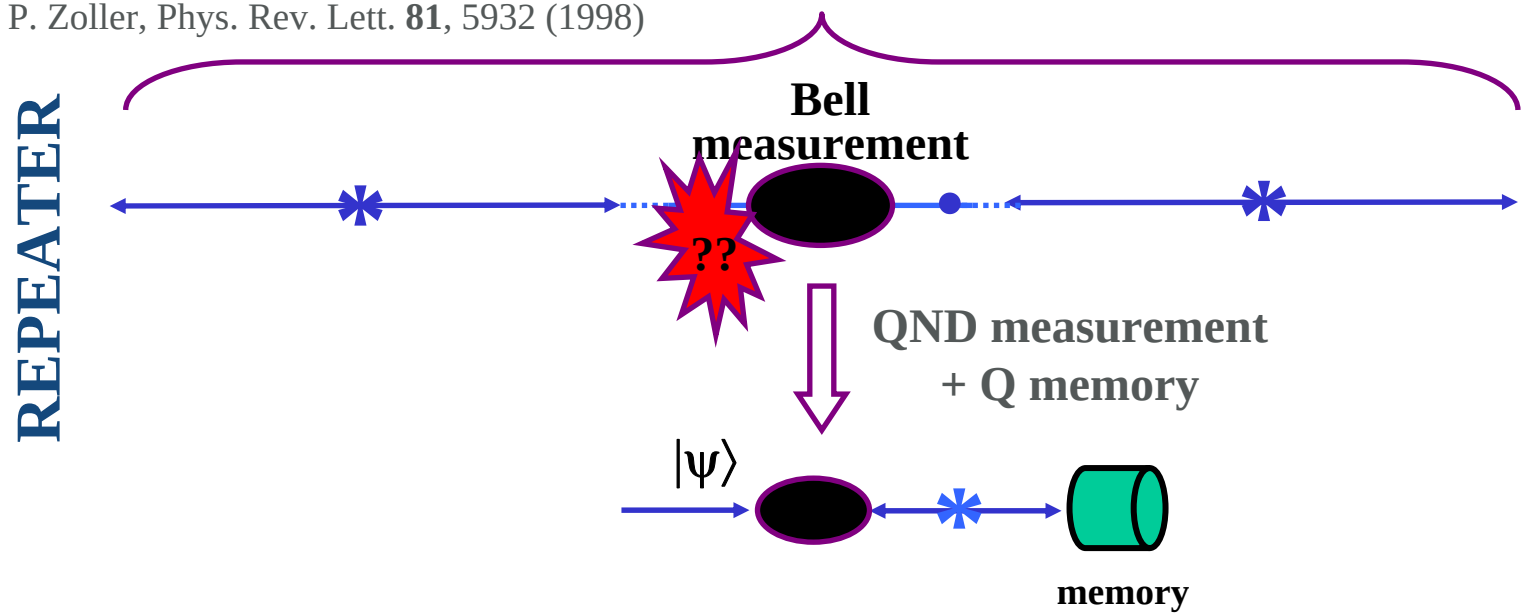
P. Zoller, Phys. Rev. Lett. **81**, 5932 (1998)



Teleportation ⇒ QND measurement

Workpackages

- WP 1.0 Subproject management, UNIGE, Nicolas Gisin
- WP 1.1 **Rare-Earth-Ion Doped Solids**, ULUND, Stefan Kröll
- WP 1.2 **NV Centres**, USTUTT, Jörg Wrachtrup
- WP 1.3 **Semiconductor Nanotechnology**, TREL, Andrew Shields
- WP 1.4 **Single Trapped Atoms**, LMU, Harald Weinfurter
- WP 1.5 **Room-Temperature Atomic Vapour**, NBI, Eugene Polzik
- WP 1.6 **Cold Atoms**, NBI, Eugene Polzik
- WP 1.7 **Comparison**, UNIGE, Nicolas Gisin

Rare-Earth-Ion Doped Solids & NV centres

- Who
  - Lund Inst. Tech.
  - U. Geneva
- Goals
  - Suitability of different rare-earth-ion doped fibres & Crystals
  - Tailor and shift the profile of an inhomogeneously broadened absorption line in a controlled way
- Status
  - Laser stabilisation
  - Characterising lifetimes

- Who
  - U. Stuttgart
- Goals
  - Phase memory time vs purity
  - Observation of EIT in the NV centers
  - Characterise dephasing time of collective spin states
- Status
  - Controlled implantation, 1,2,3 centres

Semiconductor & Nanotechnology Single Trapped Atoms

- Who
  - Toshiba
  - U. Bristol
- Goals
  - Cavity structures for efficient input/output coupling of a photon to a quantum dot.
  - Cavities design & q-values for pillar microcavities & PBG structures
- Status
  - Single photon Q.Dot sources

- Who
  - Ludwig Maximillians U.
  - Gdansk U.
- Goals
  - Atom-Photon entanglement & remote state preparation
  - Evaluation and optimisation via Quantum state tomography.
- Status
  - Photon-Atom entanglement!

Room Temperature Atomic Vapour & Cold Atoms

- Who
  - Copenhagen U.
- Goals
  - Light-to-atoms teleportation
  - Memory for entangled states
  - Long distance atomic entanglement
  - Teleportation of atomic memory
  - Quantum memory readout
- Status
  - Weak coherent pulse storage

- Who
  - Copenhagen U.
- Goals
  - Develop interfaces between light and cold atoms, Cs & Rb.
  - Spin squeezing at the Cs clock transition for improved sensitivity
  - QND measurements of the Cs atoms state at the clock transition
- Status
  - interferometric measurement of the atomic population, sensitivity $\sim N^{1/2}$(atoms)

QIAP

Comparison

- Direction
  - Characterisation
  - Classical pulses
  - Non-classical single photon fields
- Objective
  - Comparison, evaluation and analysis of the different approaches
  - Determine benchmarks
- Status
  - 1st workshop (almost!) organised

SP1-QAP Integration

- Quantum interfaces and memories are the basic ingredient of future large-scale quantum networks (SP2) utilising quantum repeaters (SP3).
- The unified expertise of SPs1-3 will enable the demonstration of the transfer, over large distances, of quantum information between nodes of a quantum network.
- Techniques developed and experience gained in Q. Simulation & Control (SP4) will directly feed into the work done in SP1.
- Close collaboration with Theory (SP5) will enable a thorough analysis and comparison of the different approaches towards quantum state storage.

SP1-QAP

A workable few-qubit quantum memory with reasonably high fidelity

Develop a more profound understanding and new ideas for using light-atom interfaces for applications in QIPC.