Optical Qubits

Li Wang

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Q.C. Criteria

- Scalability: OK
- Initialization to fiducial state: Easy
- Measurement: Problematic
- Long decoherence time: Good
- Single Qubit manipulation: Good
- Conversion to stationary qubit: OK
- Transmitting between locations: Good
- Entangling gates

Optical Qubit

$$|0\rangle \equiv |H\rangle \equiv \begin{pmatrix} 1 \\ 0 \end{pmatrix} \qquad |1\rangle \equiv |V\rangle \equiv \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$

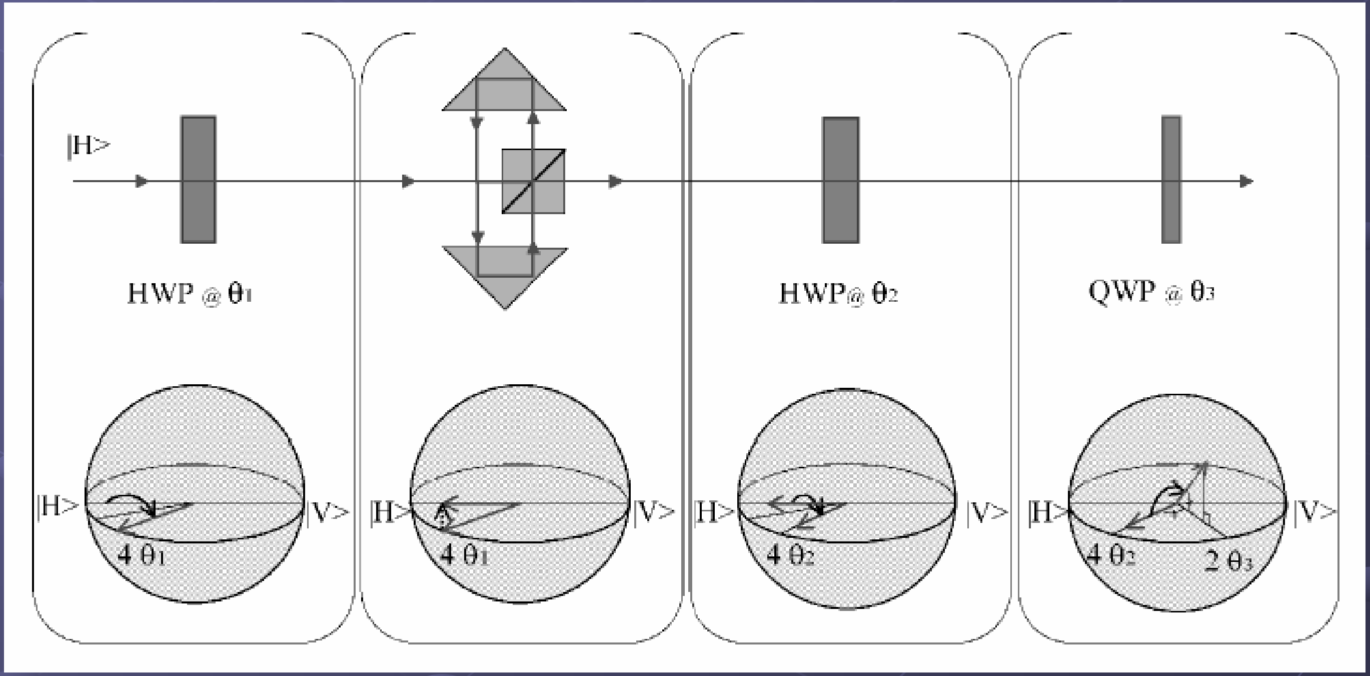
Fiducial state prepare using PBS

State characterization

- Impossible to determine polarization with single measurement (Uncertainty principle)
- Statistical measurements using many photons
- Most measurements depend on coincidence detection – many photons are discarded

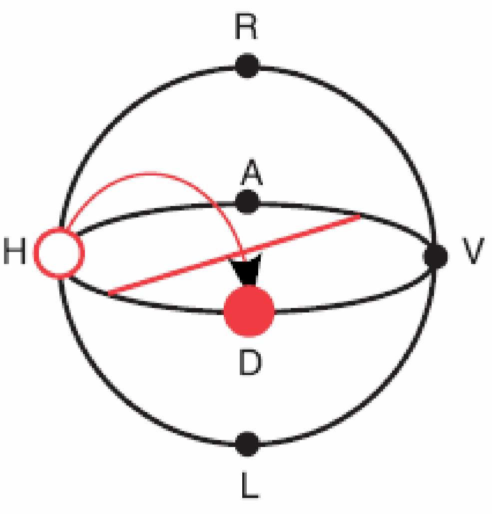
State preparation

- Using optical elements like HWP and QWP to prepare a specific state
- Fidelity > 99.7%



State preparation

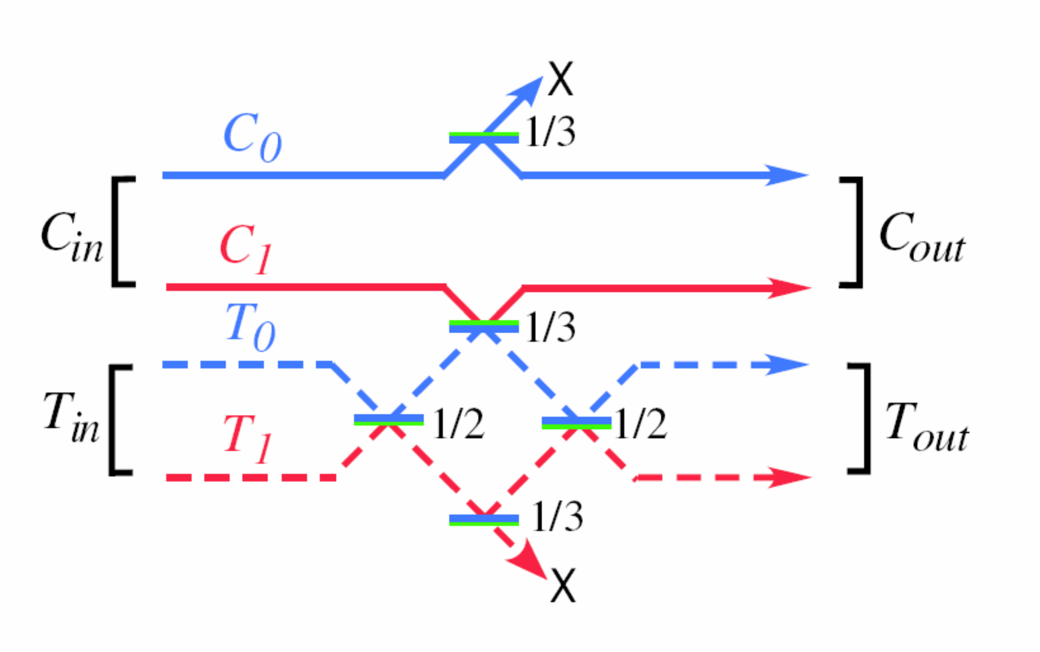
- Example: Hadamard gate
- HWP set to 22.5^{o} of the polarization



$$\begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}$$

Optical CNOT gate

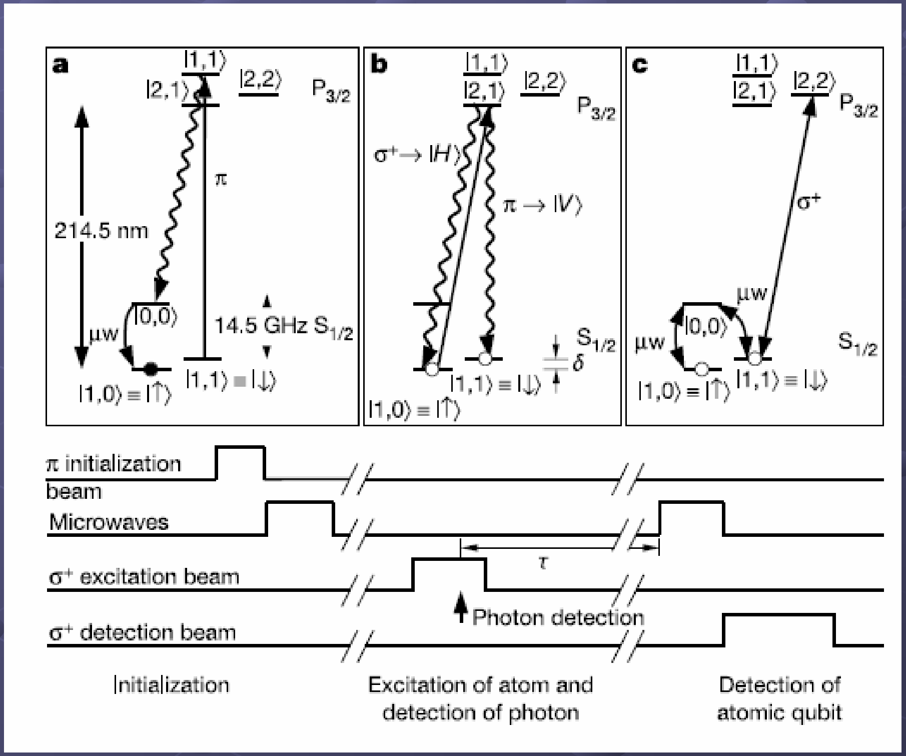
- Optical interference from different pathways (O'Brien 2003 *Nature*)
- Ability to produced entangled states (Bell states)



Photon in C1 causes Pi phase shift in upper arm of interferometer.

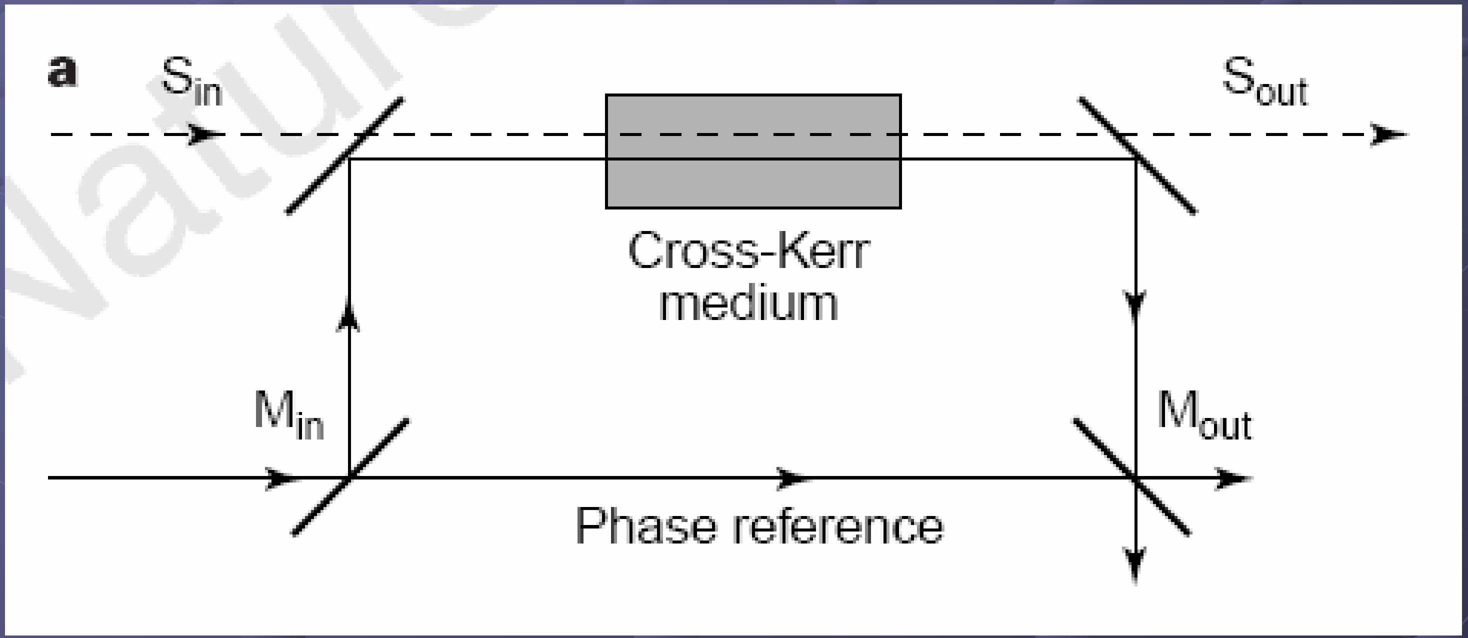
Conversion to stationary qubit

- Shown using trapped Cadmium ions (Blinov 2004 *Nature*)



Non-demolition measurements

- Building long distance quantum networks: Quantum repeaters
- Entanglement between photon number *n* and phase



Refractive index of the Kerr crystal is changed by intensity of the Signal beam, thus altering the phase of the Meter beam