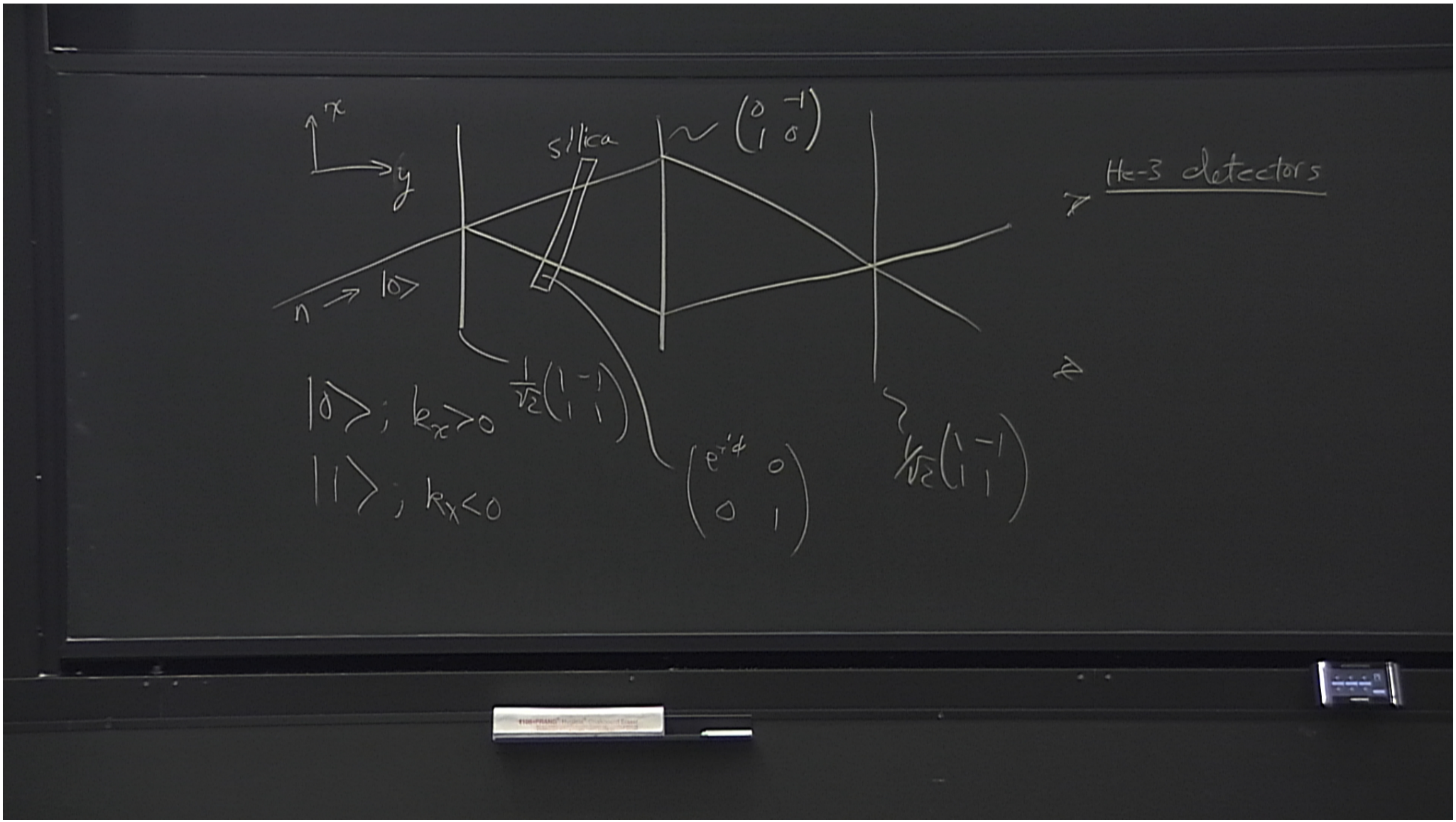
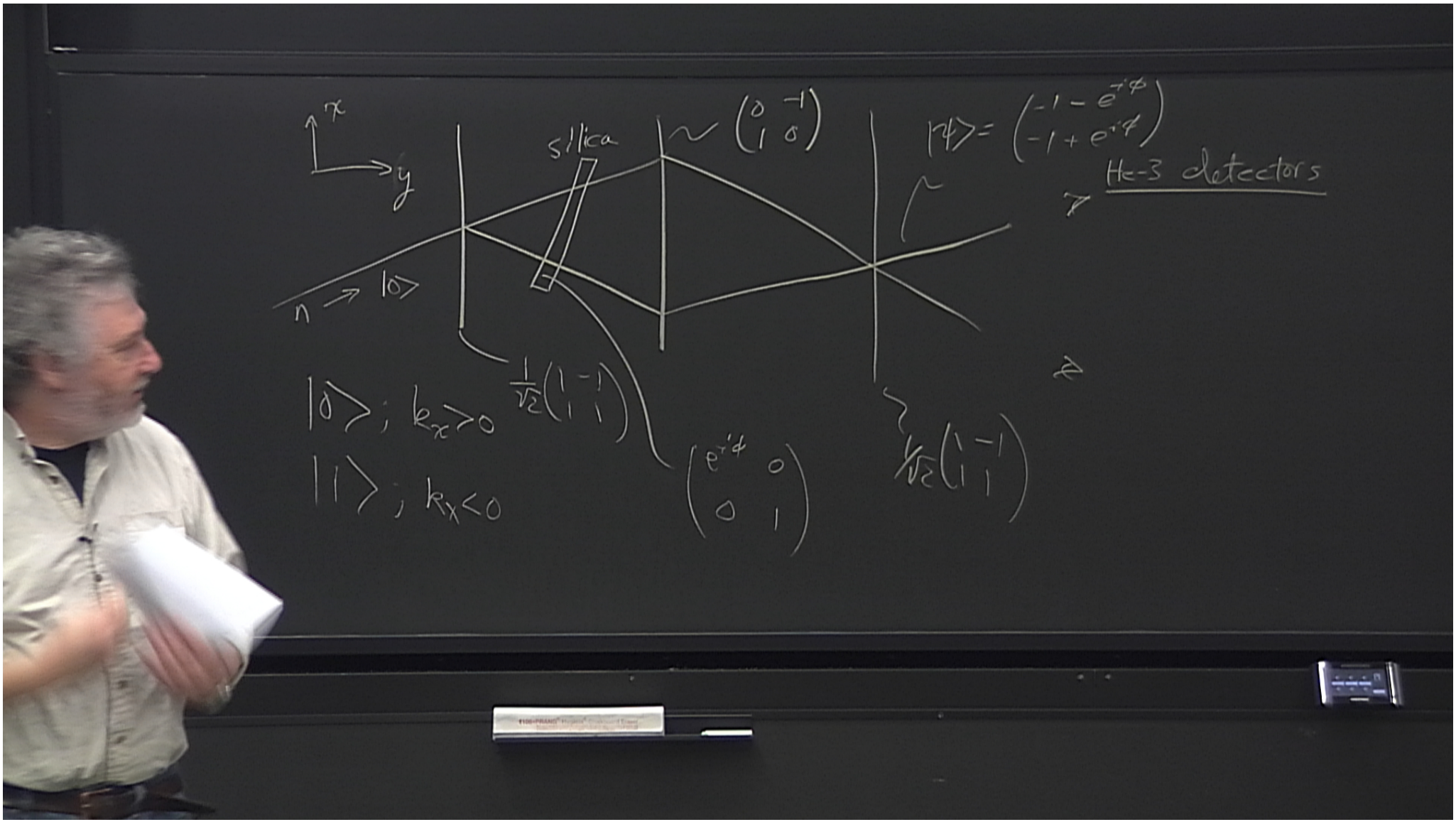
Title: 13/14 PSI - Explorations in Quantum Information - Lecture 2

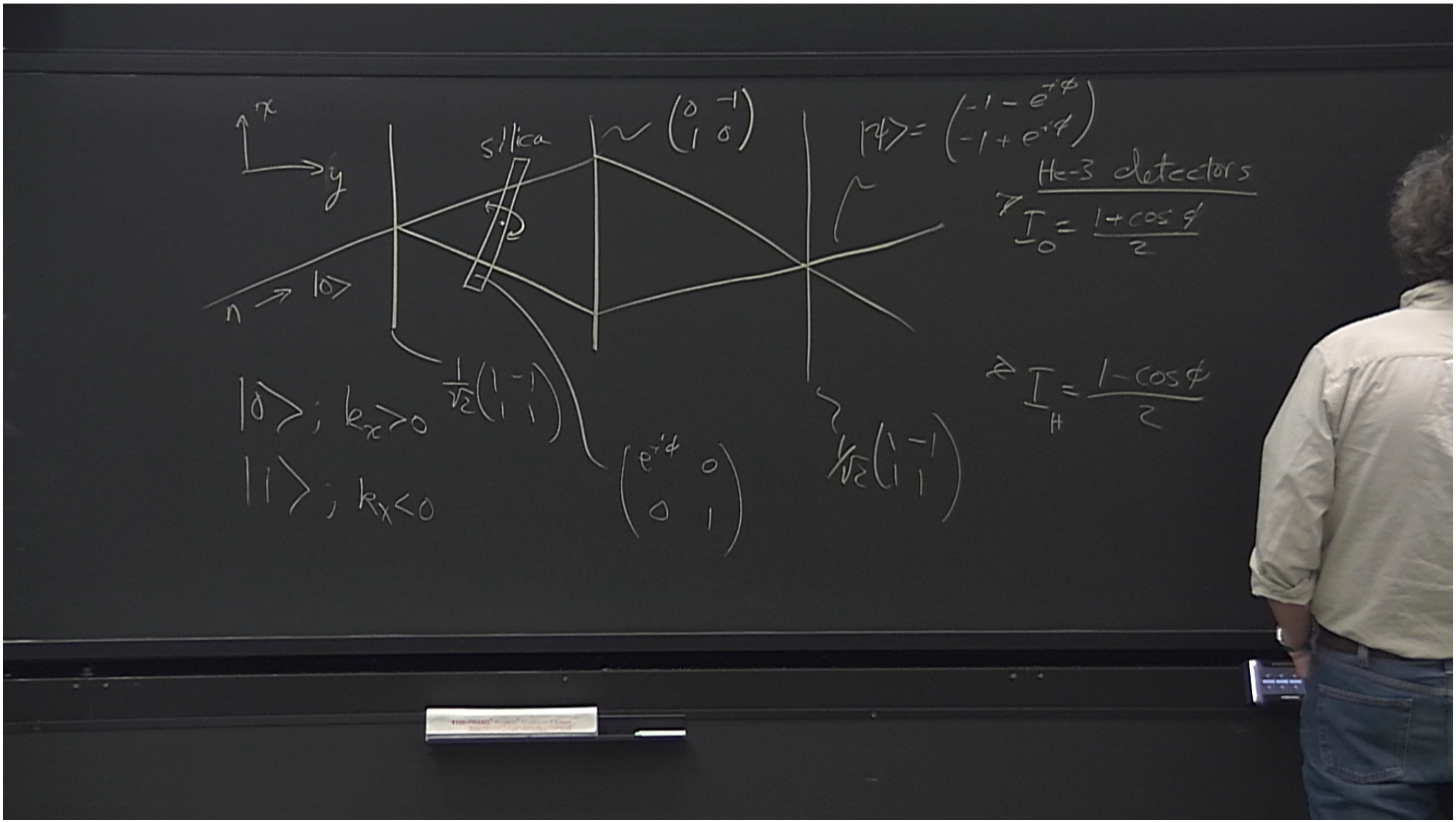
Date: Mar 18, 2014 09:00 AM

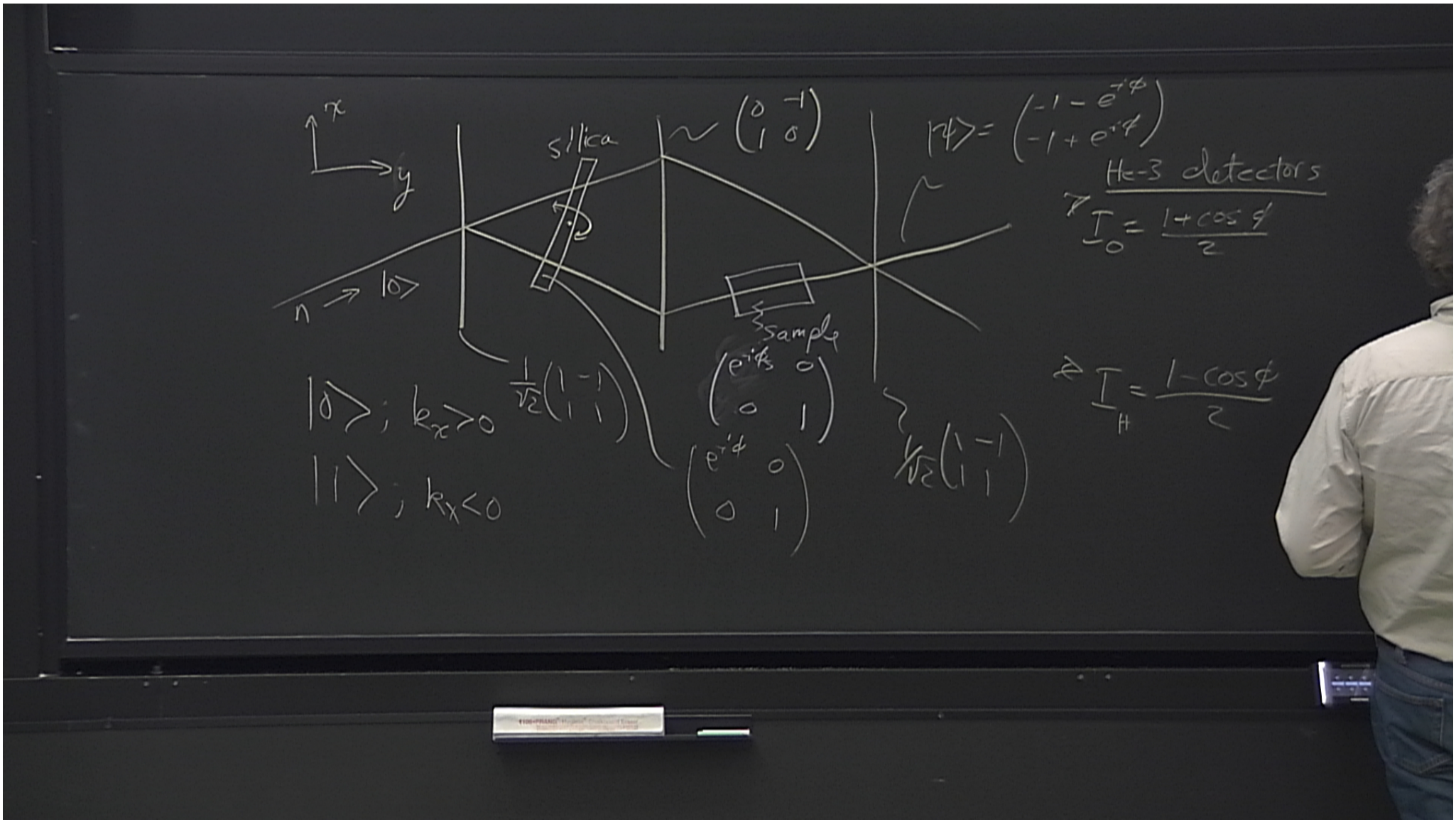
URL: http://pirsa.org/14030030

Abstract:


x
y
silica
$\sim \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$
He-3 detectors
n → |0>
$\frac{1}{\sqrt{2}}\begin{pmatrix} 1 & -1 \\ 1 & 1 \end{pmatrix}$
$\begin{pmatrix} e^{i\phi} & 0 \\ 0 & 1 \end{pmatrix}$
$\frac{1}{\sqrt{2}}\begin{pmatrix} 1 & -1 \\ 1 & 1 \end{pmatrix}$
|0>; $k_x > 0$
|1>; $k_x < 0$


x
y
silica
$\sim \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$
$|\psi\rangle = \begin{pmatrix} -1 - e^{-i\phi} \\ -1 + e^{-i\phi} \end{pmatrix}$
He-3 detectors
n → $|0\rangle$
$\frac{1}{\sqrt{2}}\begin{pmatrix} 1 & -1 \\ 1 & 1 \end{pmatrix}$
$\begin{pmatrix} e^{-i\phi} & 0 \\ 0 & 1 \end{pmatrix}$
$\frac{1}{\sqrt{2}}\begin{pmatrix} 1 & -1 \\ 1 & 1 \end{pmatrix}$
$|0\rangle$; $k_x > 0$
$|1\rangle$; $k_x < 0$


x
y
silica
$\sim \begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$
$|\psi\rangle = \begin{pmatrix} -1 - e^{-i\phi} \\ -1 + e^{-i\phi} \end{pmatrix}$
He-3 detectors
$I_0 = \frac{1+\cos\phi}{2}$
$n \rightarrow |0\rangle$
$\frac{1}{\sqrt{2}}\begin{pmatrix} 1 & -1 \\ 1 & 1 \end{pmatrix}$
$\begin{pmatrix} e^{-i\phi} & 0 \\ 0 & 1 \end{pmatrix}$
$\frac{1}{\sqrt{2}}\begin{pmatrix} 1 & -1 \\ 1 & 1 \end{pmatrix}$
$I_H = \frac{1-\cos\phi}{2}$
$|0\rangle$; $k_x > 0$
$|1\rangle$; $k_x < 0$


x
y
silica
sample
n → |0>
|0> ; kx>0
|1> ; kx<0
He-3 detectors

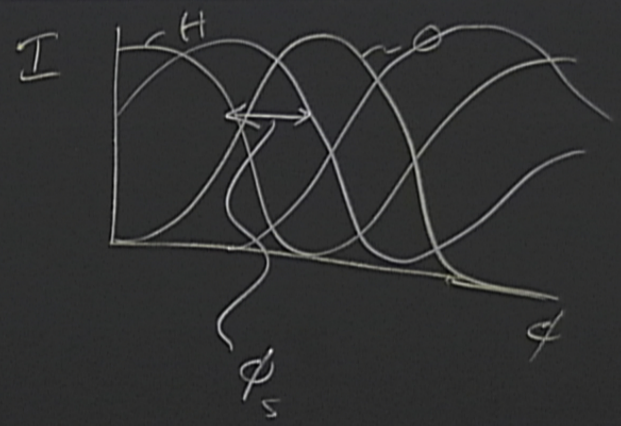
$$|\phi\rangle = \begin{pmatrix} -1 - e^{-i\phi} \\ -1 + e^{-i\phi} \end{pmatrix}$$

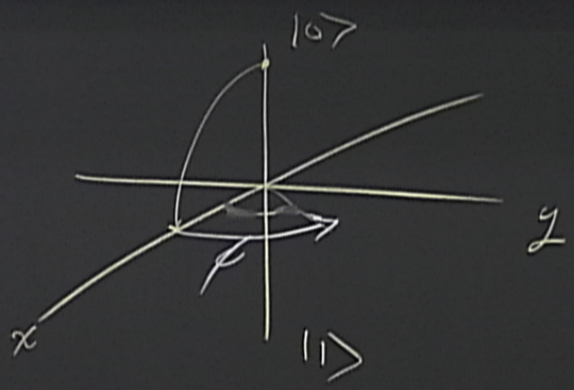
He-3 detectors

$$I_O = \frac{1+\cos\phi}{2}$$

$$I_H = \frac{1-\cos\phi}{2}$$

$$\frac{1}{\sqrt{2}}\begin{pmatrix} 1 & -1 \\ 1 & 1 \end{pmatrix}$$



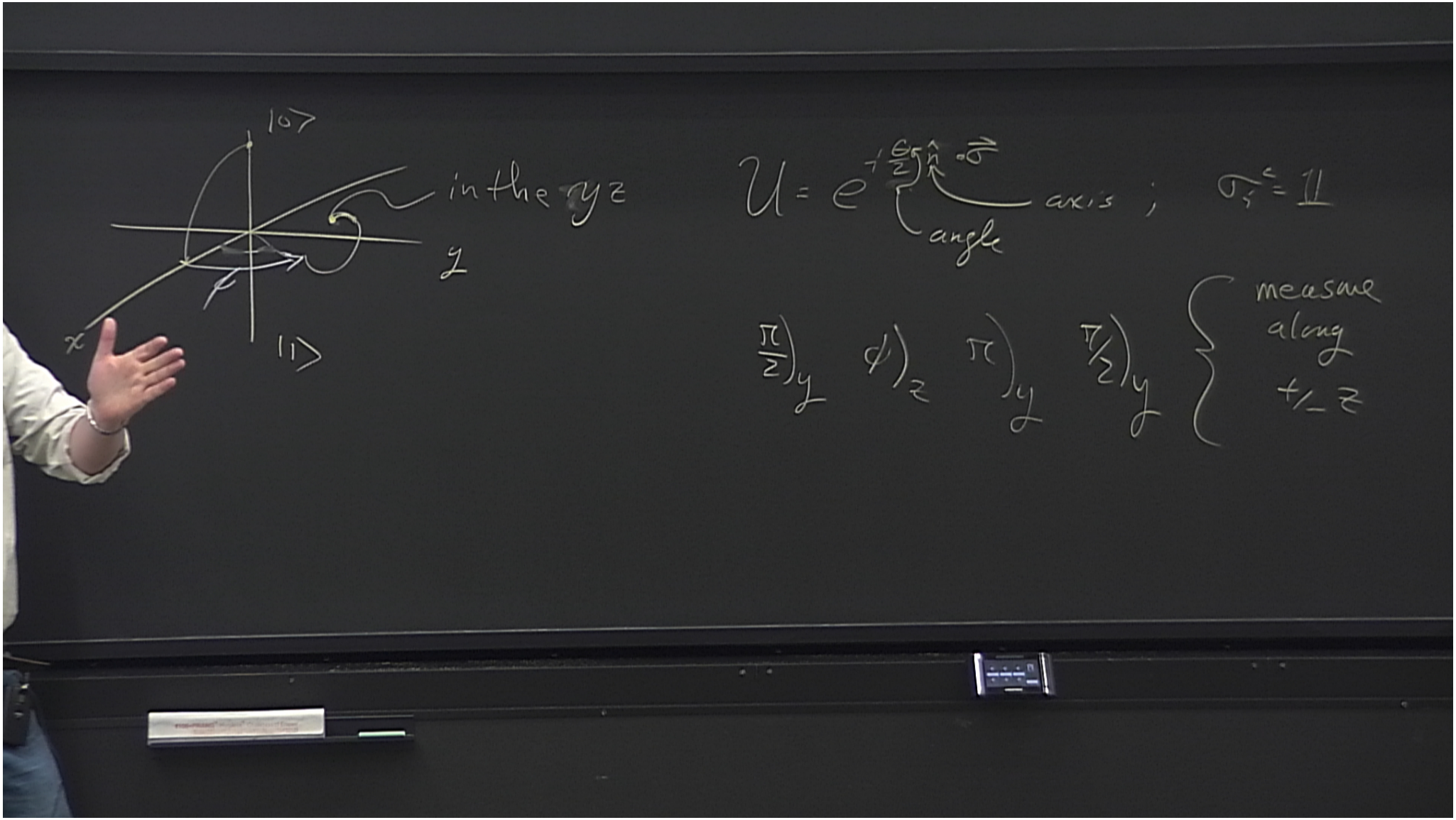


$$U = e^{-i\frac{\theta}{2}\hat{n}\cdot\vec{\sigma}}$$

$\hat{n}$ — axis ;

θ — angle

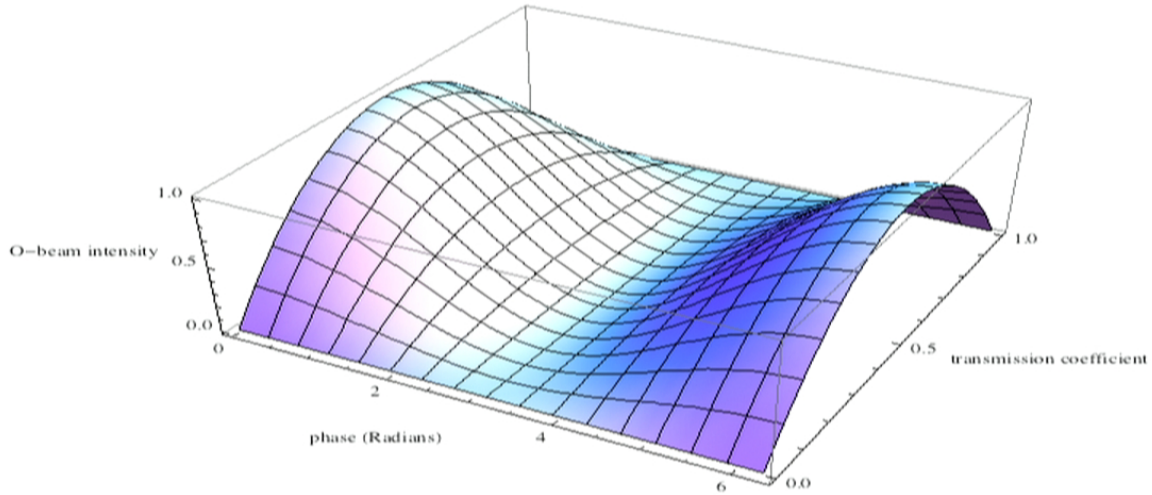
$$\left.\frac{\pi}{2}\right)_y$$


|0>
in the yz
y
x
|1>
$U = e^{+\frac{\theta}{2}\hat{n}\cdot\vec{\sigma}}$
angle
axis ;
$\sigma_i^2 = \mathbb{1}$
$\frac{\pi}{2})_y$ $\phi)_z$ $\pi)_y$ $\pi/2)_y$
measure along +/- z

Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Tue 9:36 AM dcory

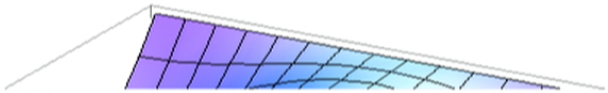
QE Lec 2.cdf

```
Plot3D[M3O[ArcSin[Sqrt[T]], a], {a, 0, 2 π}, {T, 0, 1}, {AxesLabel →
    { "phase (Radians)", "transmission coefficient", "O-beam intensity"}}]
```




```
M3H[t_, a_] := Tr[Ezm . res3[t, a]]

Plot3D[M3H[ArcSin[Sqrt[T]], a], {a, 0, 2 π}, {T, 0, 1}, {AxesLabel →
    { "phase (Radians)", "transmission coefficient", "H-beam intensity"}}]
```



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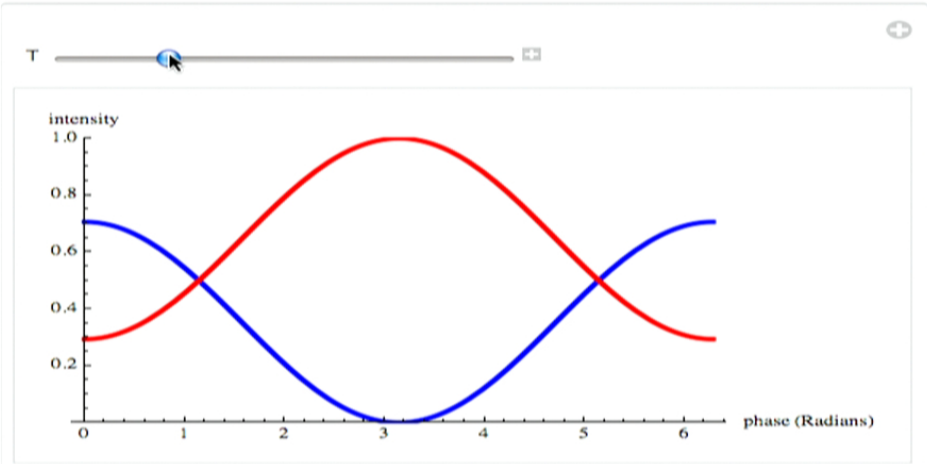
QE Lec 2.cdf

```
{AxesLabel → {"phase (Radians)", "intensity"},
 PlotStyle → {RGBColor[1, 0, 0], Thickness[0.01]},
 PlotRange → {0, 1}}]}], {T, 0, 1}, SaveDefinitions → True]
```



Note that the O-beam has zero offset in the absence of dark counts. The H-beam is always reduced from 1.
Note that at t=0 or 1 all neutrons end up in the H detector. This is not the correct physics. Look at the action of the middle blade where we still assume everything is perfect. Fix this. What you should see is that if the entire beam is transmitted no neutrons hit the detector. If the entire beam is reflected than all neutrons arrive at the H detector.

As expected the sum of the O and H-beam intensities is still 1 and is independent of the trans-

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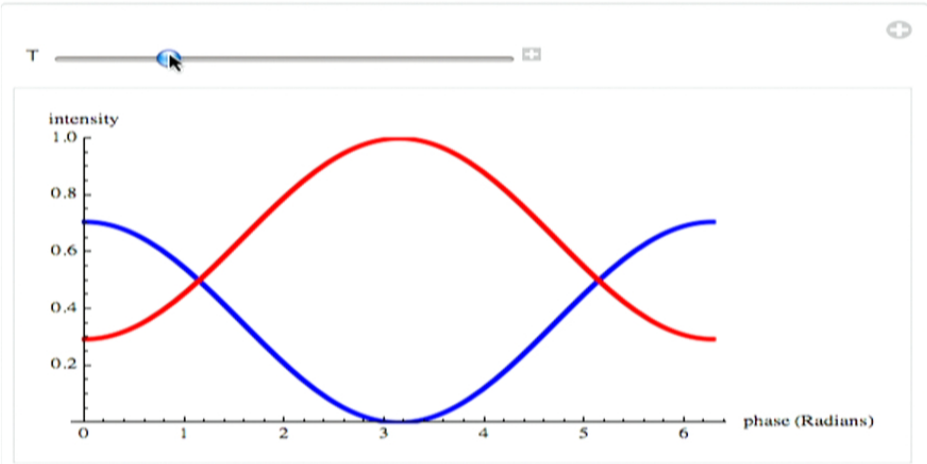
QE Lec 2.cdf

```
{AxesLabel → { phase (Radians) , intensity },
 PlotStyle → {RGBColor[1, 0, 0], Thickness[0.01]},
 PlotRange → {0, 1}}]}], {T, 0, 1}, SaveDefinitions → True]
```



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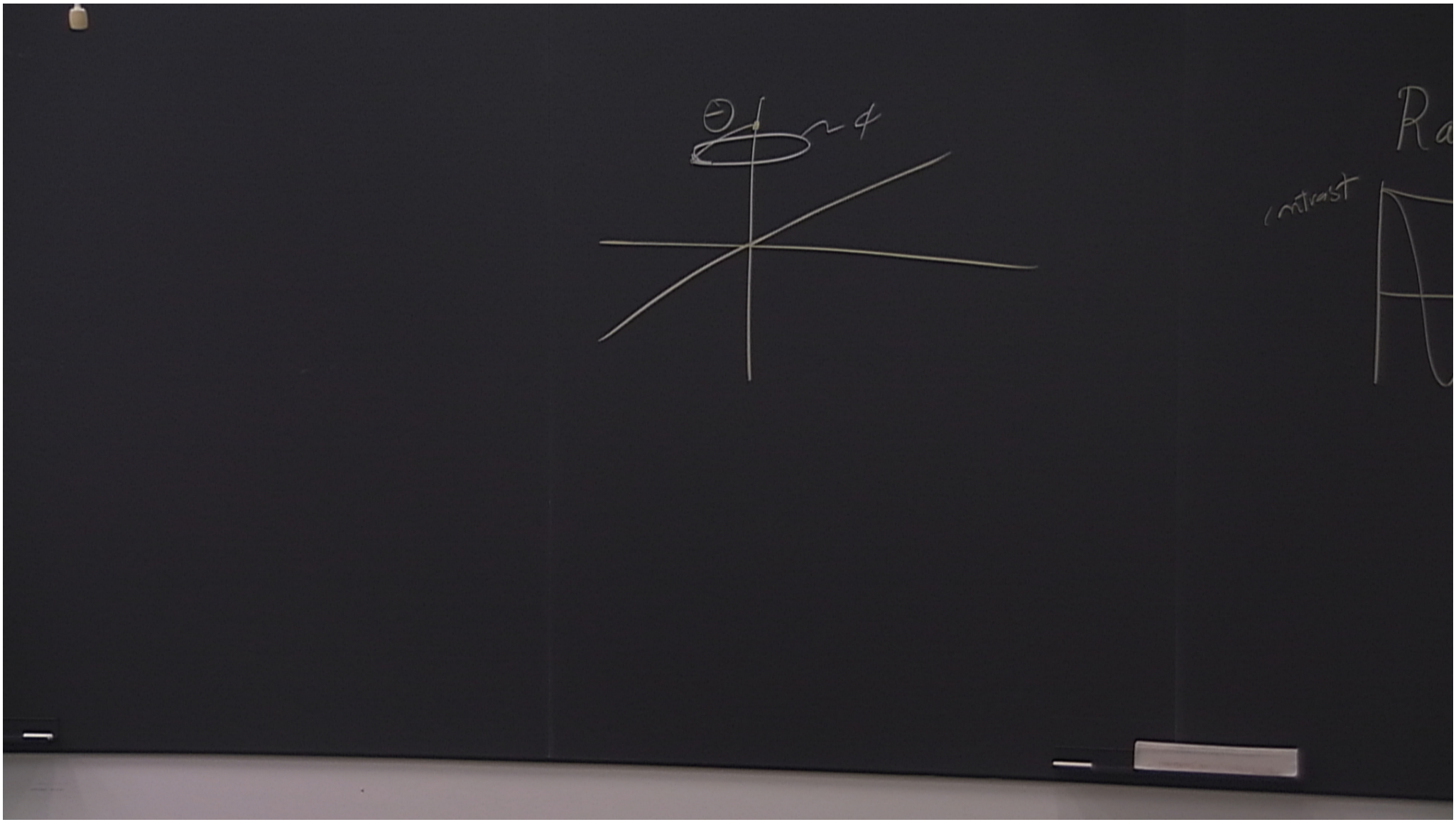
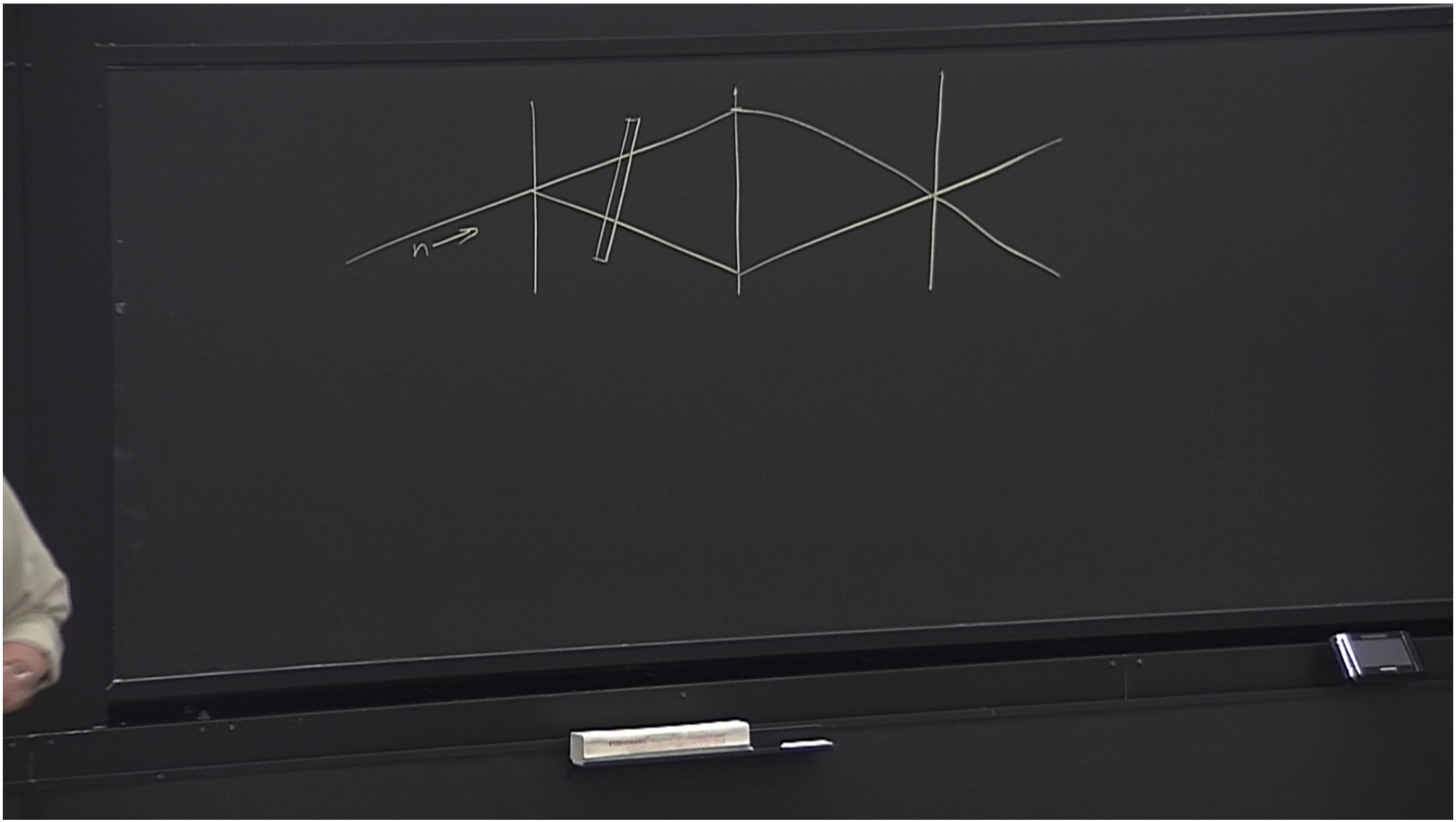
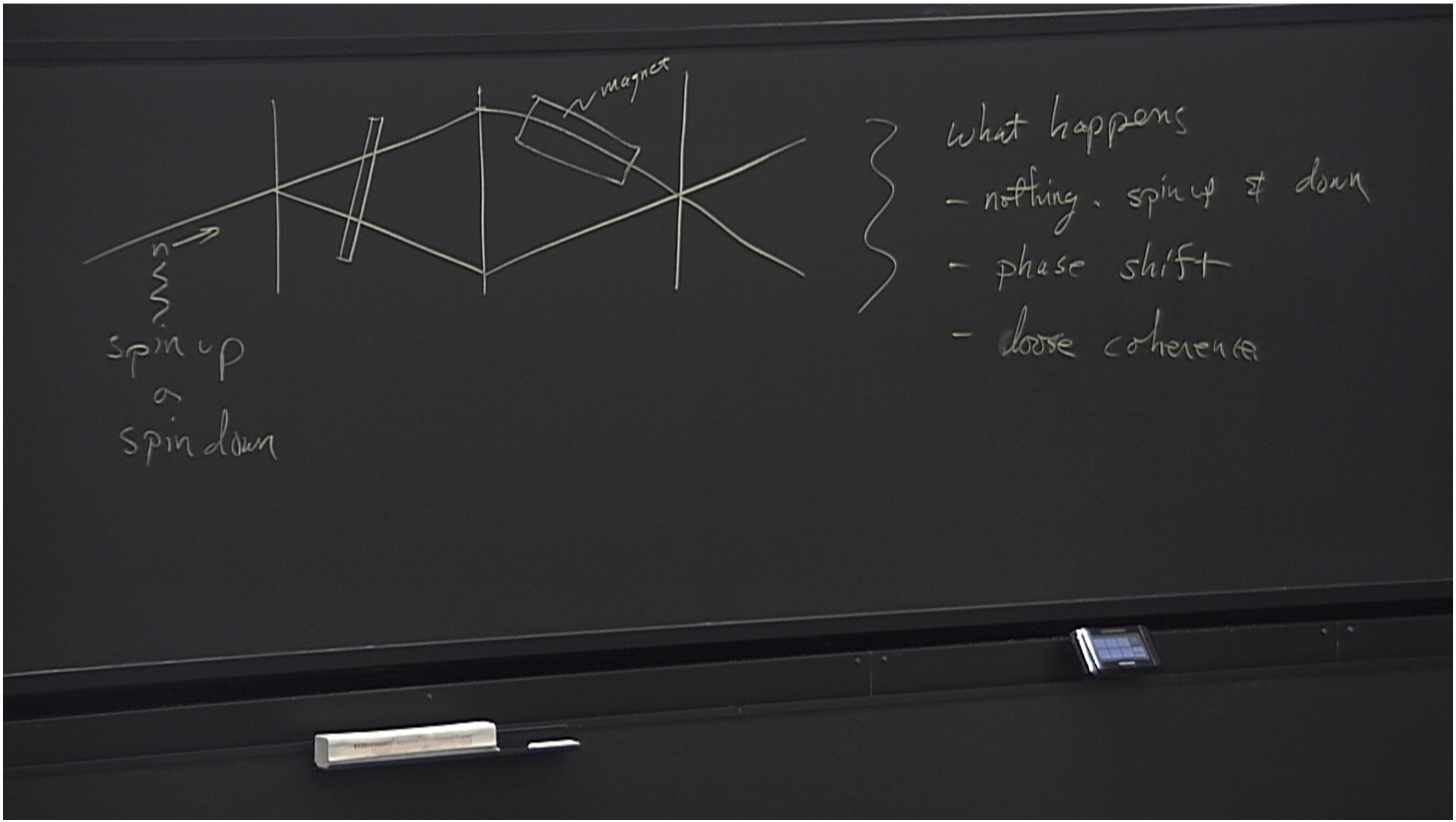
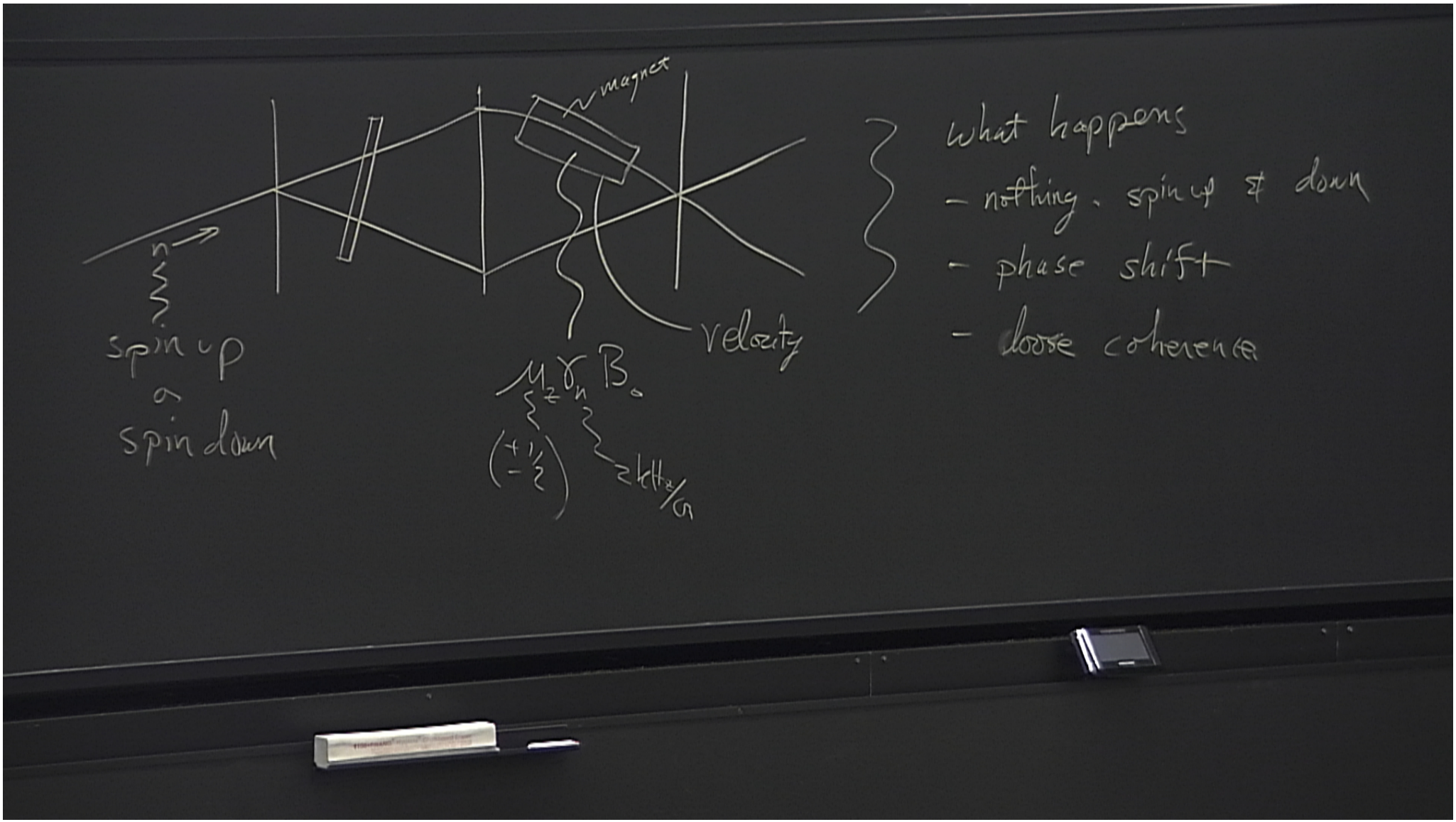

contrast


n


magnet
n
spin up
or
spin down
what happens
- nothing. spin up & down
- phase shift
- loose coherence


magnet
n
spin up
or
spin down
velocity
$\mu_z \gamma_n B_0$
$\begin{pmatrix} +1/2 \\ -1/2 \end{pmatrix}$
$2k\hbar\omega_0/G$
what happens
- nothing. spin up & down
- phase shift
- loose coherence

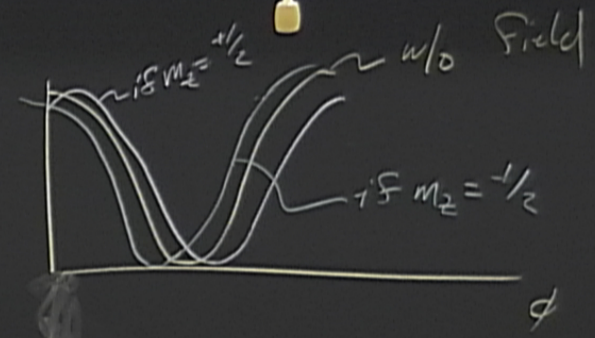
$$e^{-i\frac{\theta}{2}\hat{n}\cdot\vec{\sigma}}$$

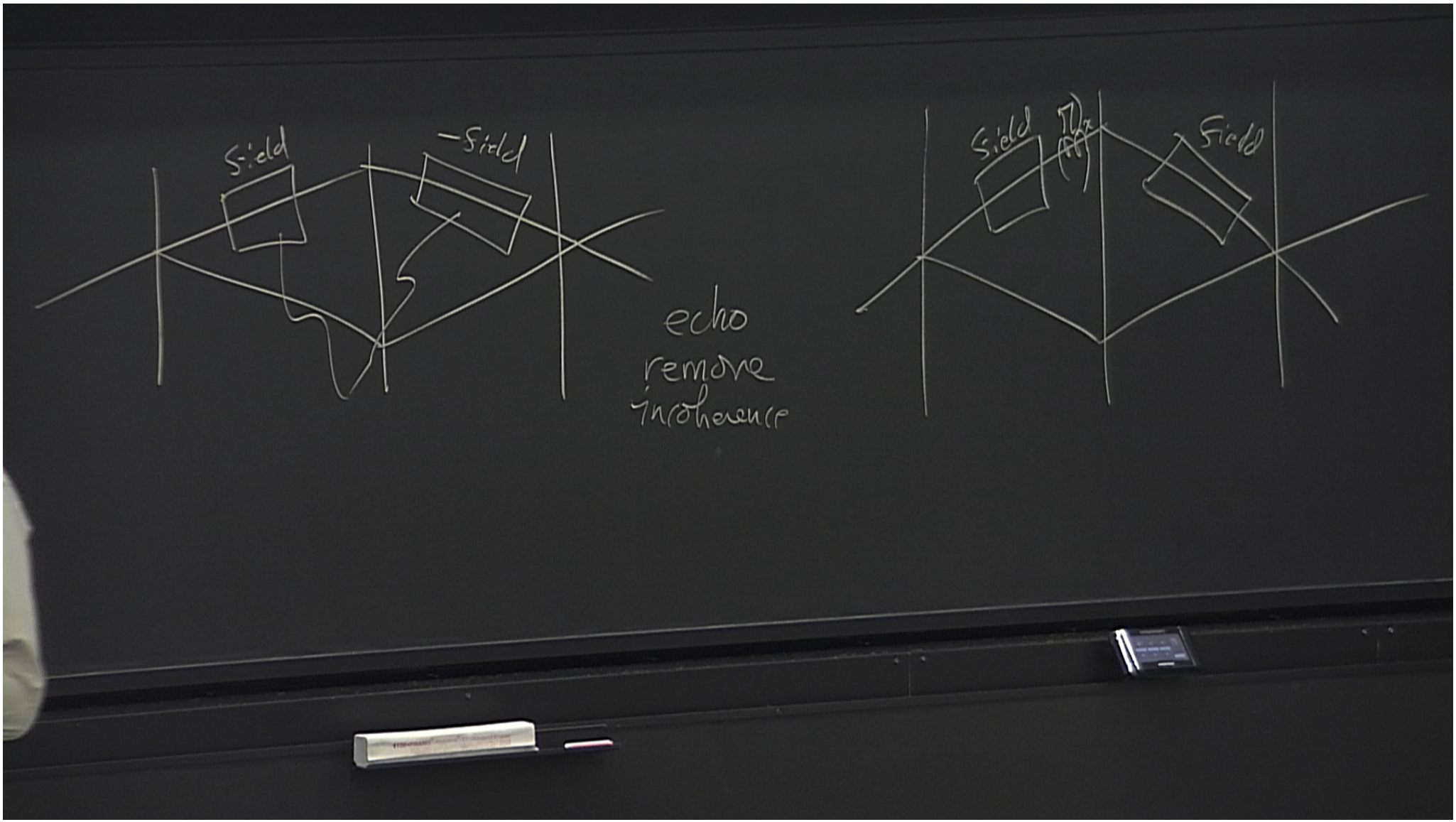
axis ; $\sigma_i^2 = \mathbb{1}$

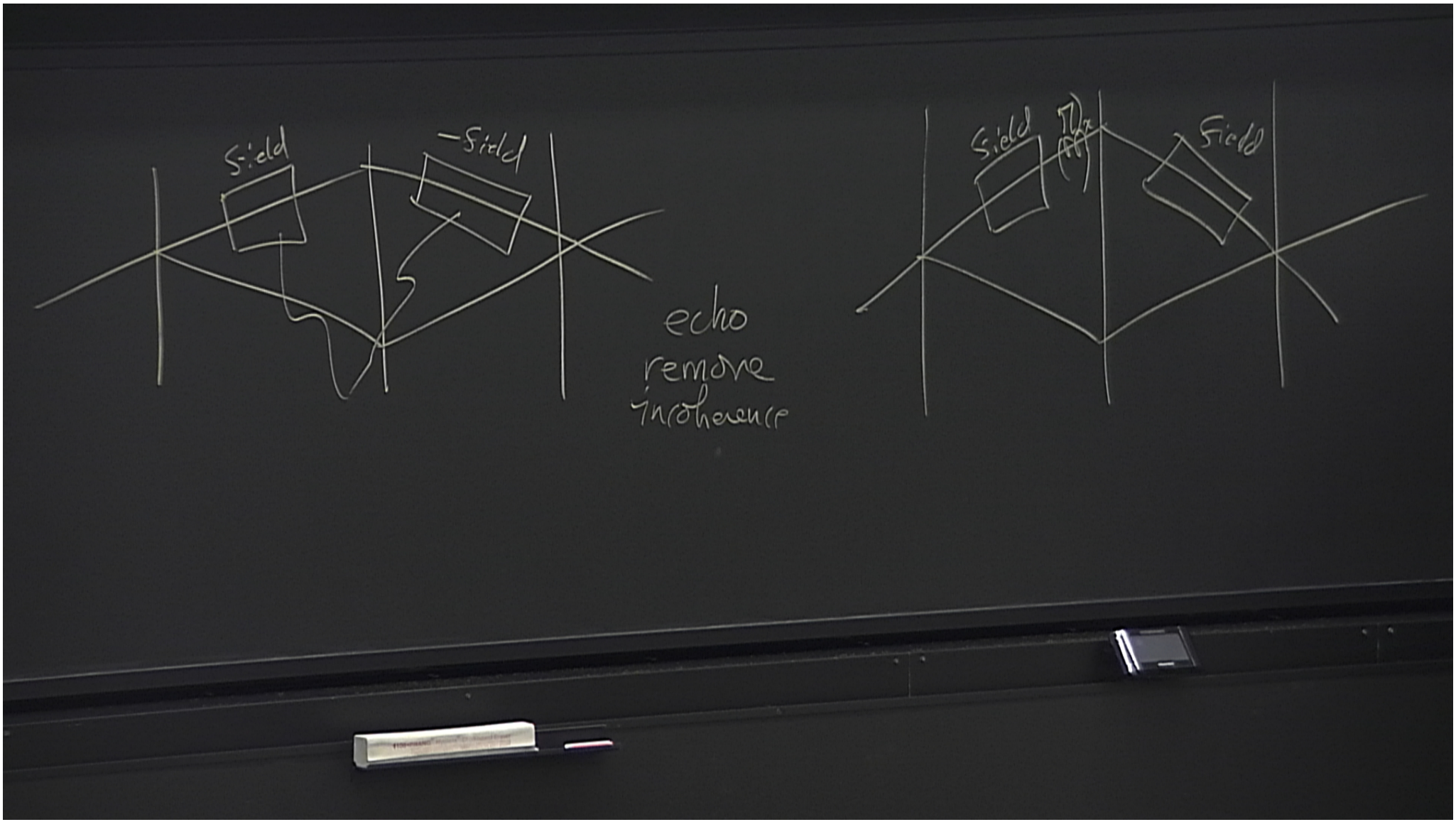
angle

$\phi)_z \quad \pi)_y \quad \pi/2)_y$ { measure along $+/-z$

$\phi)_z \quad \pi)_y \quad \theta)_y$



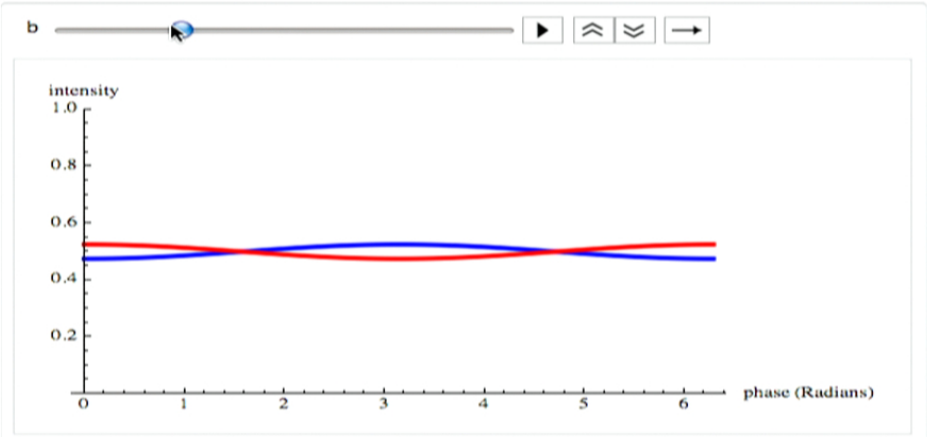

Field
-Field
echo
remove
incoherence
Field
Field


Field
-Field
echo
remove
incoherence
Field
Field

Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help Tue 9:59 AM dcory

QE Lec 2.cdf

```
Animate[Show[
  Plot[M5O[a, b], {a, 0, 2 π}, {AxesLabel → {"phase (Radians)", "intensity"},
    PlotStyle → {RGBColor[0, 0, 1], Thickness[0.01]}, PlotRange → {0, 1}}],
  Plot[M5H[a, b], {a, 0, 2 π}, {AxesLabel → {"phase (Radians)", "intensity"},
    PlotStyle → {RGBColor[1, 0, 0], Thickness[0.01]}, PlotRange → {0, 1}}]],
 {b, 0, 2 π}, AnimationRunning → False]
```



If we plot what happens to the two spin states then the total picture is easier to see.

- Problem 15: We can perform this experiment by either preparing the neutrons in a particular state or by using a spin polarized detector. Does it matter which we use?

```
Manipulate[Show[Plot[M5O[a, b], {a, 0, 2 π},
   {AxesLabel → {"phase (Radians)", "O-beam intensity"}, PlotStyle →
```

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