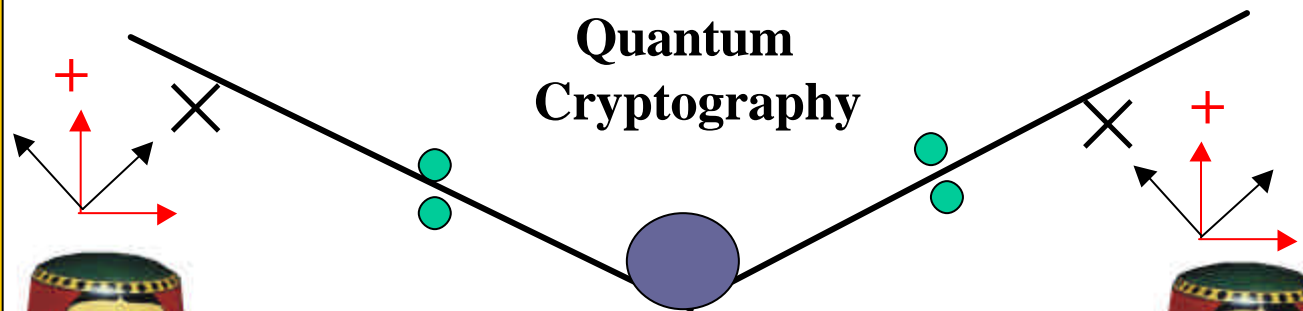


Alice

Multi-Photon Quantum Cryptography

Bob



If multiple photon-pairs are created by stimulated emission no errors are introduced due to the nested singlet structure.

$N_H \ N_V \ \Sigma$

~~$\times 1,0 \ 1$~~

~~$\times 0,2 \ 2$~~

~~$+ 2,1 \ 3$~~

$\times 1,1 \ 2$

$+ 0,3 \ 3$

$\times 0,1 \ 1$

~~$\times 2,2 \ 4$~~

~~$+ 1,2 \ 3$~~

$+ 0,1 \ 1$



Singlet

Singlet



Singlet



Singlet



$N_H \ N_V \ \Sigma$

~~$\times 0,1 \ 1$~~

~~$+ 1,1 \ 2$~~

~~$\times 1,2 \ 3$~~

$+ 1,1 \ 2$

$+ 3,0 \ 3$

$\times 1,0 \ 1$

~~$+ 0,4 \ 4$~~

~~$\times 1,2 \ 3$~~

$+ 1,0 \ 1$

Phys. Rev. Lett. **88**, 187902 (2002)

G. Durkin, C. Simon, D.B.

Quantum Cloning

NO!! Wootters & Zurek

$$|0\rangle|Y\rangle \rightarrow |0\rangle|0\rangle$$

$$|1\rangle|Y\rangle \rightarrow |1\rangle|1\rangle$$

$$(a|0\rangle + b|1\rangle)|Y\rangle \rightarrow a|0\rangle|0\rangle + b|1\rangle|1\rangle$$

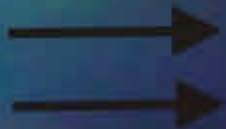
$$\not\rightarrow (a|0\rangle + b|1\rangle)^2$$

BUT!! Buzek & Hillery ('96)

Fidelity 5/6

Stimulated emission

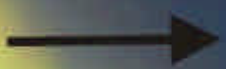
$$|1,0\rangle_{\text{in}}$$



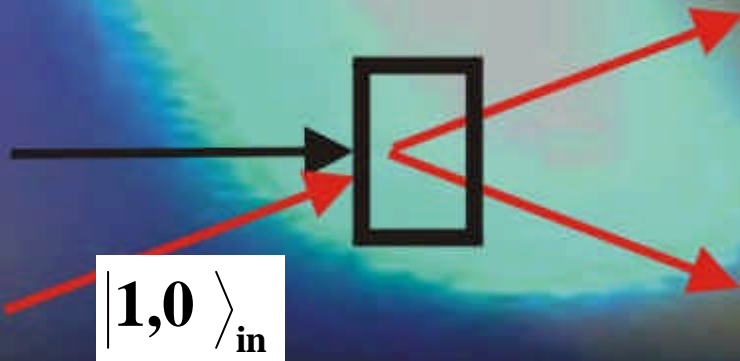
$$a_H^+ |1,0\rangle_{\text{in}} = \sqrt{2} |2,0\rangle$$

Spontaneous emission

$$|1,0\rangle_{\text{in}}$$



$$a_V^+ |1,0\rangle_{\text{in}} = |1,1\rangle$$

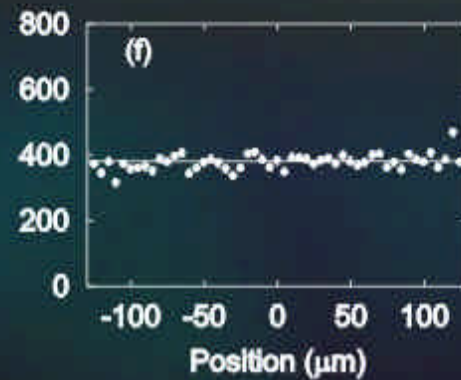
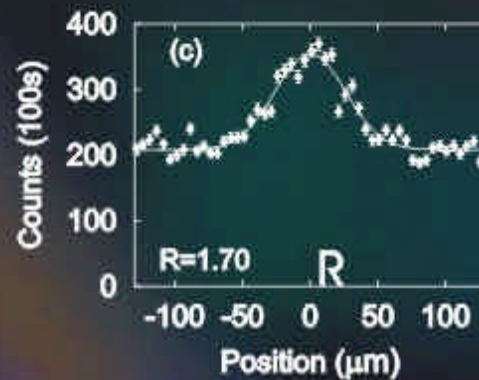
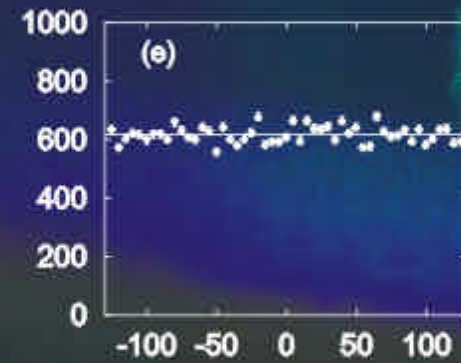
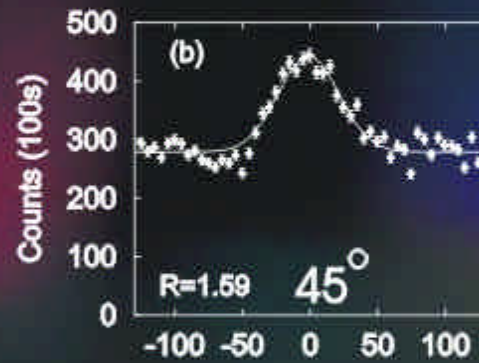
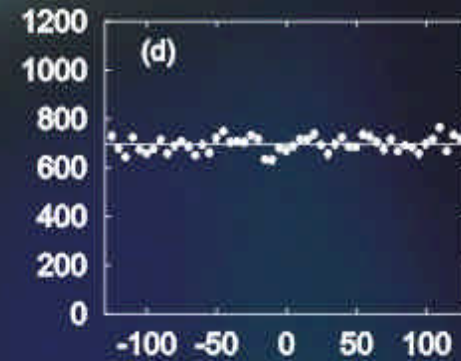
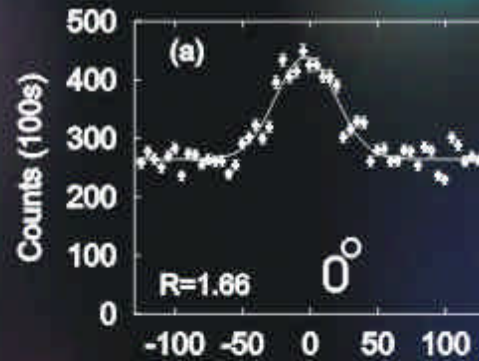


$$\frac{1}{\sqrt{2}} (a_H^+ b_V^+ - a_V^+ b_H^+) |1,0\rangle$$

Theory
 $F=0.833$

Experiment
 $F=0.81 \pm 0.01$

Science, May 2002,
A.Lamas-Linares, J.C. Howell,
C. Simon, D.B.



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Antia Lamas
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Gabriel Durkin
Ireland



Andrey Bychkov
Russia



Simon Anders
Germany



William Irvine
Italy + UK



George Khoury
USA