

Title: 13/14 PSI - Explorations in Quantum Information - Lecture 1

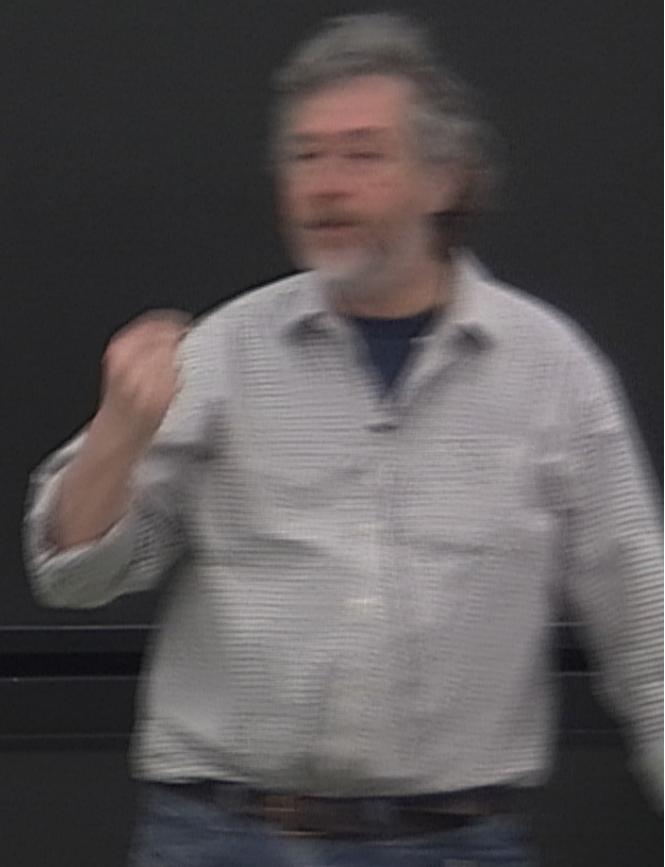
Date: Mar 17, 2014 09:00 AM

URL: <http://pirsa.org/14030029>

Abstract:

## Quantum Devices

- sensors (magnetic, charge)
- actuator



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- sensors (magnetic, charge)
- actuator (transport, cooling)
- simulators

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- sensors (magnetic, charge)
- actuator (transport, cooling)
- simulators
- communication (QKD)
- processor (100 qubits)

dcory@uw

## Devices

(magnetic, charge)  
(transport, cooling)

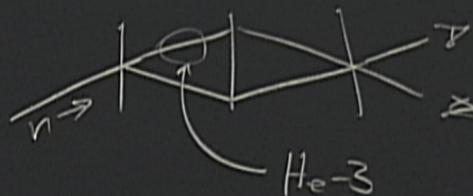
tion (QKD)  
(coherence)

### • Neutron Interferometry



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• Neutron Interferometry



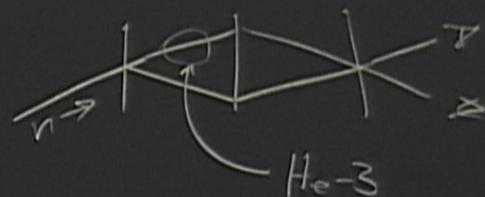
$\text{He-3}$

• Magnetic Resonance  
tensor product

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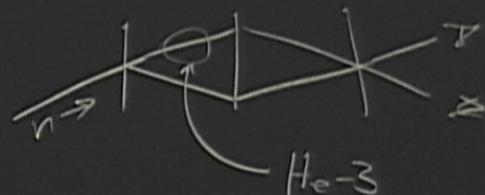
### • Magnetic Resonance tensor product

### • Nitrogen Vacancy in diamond optics

## Quantum Devices

- sensors (magnetic, charge)
- actuator (transport, cooling)
- simulators →
- communication (QKD)
- processor (100 qubits)

### • Neutron Interferometry



### • Magnetic Resonance

$\uparrow \downarrow$  tensor product

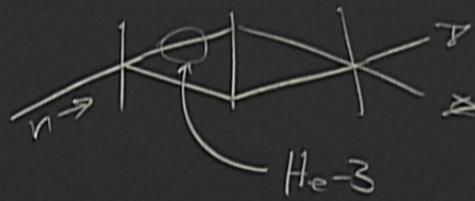
### • Nitrogen Vacancy in diamond

$\uparrow \downarrow$  optics

### $\text{O}^+$ Superconducting

charge)  
cooling)

• Newton Interferometry



• Magnetic Resonance

$\uparrow B_0$  tensor product

• Nitrogen Vacancy in diamond

$\downarrow$  optics

• Superconducting

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1957

de Gennes

$$\alpha H = \sum_{ij} -\frac{a}{r_{ij}^3} (3\cos^2\theta_{ij}) \underbrace{(\sigma_+^i \sigma_-^j + \sigma_-^i \sigma_+^j)}_{\text{flip-flop}}$$

$$\partial H = \sum_{ij} \frac{a}{r_{ij}^3} (3\cos^2\theta_{ij}) (\underbrace{\sigma_+^i \sigma_-^j + \sigma_-^i \sigma_+^j}_{\text{flip-flop}})$$

$t_c = 6\mu s$

$T_1 \sim \text{hrs}$

Phase coherence, 100s

spin transport

# 10 Superconducting

$$\frac{D_{2\text{ spin}}}{D_{1\text{ spin}}} = 1 = 2 = 4 = 8 \\ \exp > 12$$

quantum system  
 $\frac{100 \text{ qubit}}{\rho_{in} \underline{\mathcal{H}'}}$

$$\frac{D_{z\text{ spin}}}{D_{x\text{ spin}}} = 1 = 2 = 4 = 8$$

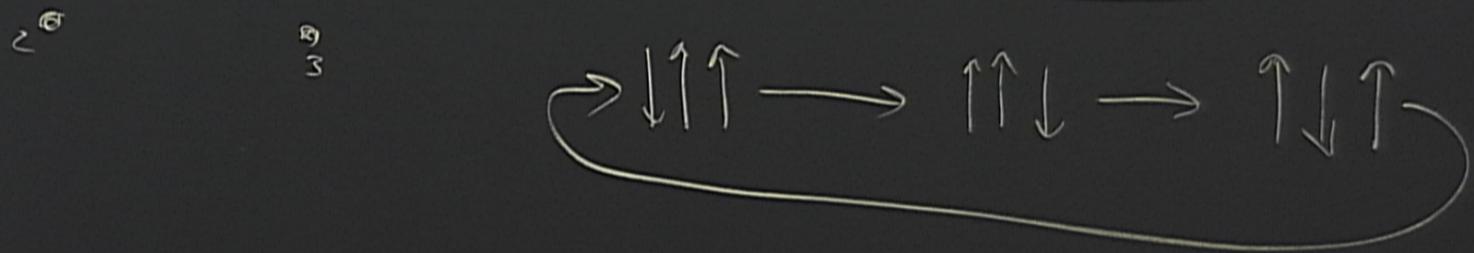
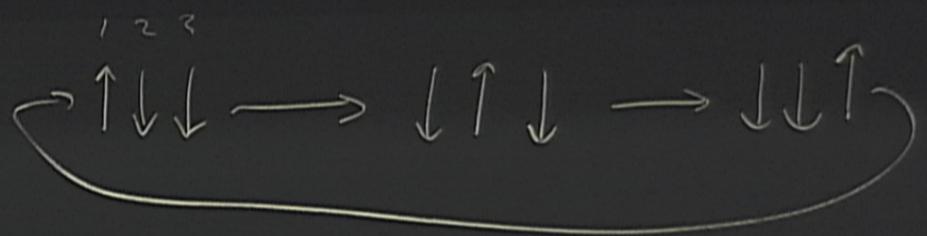
$$\exp > 12$$

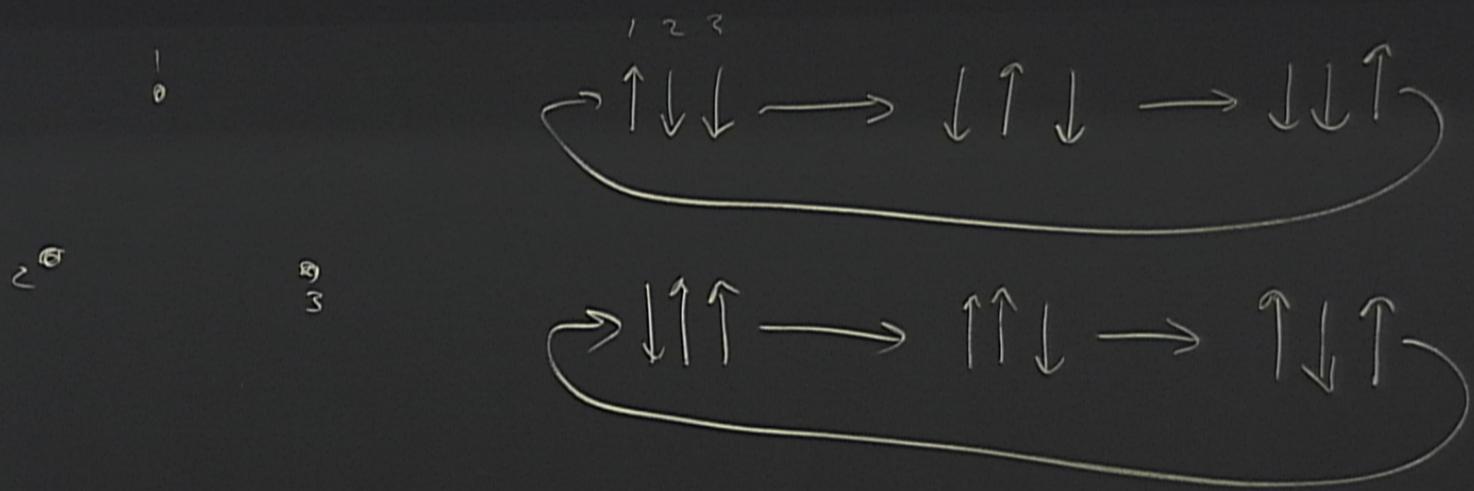
## 10 Superconducting

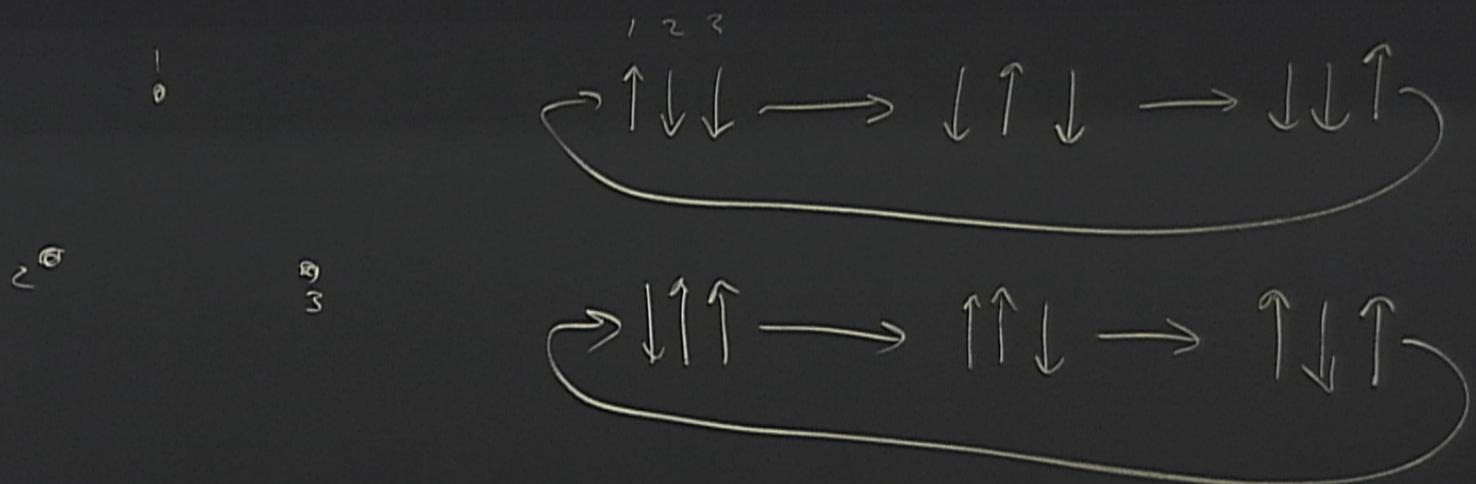
quantum system

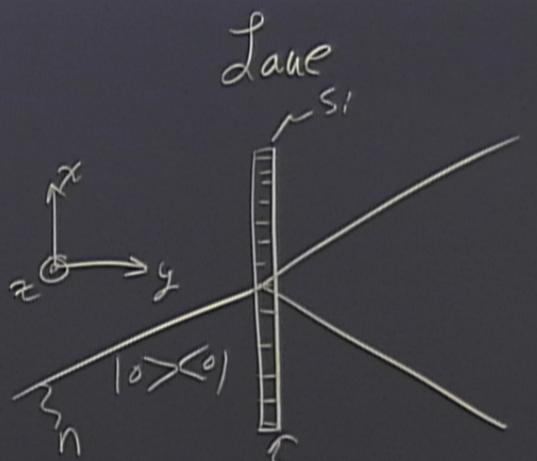
100 sub<sup>+</sup>

$$E_m = \frac{\hbar t}{\rho_{\text{out}}} \int_{\text{out}} \frac{\Omega_{\text{max}}}{\Omega} \langle \Omega \rangle$$



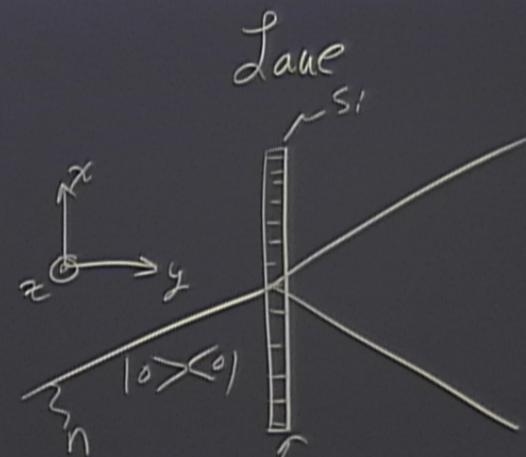






$$|0\rangle; k_x > 0 \quad U_b = \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & -1 \\ 1 & 1 \end{pmatrix}$$
$$|1\rangle; k_x < 0$$

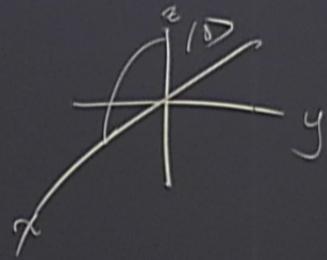
$$U_4 = e^{i\pi \frac{(\sigma_x + i\sigma_z)}{2\sqrt{2}}}$$



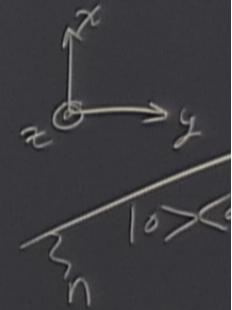
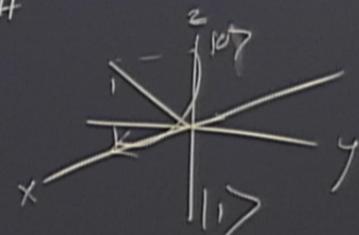
$$|0>; k_x > 0 \quad U_b = \frac{1}{\sqrt{2}} \begin{pmatrix} 1 & -1 \\ 1 & 1 \end{pmatrix}$$

$$|1>; k_x < 0$$

$$\mathcal{U}_{\text{blade}} = e^{-i \frac{\pi}{c} \frac{\sigma_y}{2}}$$



$$\mathcal{U}_4 = e^{i \frac{\pi}{c} \left( \frac{\sigma_x + \sigma_z}{2\sqrt{2}} \right)}$$

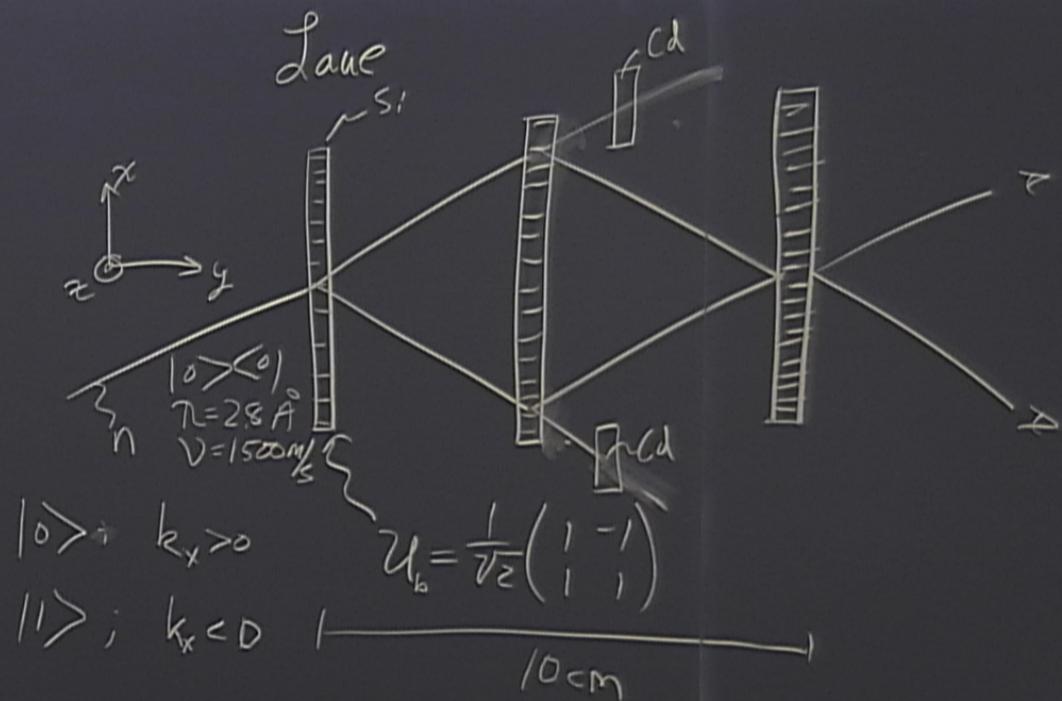


$$|0\rangle; k_x > 0$$

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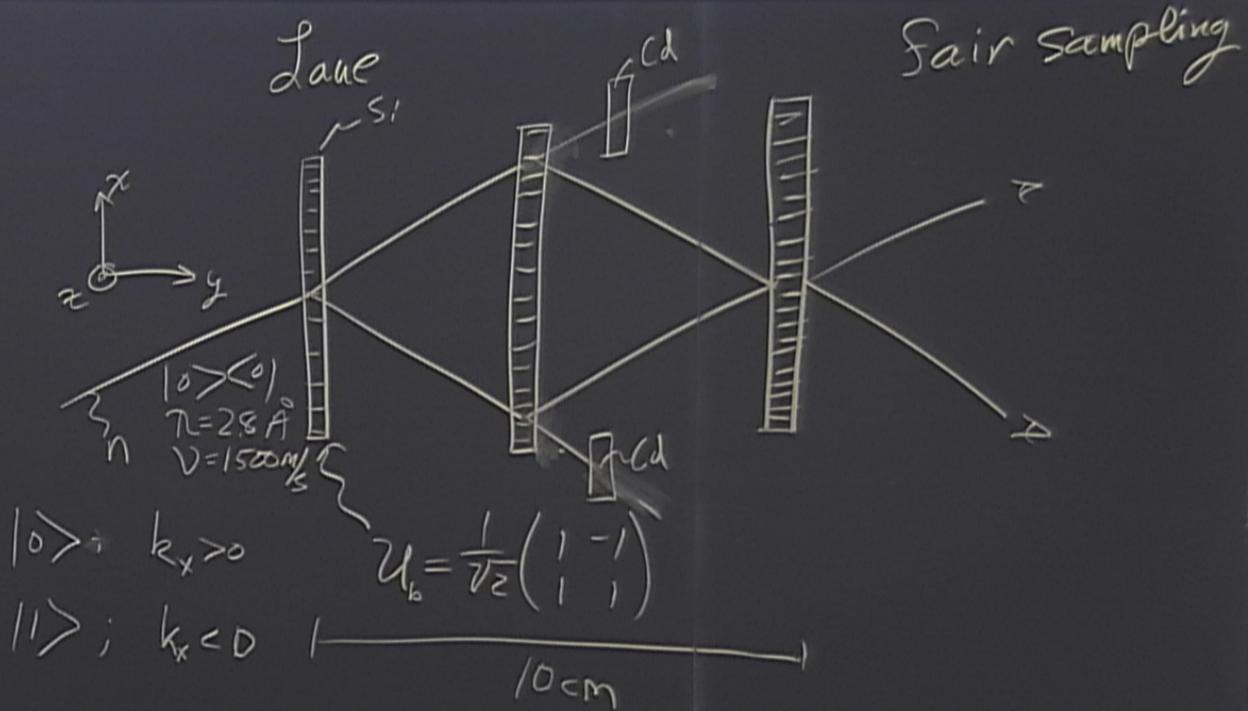
angle

$$U_H = e^{i\pi \frac{(O_x + O_z)}{2\sqrt{2}}}$$



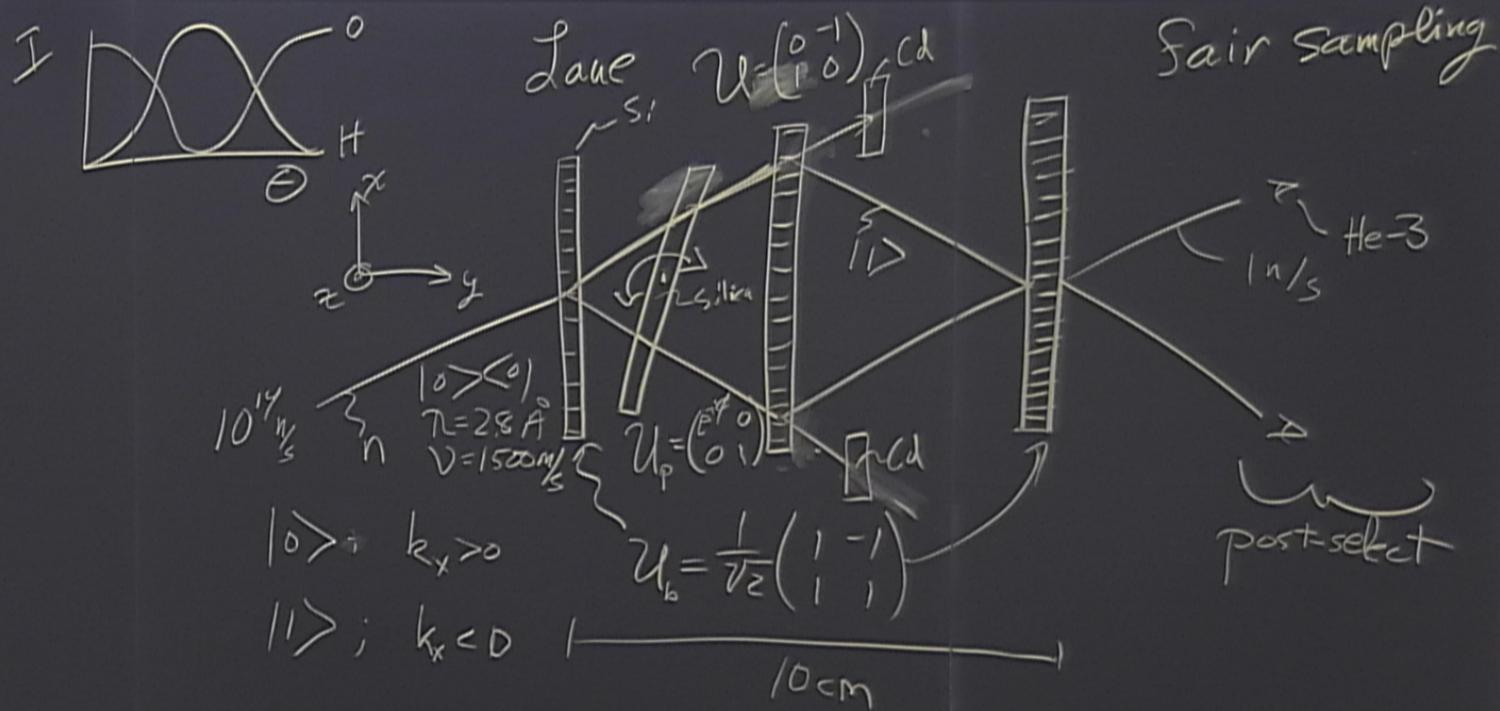
angle

$$U_4 = e^{i\pi \frac{(S_x + S_z)}{2\sqrt{2}}}$$

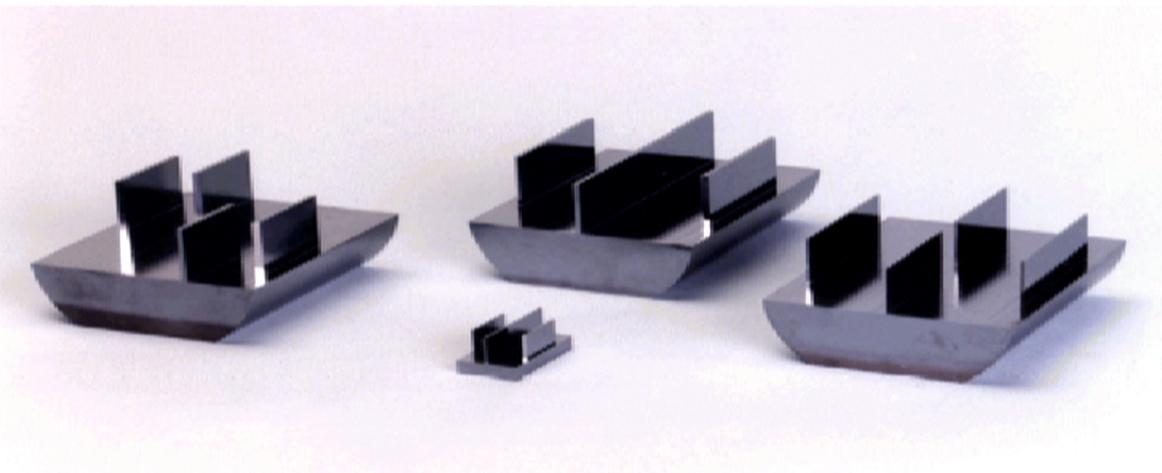


angle

$$U_H = e^{i \pi \frac{(S_x + S_z)}{2\sqrt{2}}}$$



blade. There are two neutron beams of interest leaving the crystal. We can conveniently detect the neutrons in either of these beams with a He-3 detector. A phase flag and set of prisms are shown inside the interferometer. We will describe the actions of these latter.



Picture of a variety of single crystal neutron interferometers. All are examples of Mach-Zehnder interferometers.

**■ He-3 detector**

We use a gas filled detector to measure neutrons. The gas is helium-3 which has a high absorption cross section of 5333 barns for 2200 m/s neutrons. 1 barn is  $10^{-28} \text{ m}^2$  or 100 square femtometers ( $\text{fm}^2$ ). Since the absorption cross-section is so high the stopping power is large. In a well designed detector

