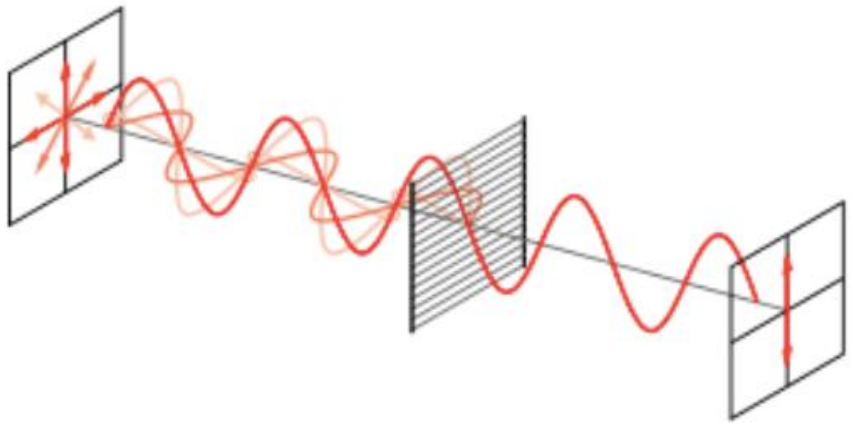
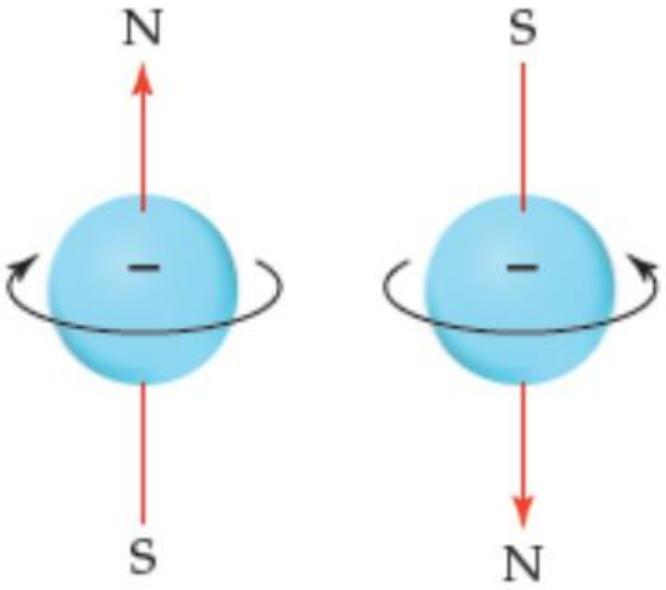
Fotónica cuántica integrada


Generar
Manipular
Detectar

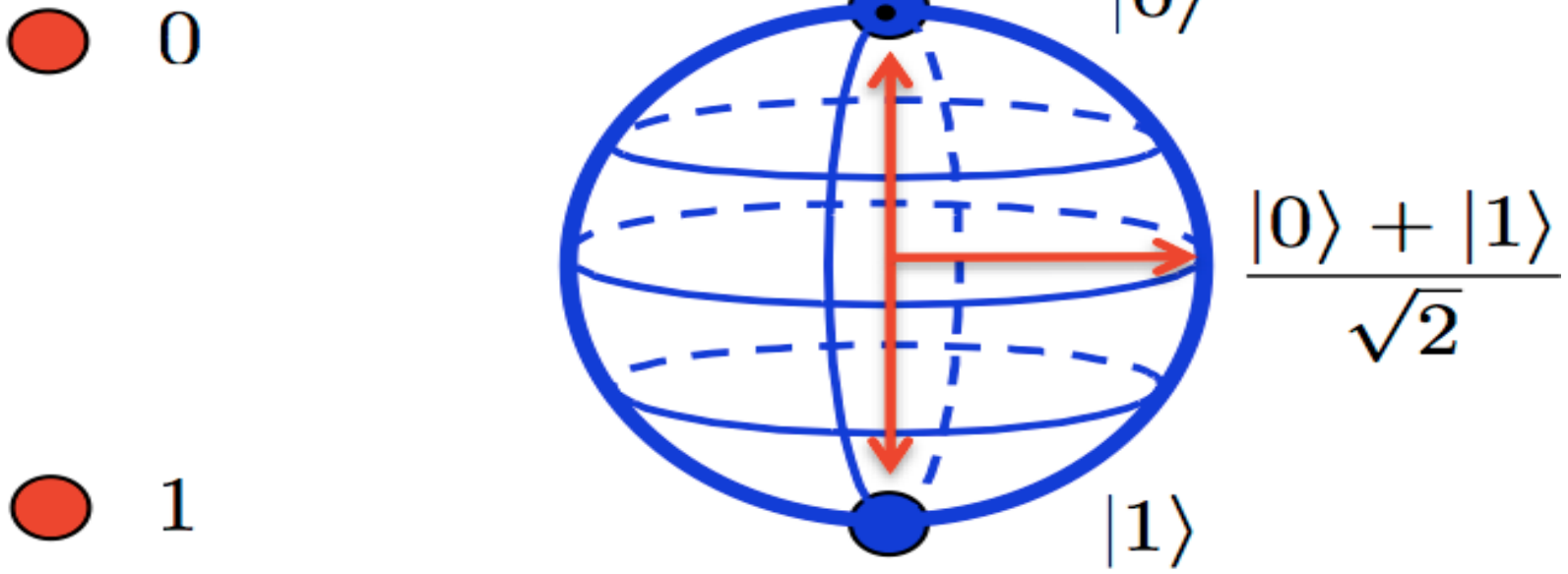
Qubit





$$|\psi\rangle = \alpha|0\rangle + \beta|1\rangle$$

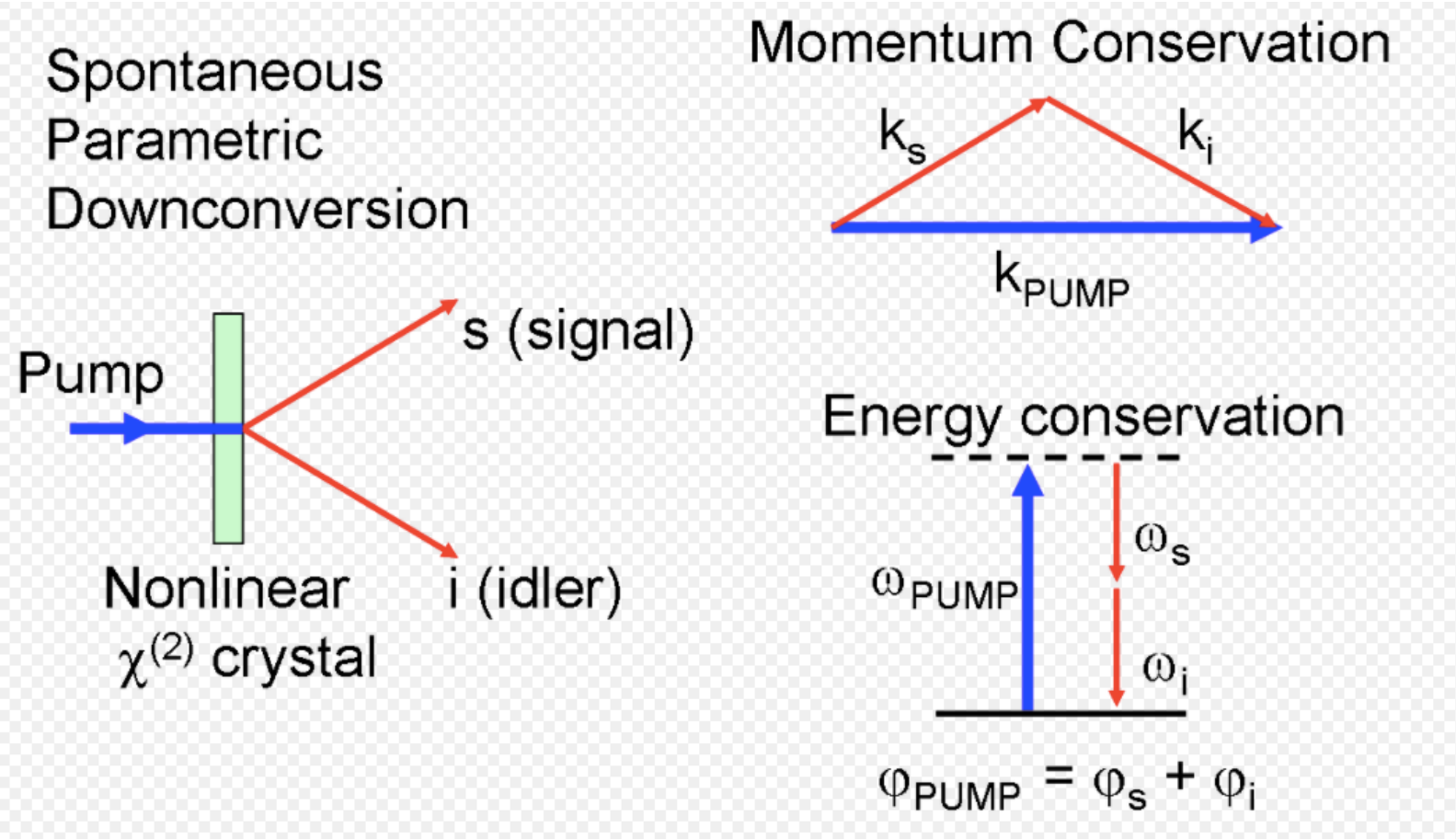
$$|\alpha|^2 + |\beta|^2 = 1$$



Classical Bit **Qubit**

$$|\psi\rangle = \cos\left(\frac{\theta}{2}\right)|0\rangle + e^{i\phi}\sin\left(\frac{\theta}{2}\right)|1\rangle$$

Generar


Spontaneous
Parametric
Downconversion
Pump
s (signal)
i (idler)
Nonlinear
$\chi^{(2)}$ crystal
Momentum Conservation
k_s
k_i
k_{PUMP}
Energy conservation
ω_{PUMP}
ω_s
ω_i
$\varphi_{PUMP} = \varphi_s + \varphi_i$

Entrelazamiento cuántico

Electrónica

Puerta lógica

NOT

INPUT	OUTPUT
A	NOT A
0	1
1	0

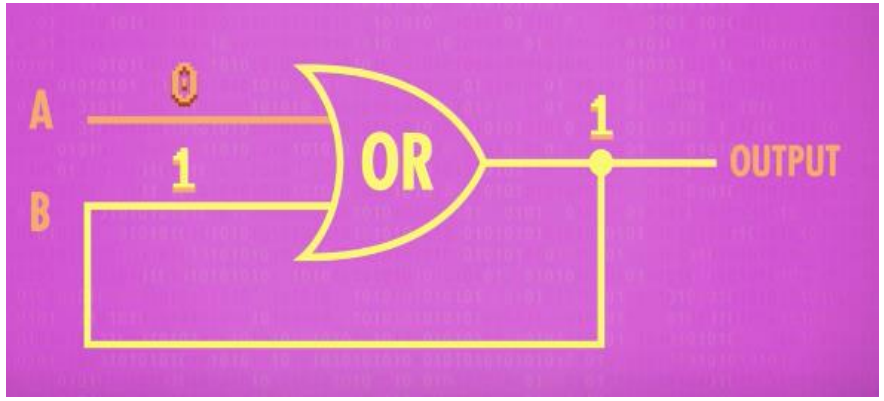
AND

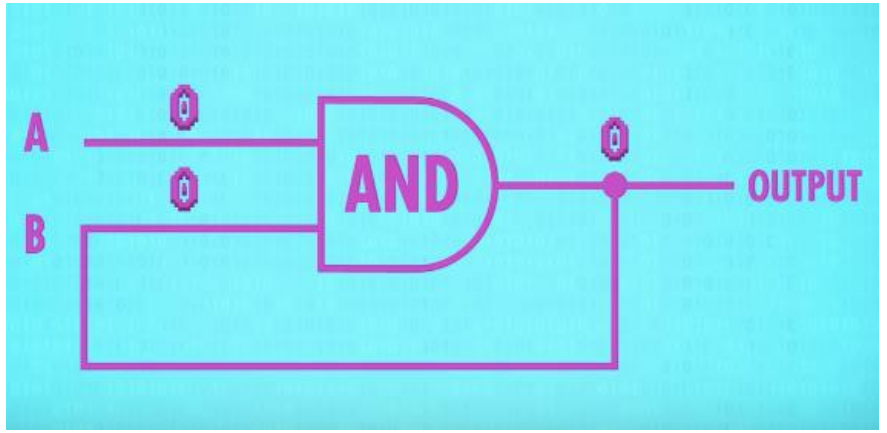
INPUT		OUTPUT
A	B	A AND B
0	0	0
0	1	0
1	0	0
1	1	1

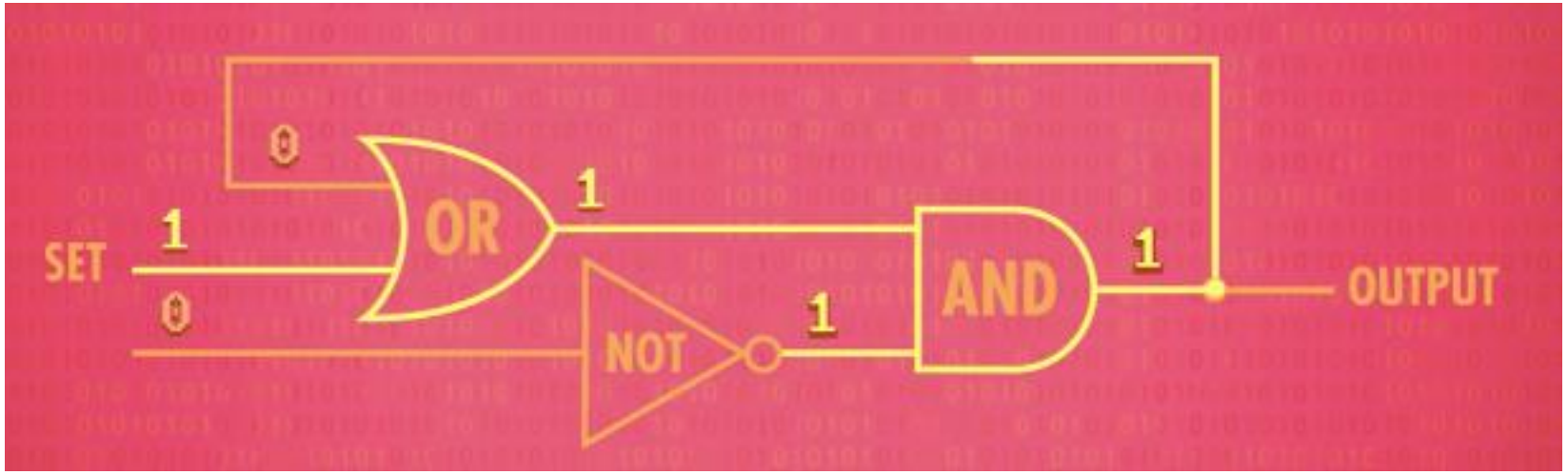
XOR

INPUT		OUTPUT
A	B	A XOR B
0	0	0
0	1	1
1	0	1
1	1	0

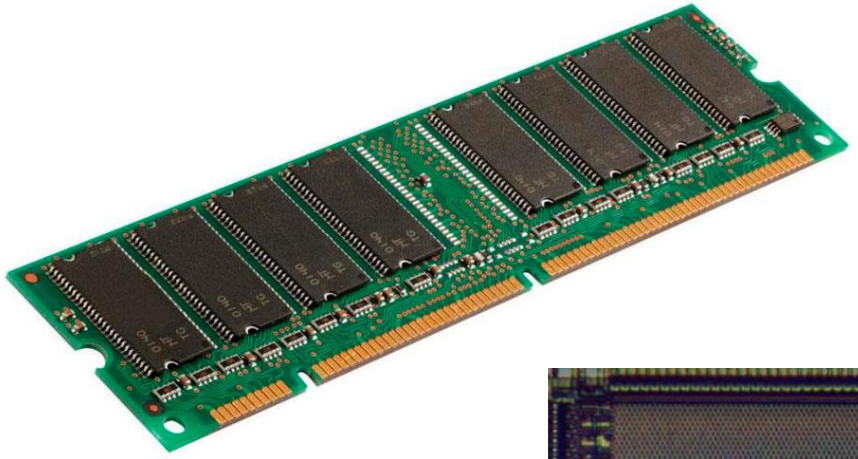
Electrónica

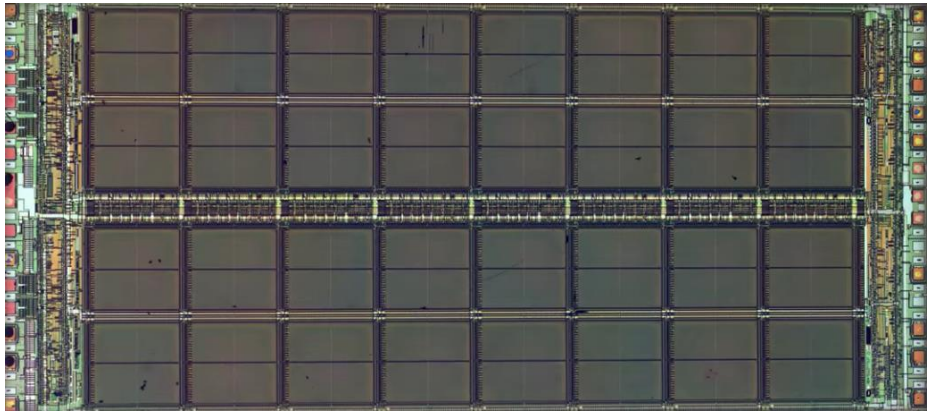


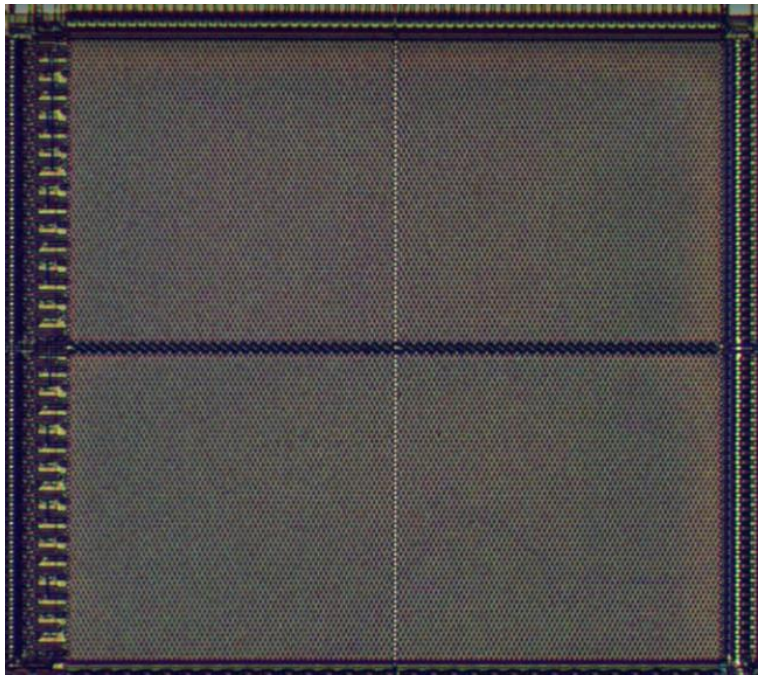




Almacenamiento Bit







Fotónica cuántica integrada

Hardware

1. Fuentes de qubits (fotones)
2. Circuitos fotónicos
3. Compuertas lógicas
4. Memoria
5. Dispositivos de lectura

Compuerta lógica cuántica

- Manera de manipular información cuántica
- Bloques fundamentales en los circuitos cuánticos
- Compuertas lógicas cuánticas son representadas por matrices unitarias

NOT Gate

cNOT Gate

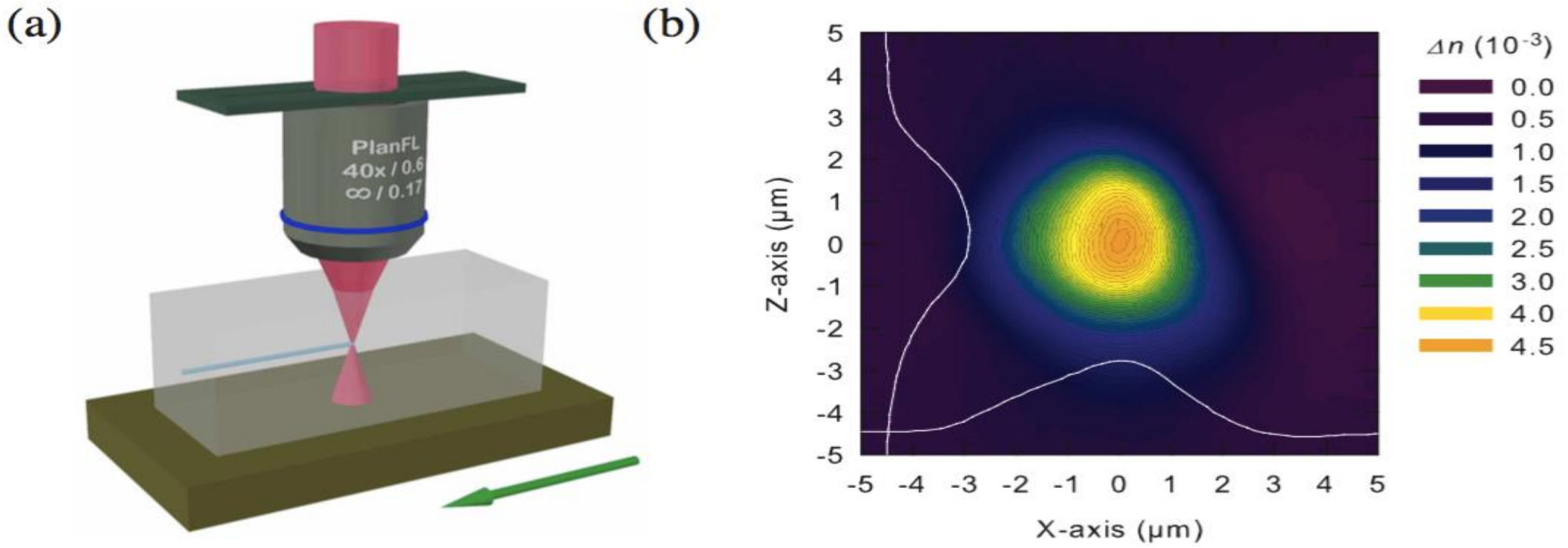
Almacenamiento Información

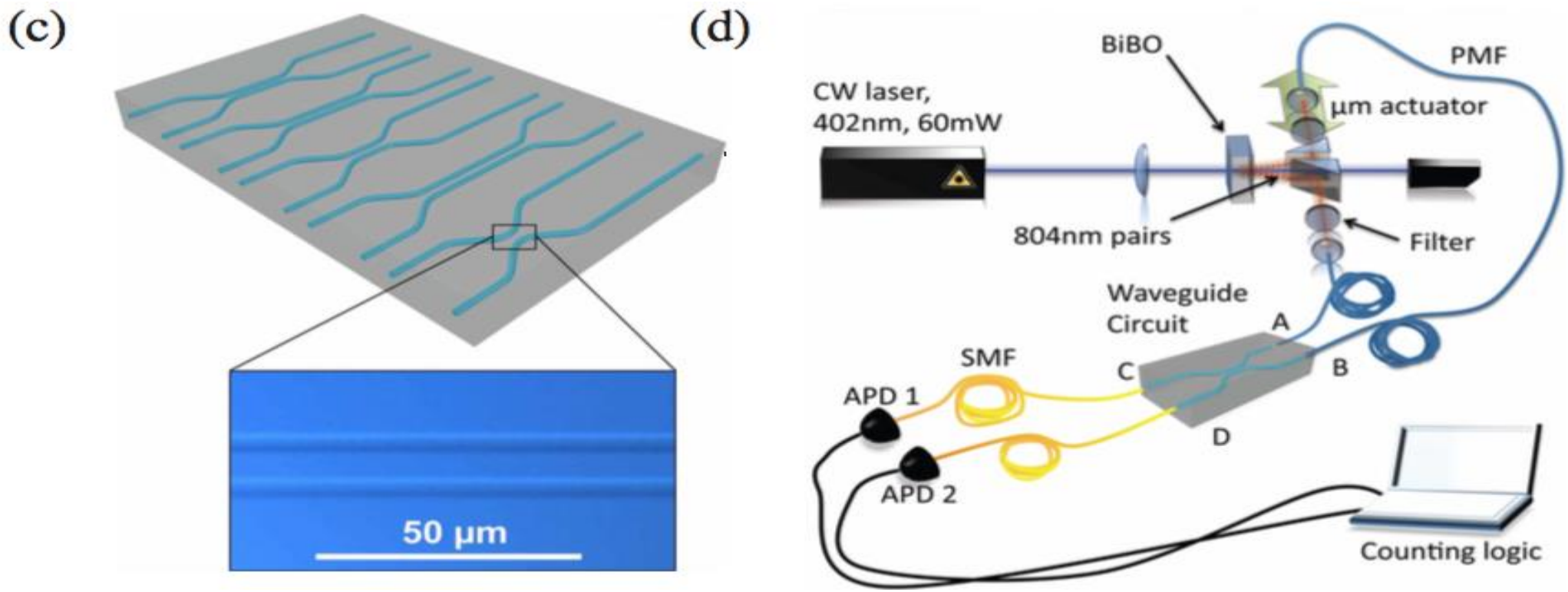
- “Solid state quantum memory using the 31P nuclear spin”
- Spin electrón
- Interface entre luz y materia
- Guardar y recuperar
- Se debe mantener superposición

Circuitos

“Laser written waveguide photonic quantum circuits”

- Chips de Silice de alta pureza





Fotones recibidos en el chip mediante SMF (Single Mode Fibers)

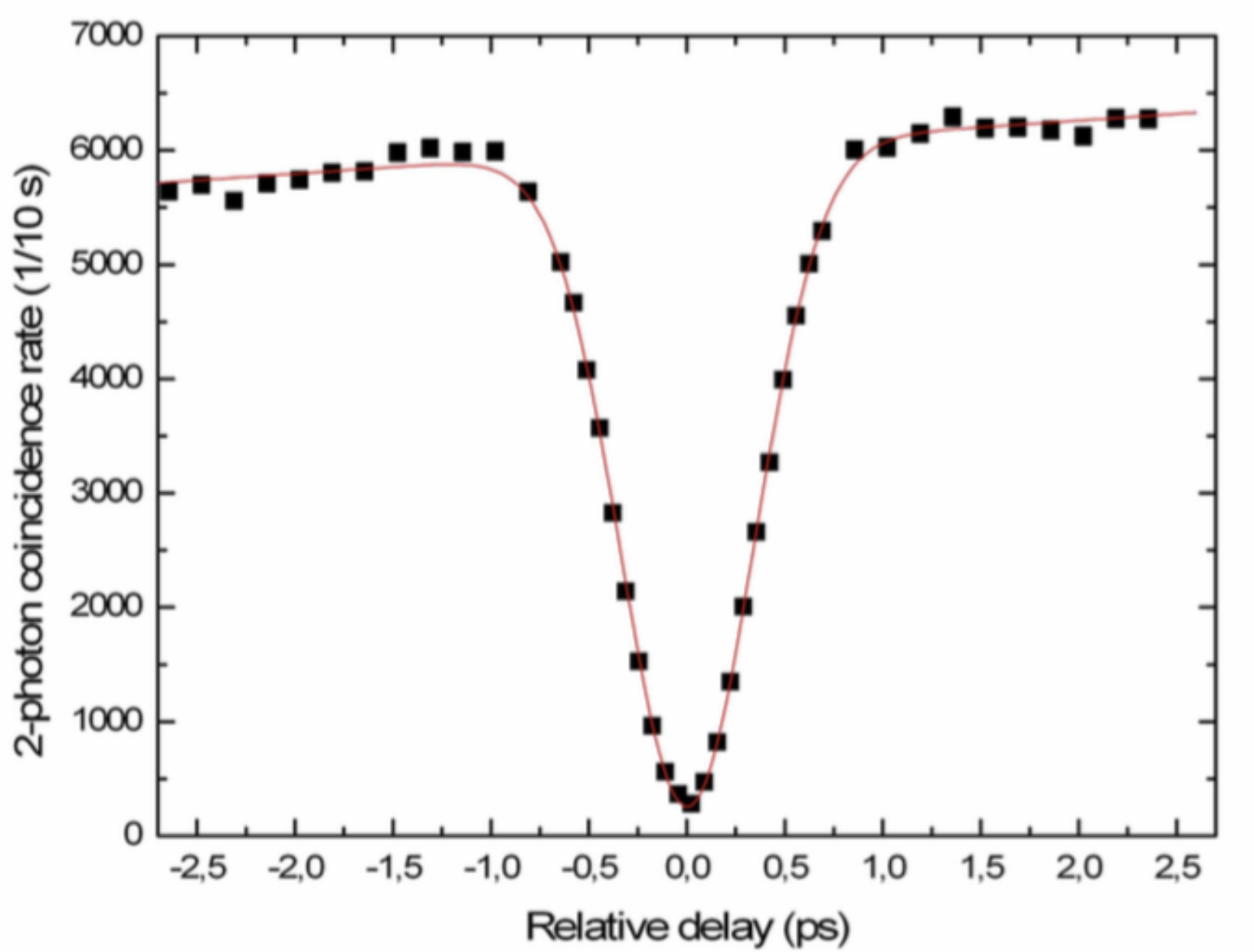
Acople a Fotodiodo de avalancha

Observaciones

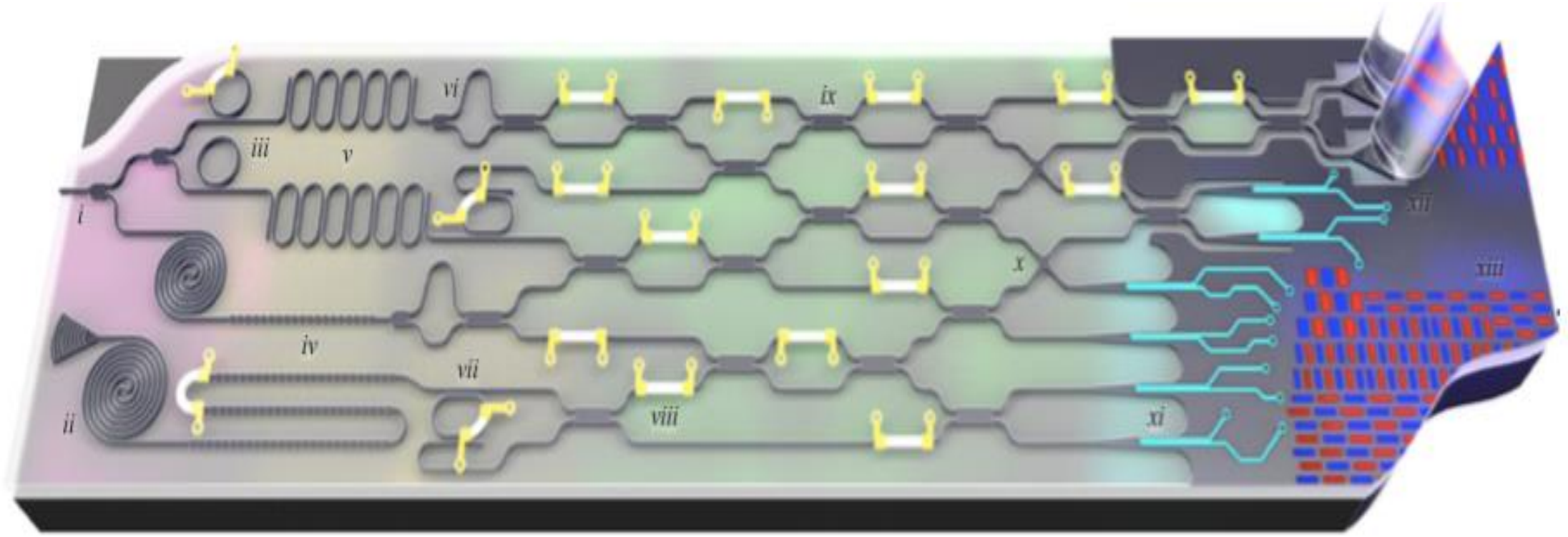
- Transmisión de eficiencia del 50% (2 Fotones distinguibles)

  Tiempo
- Fotones degenerados (No hay detección simultanea)

$$|11\rangle_{AB} \rightarrow \frac{|20\rangle_{CD} - |02\rangle_{CD}}{\sqrt{2}}$$


7000
6000
5000
4000
3000
2000
1000
0
2-photon coincidence rate (1/10 s)
-2,5
-2,0
-1,5
-1,0
-0,5
0,0
0,5
1,0
1,5
2,0
2,5
Relative delay (ps)

¿Futuro?



Referencias

- Graham D. Marshall,1,†,⋆ Alberto Politi,2,⋆ Jonathan C. F. Matthews, July 20, 2009, “Laser written waveguide photonic quantum circuit”, Vol. 17, No. 15 / OPTICS EXPRESS 12546
- Jeremy L. O’Brien,1 Akira Furusawa , “Photonic quantum technologies”, March 23, 2010
- Joshua W. Silverstone, Damien Bonneau, Jeremy L. O’Brien, and Mark G. Thompson, “Silicon Quantum Photonics”, NOVEMBER/DECEMBER 2016 , IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS, VOL. 22, NO. 6