

Title: 12/13 PSI - Explorations on Quantum Information Lecture 13

Date: Apr 04, 2013 09:00 AM

URL: <http://www.pirsa.org/13040036>

Abstract:

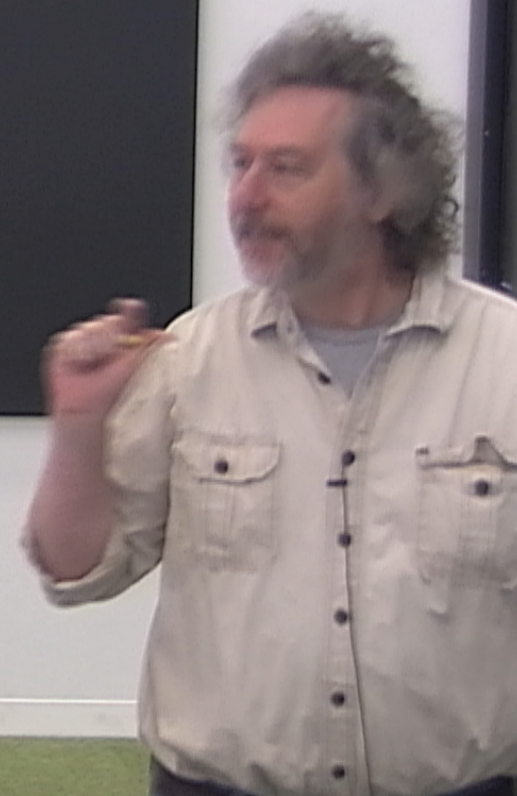
Diamond

2 electrons : $\mathcal{H} = \frac{w_0}{4} \sigma^x \sigma^z$

Diamond

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eigenstates



Diamond

2 electrons : $\mathcal{H} = \frac{\omega_c}{4} \sigma^A \sigma^B$

eigenstates
 $\omega_c/4$



$-\frac{\omega_c}{2\sqrt{2}}$ $\frac{|\uparrow\downarrow\rangle + |\downarrow\uparrow\rangle}{\sqrt{2}}$

Diamond

2 electrons : $\mathcal{H} = \frac{\omega_c}{4} \sigma^A \cdot \sigma^B$

eigenstates
 $\frac{\omega_c}{4}, m_s = -1 \quad \uparrow\downarrow$
 $\frac{\omega_c}{4}, m_s = +1 \quad \downarrow\uparrow$

$m_s = 0 \quad \frac{1}{\sqrt{2}} (\uparrow\downarrow)$

$-\frac{\omega_c}{2\sqrt{2}}, m_s = 0, \frac{1}{\sqrt{2}} (\uparrow\downarrow)$

Diamond

2 electrons : $\mathcal{H} = \frac{\omega_c}{4} \sigma^A \cdot \sigma^B$

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 $\omega_c/4, m_s = -1 \uparrow\downarrow$
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$m_s = 0$ ——— $\frac{1}{\sqrt{2}}(|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle)$ ○

$-\frac{\omega_c}{2\sqrt{2}}, m_s = 0, \frac{1}{\sqrt{2}}(|\uparrow\downarrow\rangle + |\downarrow\uparrow\rangle)$ ———

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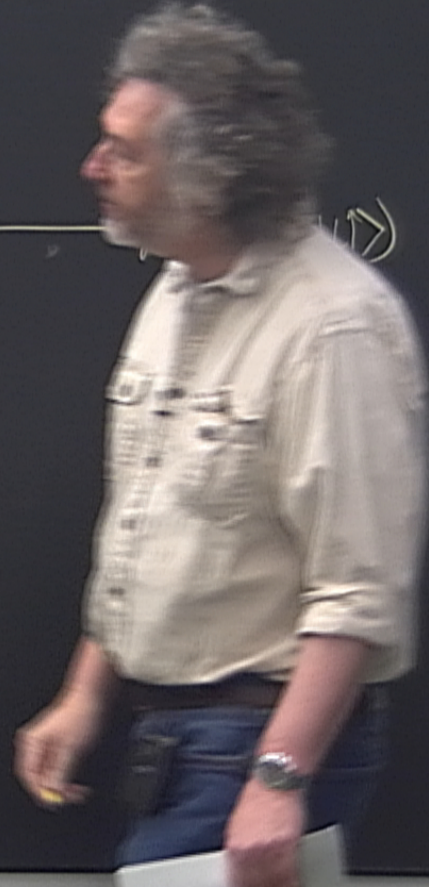
what are the
dipole allowed
transitions

$$S = (\sigma_x^A + \sigma_x^B)$$

$$-\frac{\omega_c}{2\sqrt{2}} m_s = 0, \frac{1}{\sqrt{2}} (\uparrow\downarrow + \downarrow\uparrow)$$

$m_s = 0$

$(\uparrow\downarrow)$ \circ



Diamond

2 electrons : $\mathcal{H} = \frac{\omega_c}{4} \sigma^A \sigma^B$

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$$-\frac{\omega_c}{2\sqrt{2}}, m_s = 0, \frac{1}{\sqrt{2}}(\uparrow\downarrow - \downarrow\uparrow)$$

Diamond

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$m_s = 0 \longrightarrow \frac{1}{\sqrt{2}}(\uparrow\downarrow - \downarrow\uparrow)$

$-\frac{\omega_c}{2\sqrt{2}}, m_s = 0, \frac{1}{\sqrt{2}}(\uparrow\downarrow + \downarrow\uparrow)$

spin 1

spin 0

Diamond

2 electrons : $\mathcal{H} = \frac{W_E}{4} \sigma^A \sigma^B$

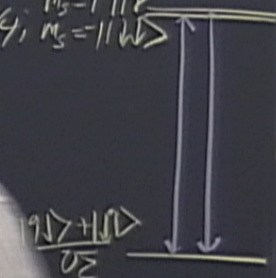
weakly allowed
 $\Omega = (\sigma_x^A + \alpha \sigma_x^B)$

what are the
dipole allowed
 transitions

$\Omega = (\sigma_x^A + \alpha \sigma_x^B)$

generates

$\frac{W_E}{4}, m_s = -1/2$
 $\frac{W_E}{4}, m_s = +1/2$



$m_s = 0 \rightarrow \frac{1}{\sqrt{2}}(|↑↓⟩ - |↓↑⟩)$

spin 1

spin 0

weakly allowed
 $\Omega = (\sigma_x^A + \alpha \sigma_x^B)$

what are the
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$$S = (\sigma_x^A + \sigma_x^B)$$

Diamond

2 electrons

$$\mathcal{H} = \frac{\omega_e}{4} \sigma^A \sigma^B$$

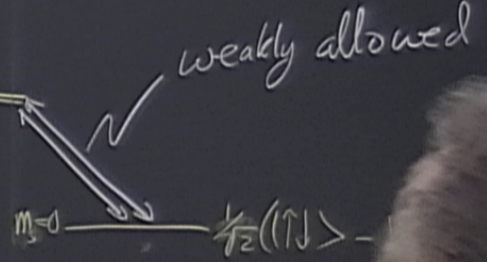
eigenstates

$\frac{\omega_e}{4}, m_s = 1 \uparrow\uparrow$
 $\frac{\omega_e}{4}, m_s = -1 \downarrow\downarrow$

$$-\frac{\omega_e}{2\sqrt{2}} m_s = 0, \frac{1}{\sqrt{2}}(\uparrow\downarrow + \downarrow\uparrow)$$

spin 1

spin 0



Diamond

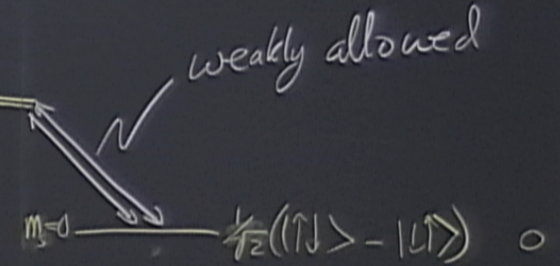
2 electrons

$$\mathcal{H} = \frac{\omega_e}{4} \sigma^A \sigma^B$$

eigenstates

$$\frac{\omega_e}{4}, m_s = -1/2$$

$$\frac{\omega_e}{4}, m_s = +1/2$$



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what are the
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transitions

$$\Omega = (\sigma_x^A + \sigma_x^B)$$

$$-\frac{\omega_e}{2\sqrt{2}} |m_s=0\rangle, \frac{\omega_e}{2\sqrt{2}} |m_s=0\rangle$$

spin 1

spin 0

weakly allowed
 $\Omega = (\sigma_x^A + \alpha \sigma_x^B)$

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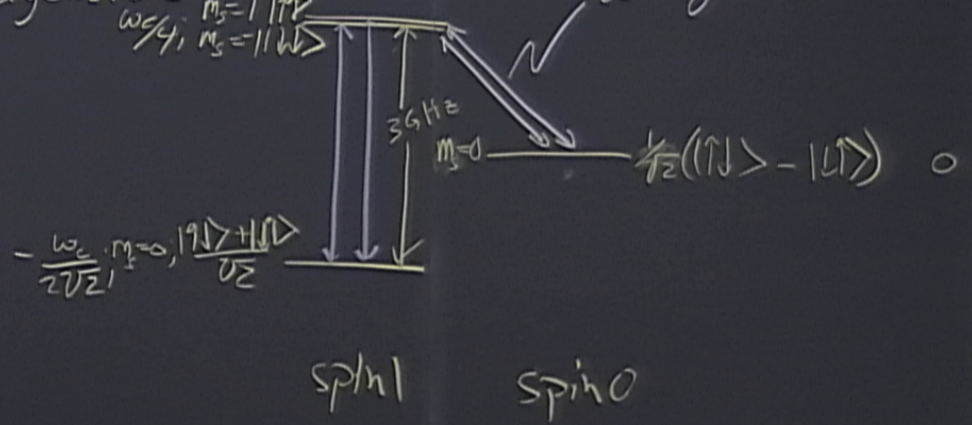
Diamond

2 electrons

$$\mathcal{H} = \frac{\omega_e}{4} \sigma^A \sigma^B$$

eigenstates

$$\frac{\omega_e}{4}, m_s = \pm 1/2$$



weakly allowed

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spin 0

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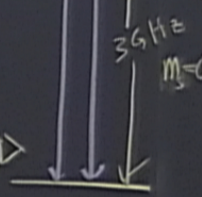
Diamond

2 electrons

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eigenstates

$\frac{\omega_e}{4}, m_s = 1 \uparrow \uparrow$
 $\frac{\omega_e}{4}, m_s = -1 \downarrow \downarrow$



mw driven transitions

weakly allowed

$$\frac{1}{\sqrt{2}}(|\uparrow \downarrow\rangle - |\downarrow \uparrow\rangle)$$

spin 1

spin 0

weakly allowed
 $\Omega = (\sigma_x^A + \alpha \sigma_x^B)$

what are the
dipole allowed
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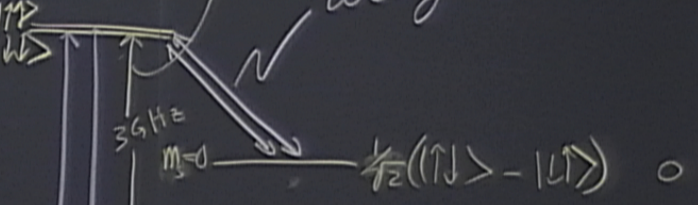
$$S = (\sigma_x^A + \sigma_x^B)$$

Diamond

2 electrons

$$\mathcal{H} = \frac{\omega_e}{4} \sigma^A \sigma^B$$

eigenstates
 $\omega_e/4, m_s = \pm 1/2$

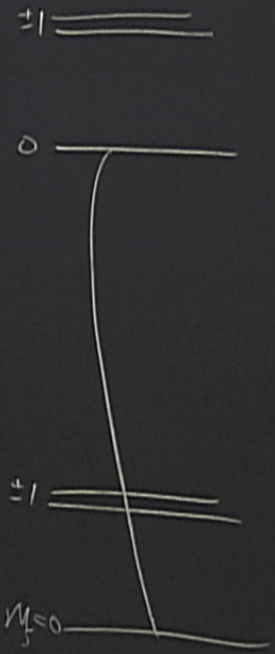


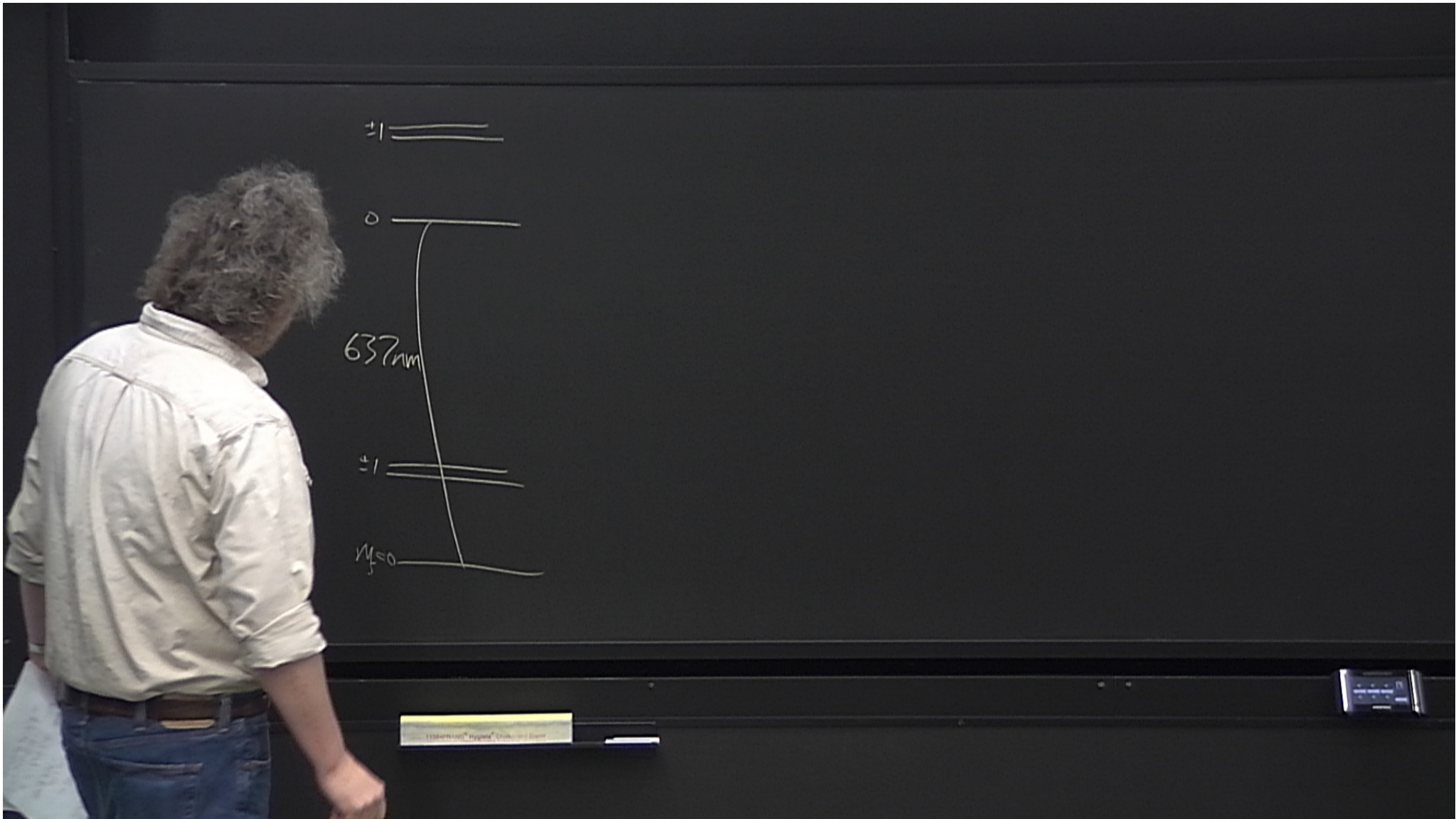
mw driven transitions

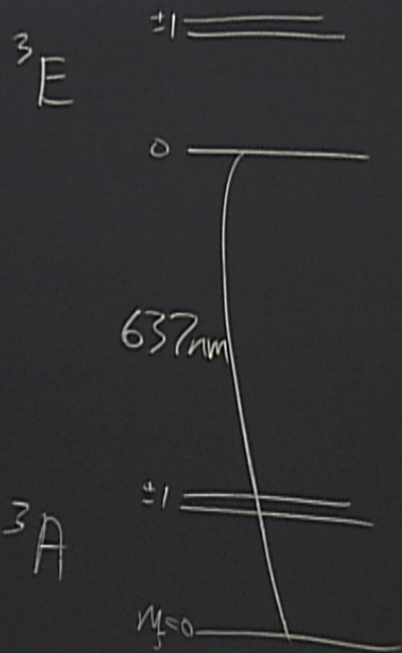
weakly allowed

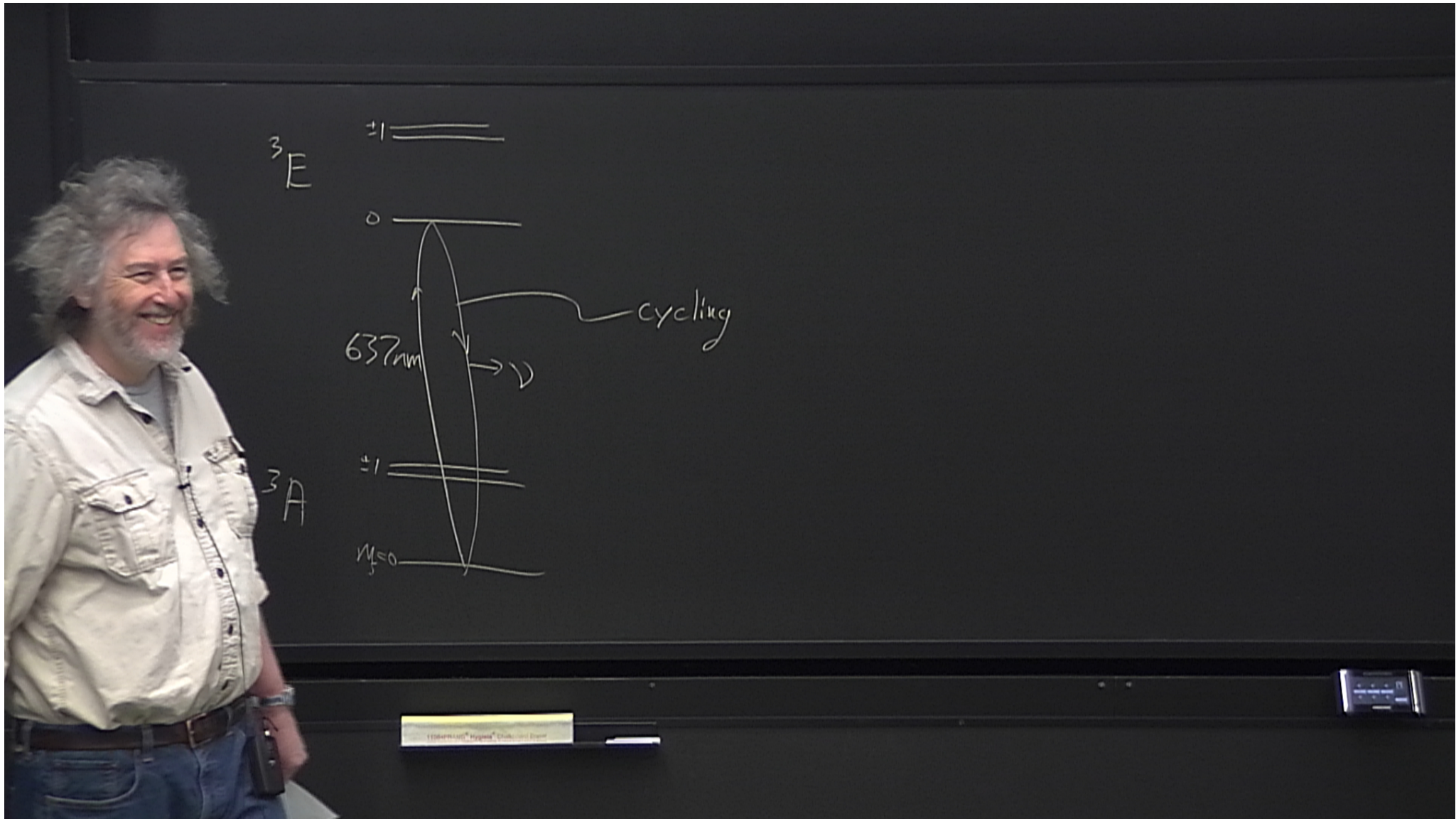
spin 1

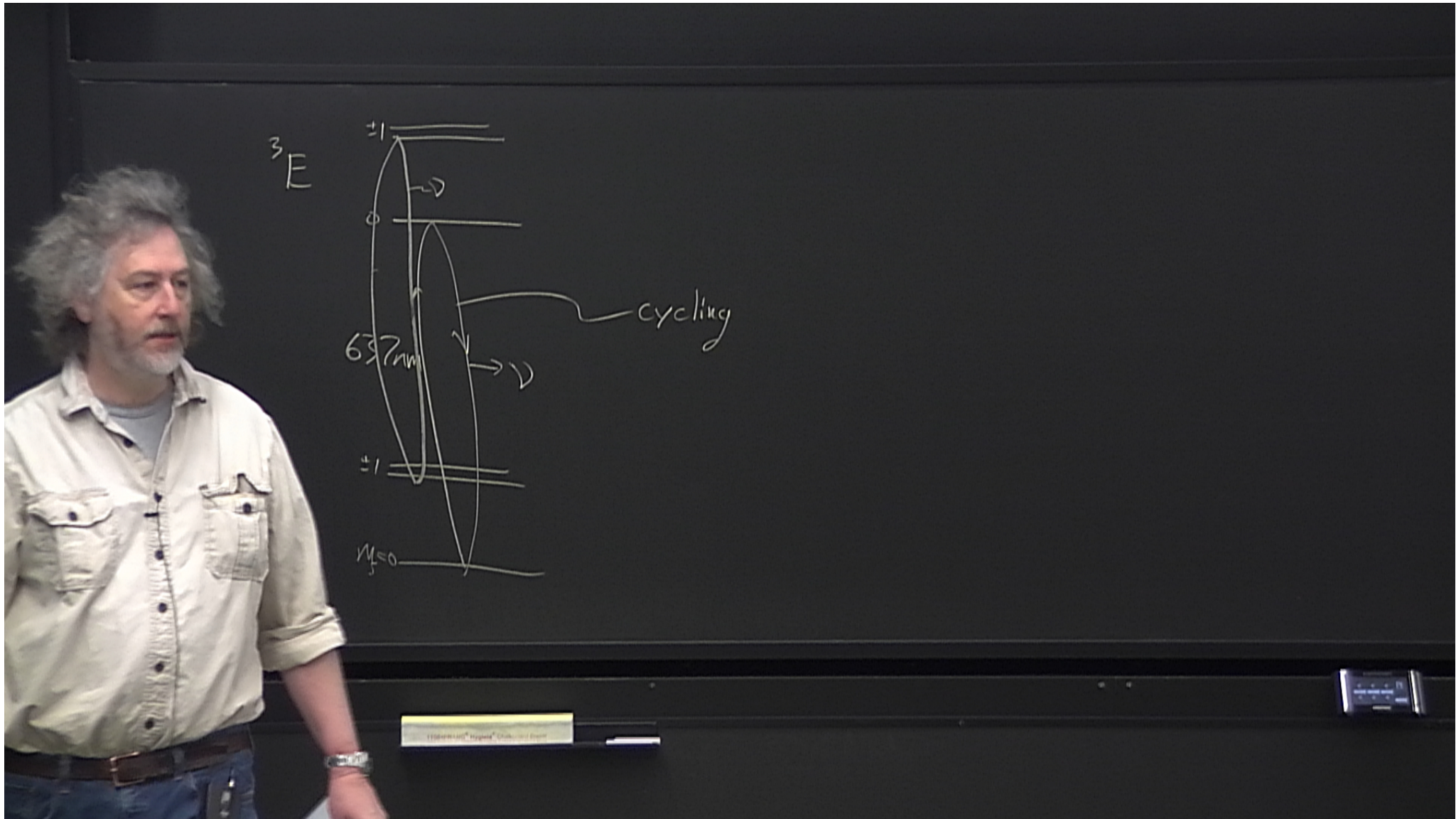
spin 0

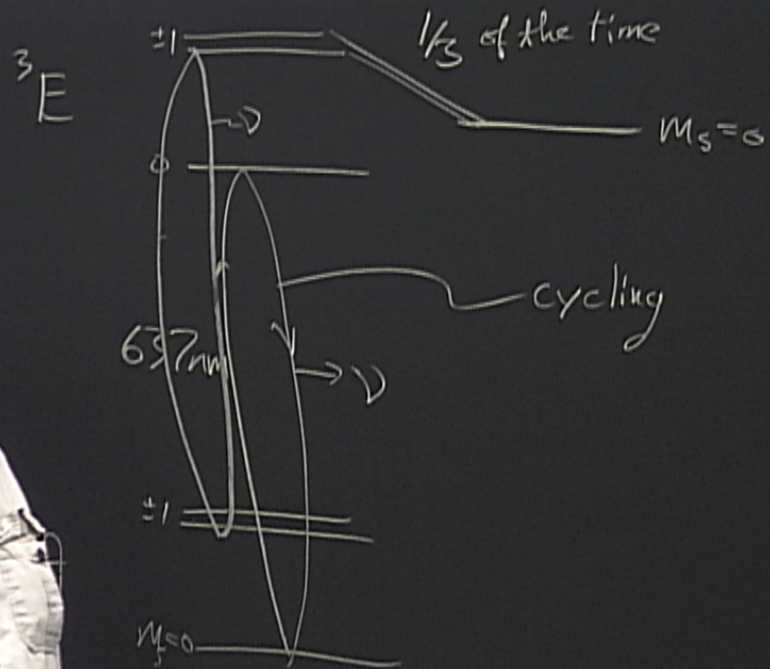


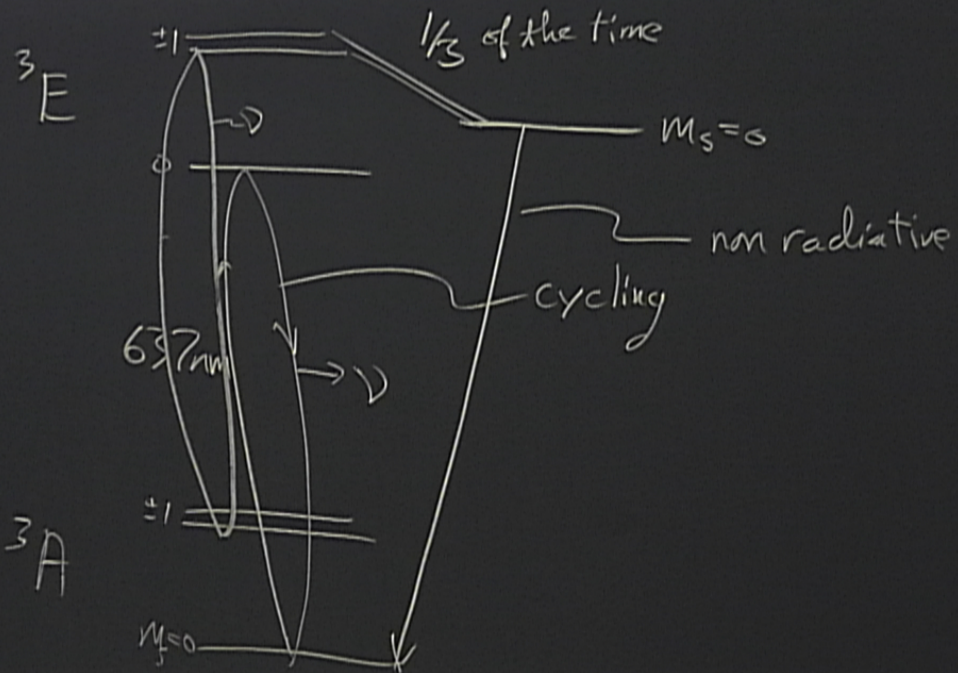


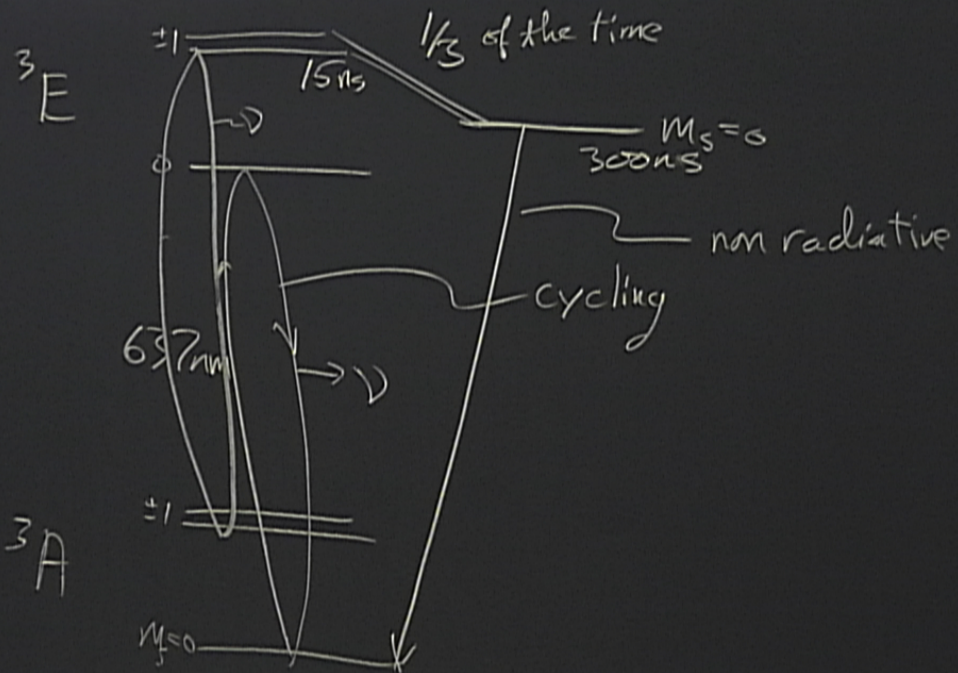


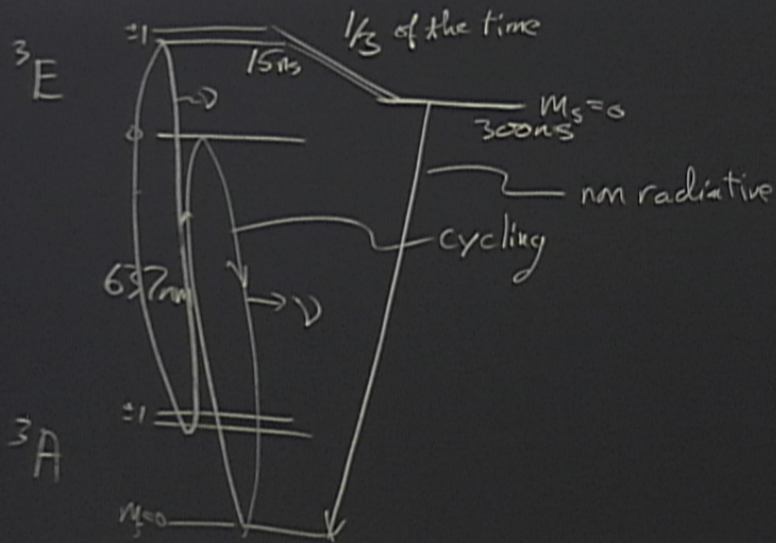












initialize - laser for $\sim 300ns$

1/3 of the time

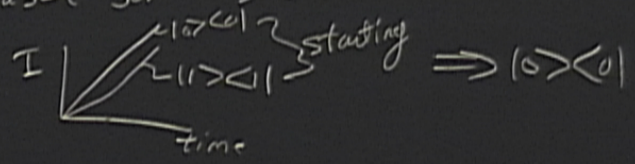
$M_S = 0$
300ns

nm radiative

ling

initialize - laser for ~300ns

measurement -

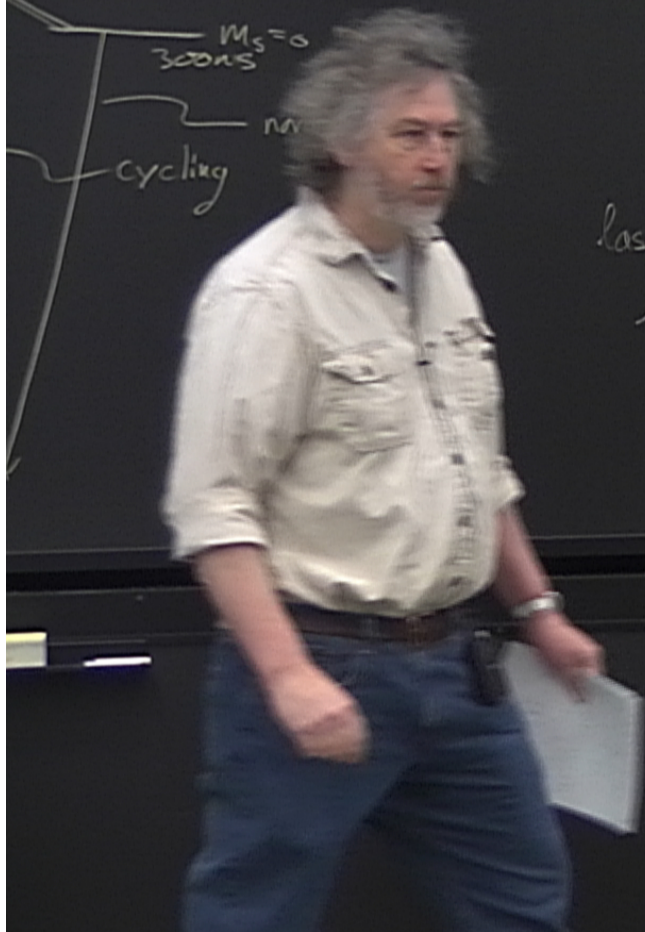
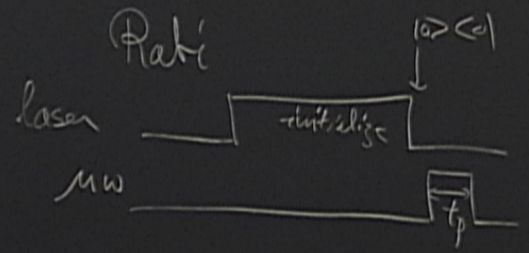
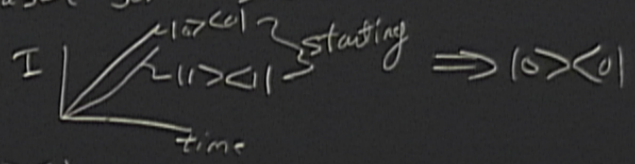


1/3 of the time

$M_S = 0$
300ns
cycling

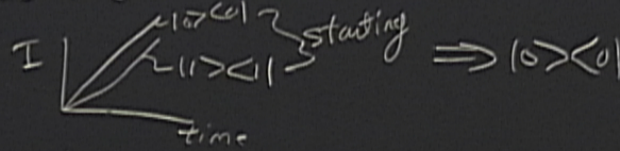
initialize - laser for ~300ns

measurement -



initialize - laser for ~ 300 ns

measure



$$H_{\text{eff}} = \frac{\omega_{\text{ZF}}}{4} S_z^2$$

zero field splitting

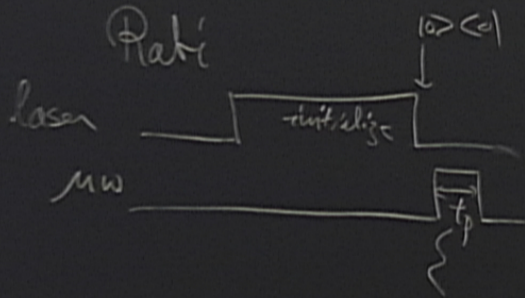
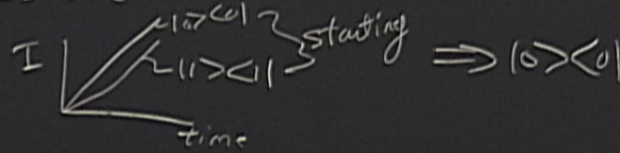
Plate

laser

M

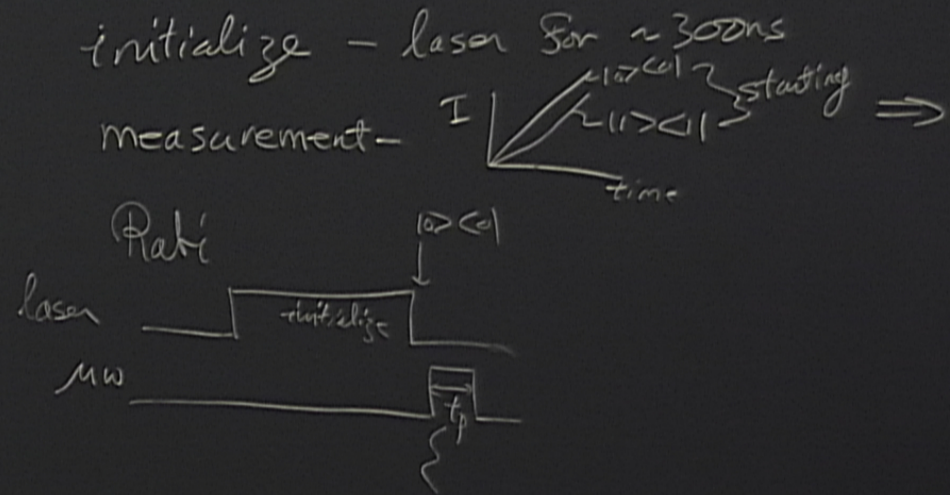
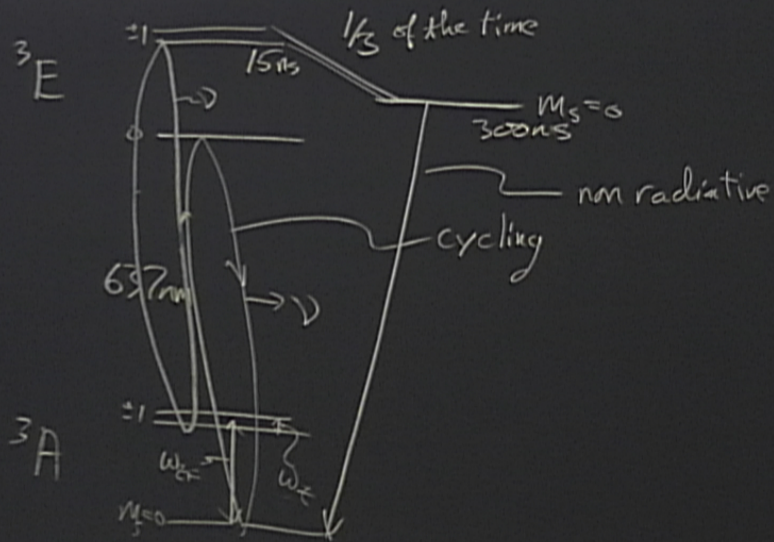
initialize - laser for ~ 300 ns

measurement -



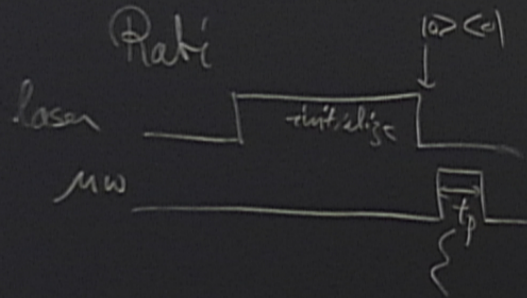
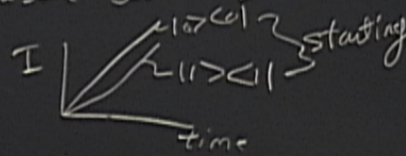
$$H_{MW} = \frac{\omega_{ZF}}{4} S_z^2 + \frac{\omega_z}{2} S_z$$

zero field splitting



initialize - laser for ~ 300 ns

measurement -



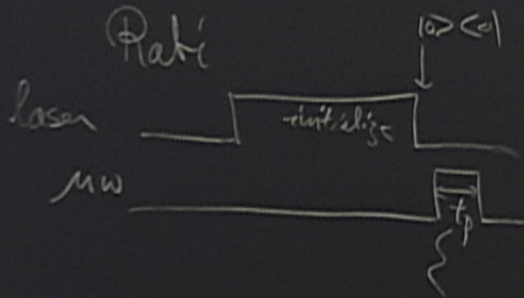
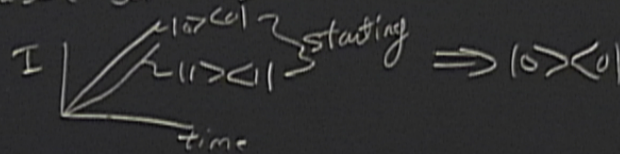
$$H_{NV} = \frac{\omega_{zF}}{4} S_z^2 + \frac{\omega_z}{2} S_z$$

zero field splitting

$$S_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}; S_z^2 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

initialize - laser for ~ 300 ns

measurement -



$$H_{NV} = \frac{\omega_{zF}}{4} S_z^2 + \frac{\omega_z}{2} S_z$$

zero field splitting

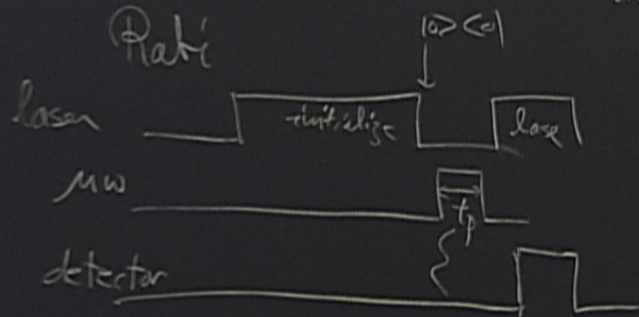
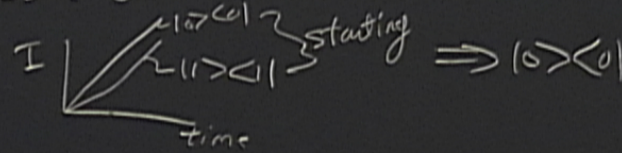
$$S_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}; S_z^2 = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

$$S_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{pmatrix}$$

$$H_{ad} = \frac{\omega_{ad}}{2} S_x$$

initialize - laser for ~ 300 ns

measurement -



$$H_{NV} = \frac{\omega_{zF}}{4} S_z^2 + \frac{\omega_z}{2} S_z$$

zero field splitting

$$S_z = \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}; S_x = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

$$S_x = \begin{pmatrix} 0 & 1 \\ 1 & 0 \\ 0 & 1 \\ 0 & 0 \end{pmatrix}$$

$$H_{mw} = \frac{\omega_{mw}}{2} S_x$$

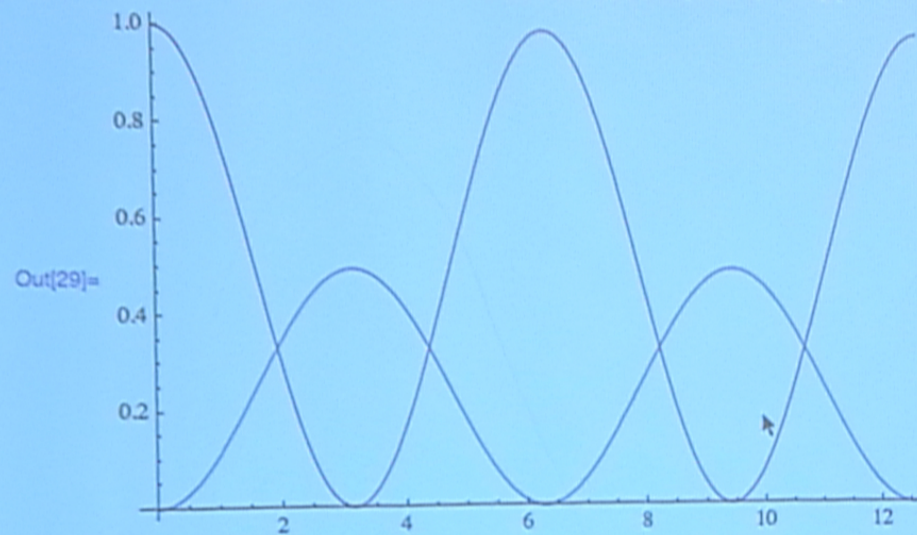

```
In[8]:= Ui[wz_, wzf_, t_] := MatrixExp[- I (wz Sz + wzf Szz) t]
```

```
In[19]:= Upulse[ $\theta$ ] := MatrixExp[I  $\theta$  Sx / (2 Sqrt[2])]
```

```
In[20]:= Upulsei[ $\theta$ ] := MatrixExp[- I  $\theta$  Sx / (2 Sqrt[2])]
```

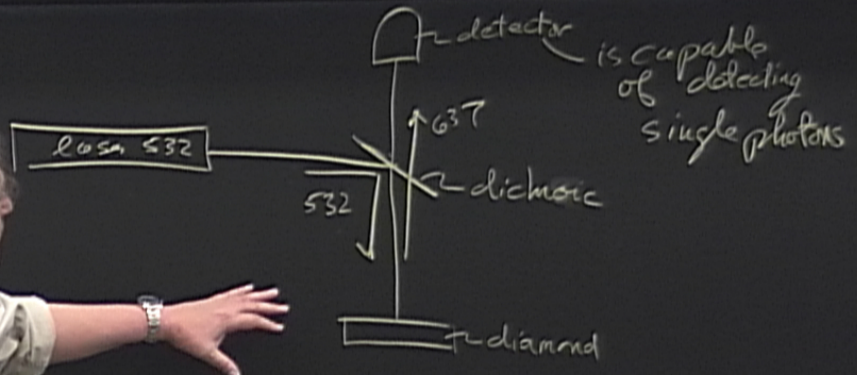
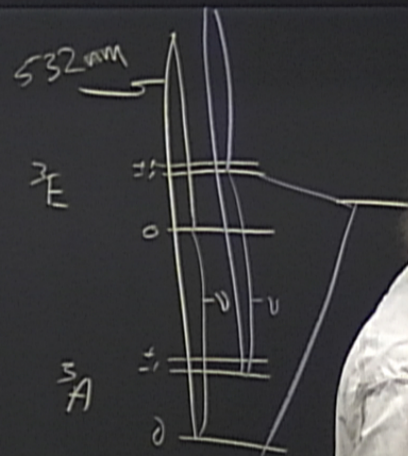
```
In[28]:=  $\rho$ [ $\theta$ ] := Upulse[ $\theta$ ] .  $\rho$ in . Upulsei[ $\theta$ ]
```

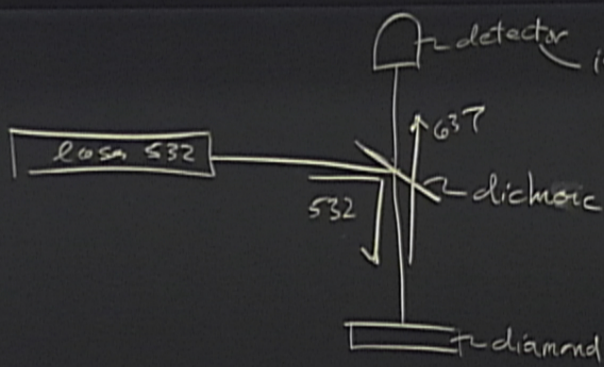
```
In[29]:= Plot[{ $\rho$ [ $\theta$ ][[1, 1]],  $\rho$ [ $\theta$ ][[2, 2]]}, { $\theta$ , 0, 4  $\pi$ }]
```



```
In[32]:=  $\rho$ 2[ $\theta$ , t_, wz_, wzf_] :=  
Upulse[ $\theta$ ] . U[wz, wzf, t] . Upulse[ $\theta$ ] .  $\rho$ in . Upulsei[ $\theta$ ] . Ui[wz, wzf, t] .  
Upulsei[ $\theta$ ]
```

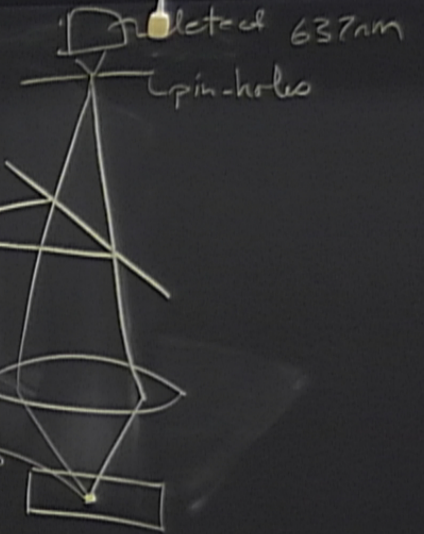
```
In[39]:= Re[ $\rho$ 2[2, .01, 0, 3000]][[2, 2]] // N
```

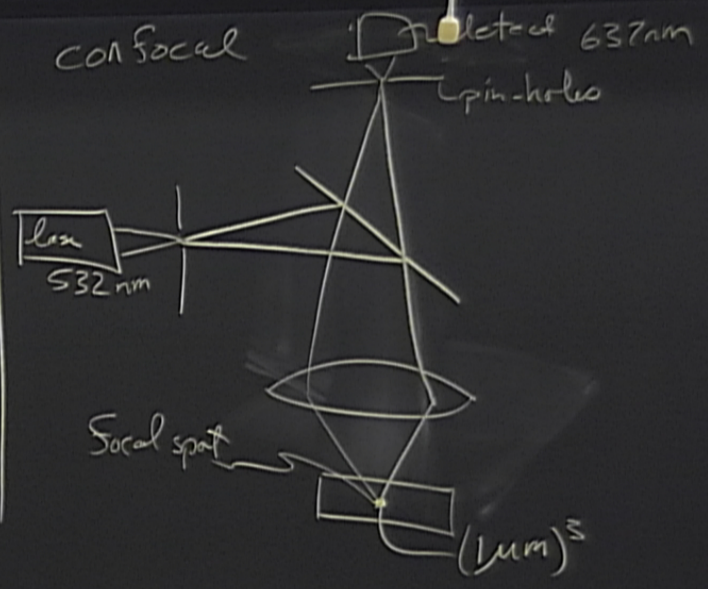
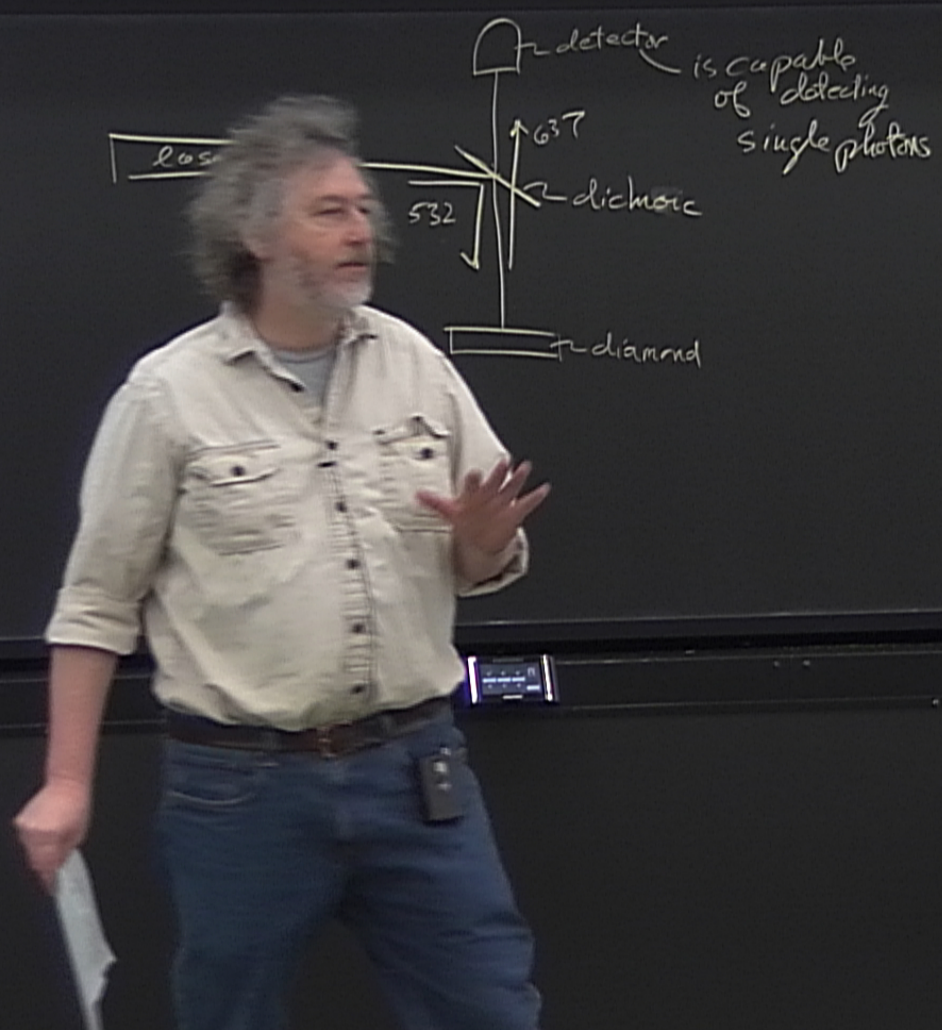



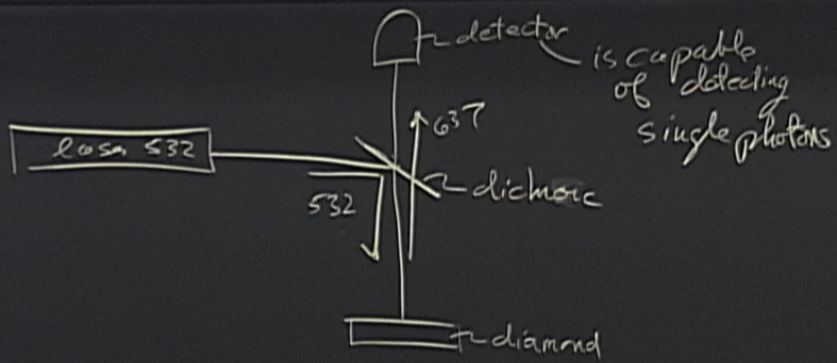


is capable of detecting single p

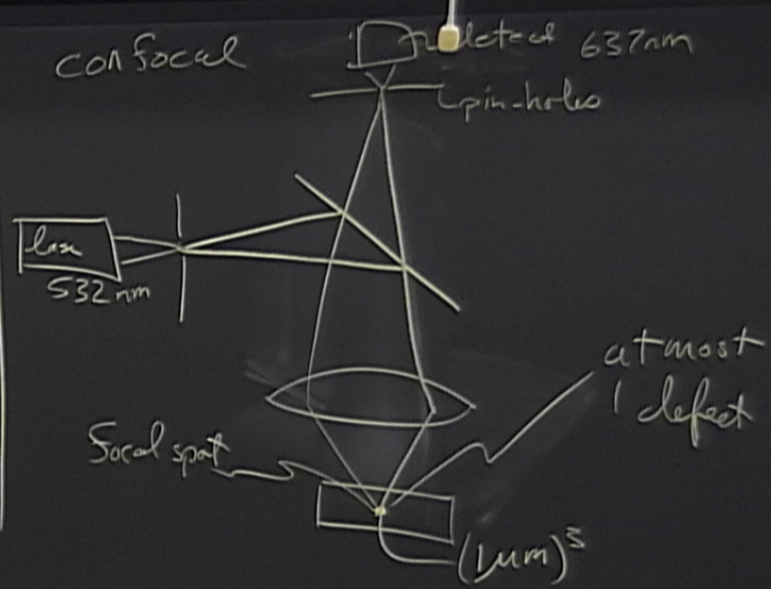
CONFOCAL

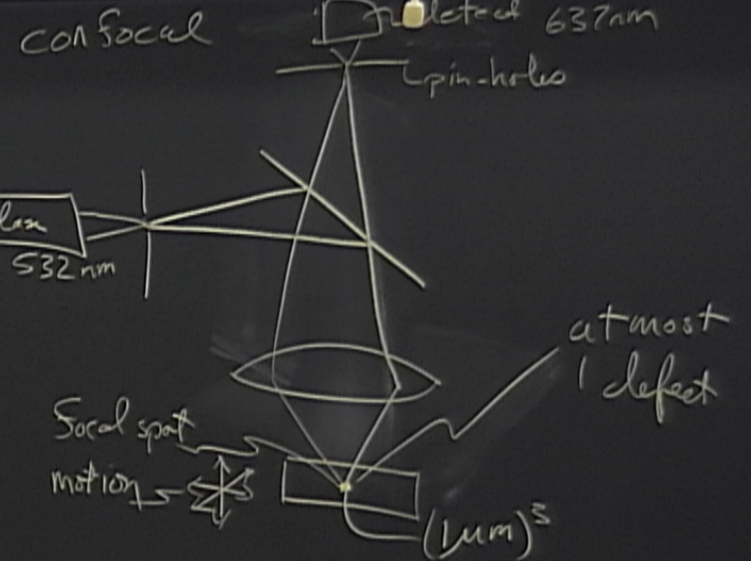
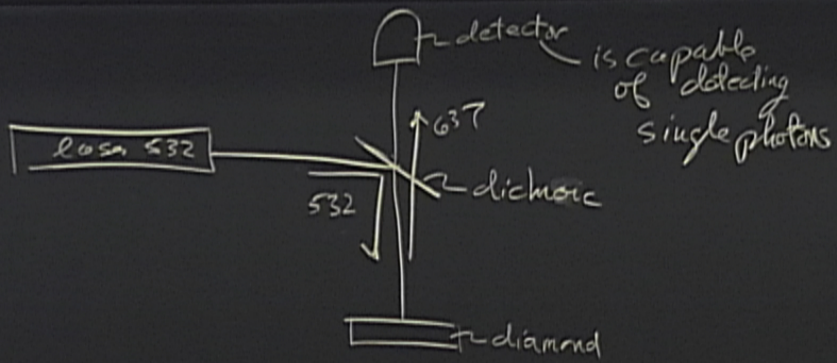






CONFOCAL



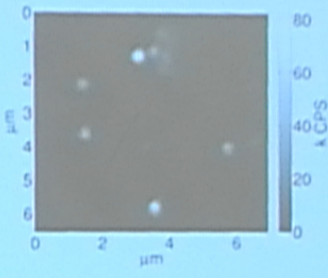
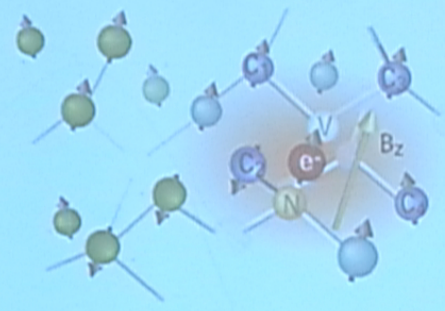


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Slide Themes Slide Layouts Transitions Table Styles Charts SmartArt Graphics WordArt

Diamond NV



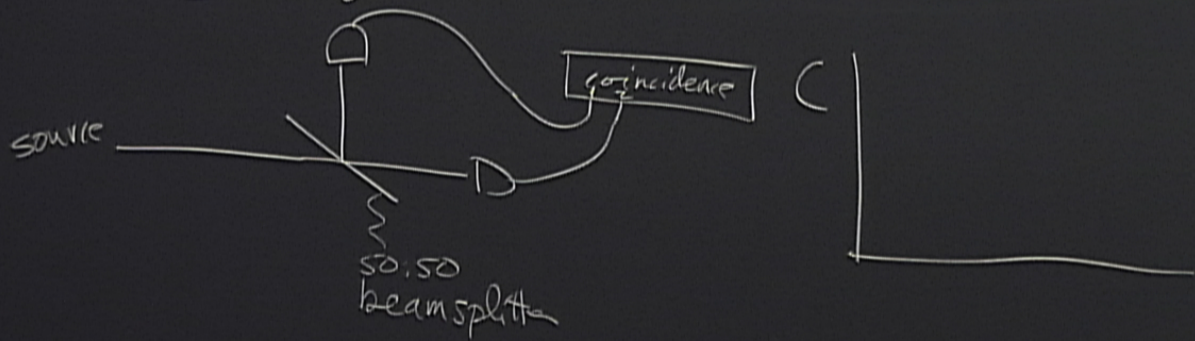
Microsoft PowerPoint IQC

Click to add notes

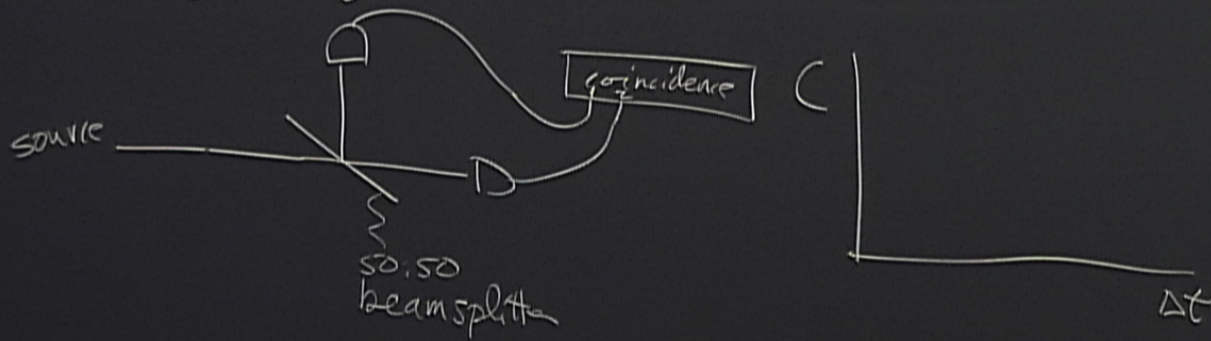
4

Calendar, Search, Network, and other system tray icons are visible at the bottom of the screen.

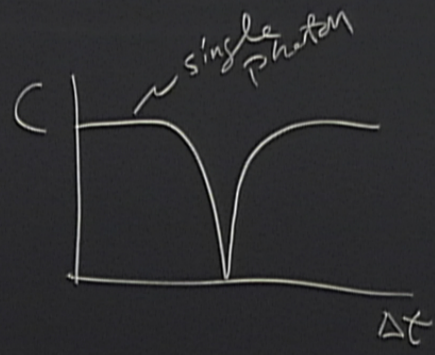
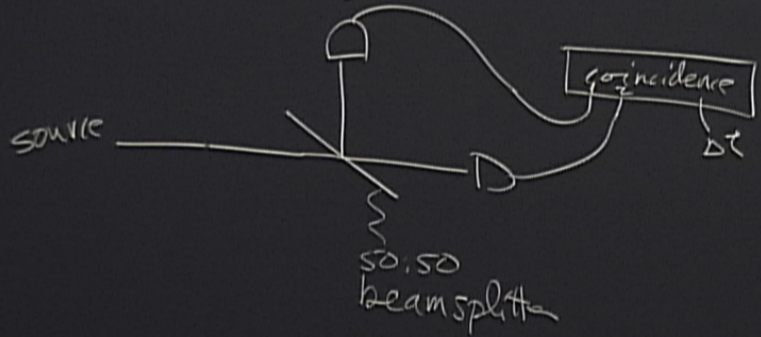
Hanbury Brown Twiss



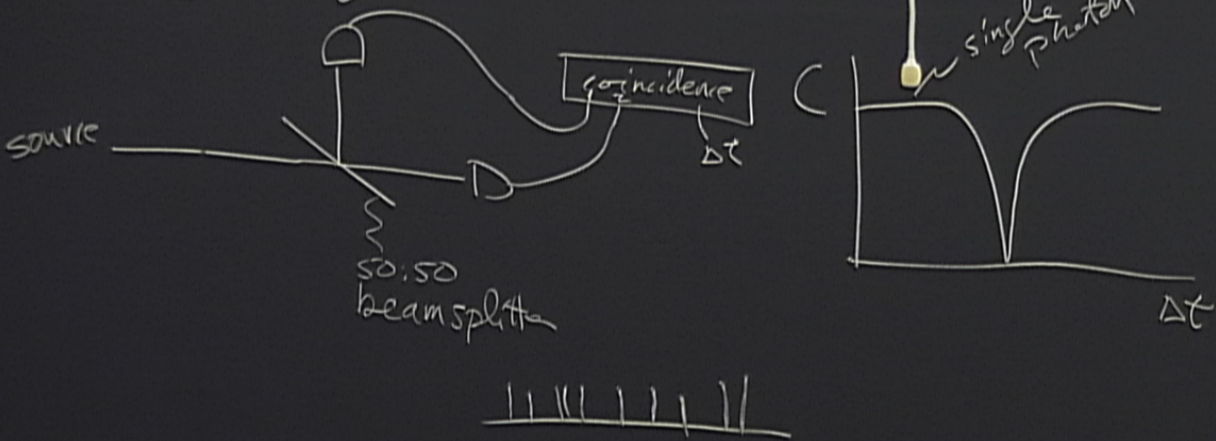
Hanbury Brown Twiss



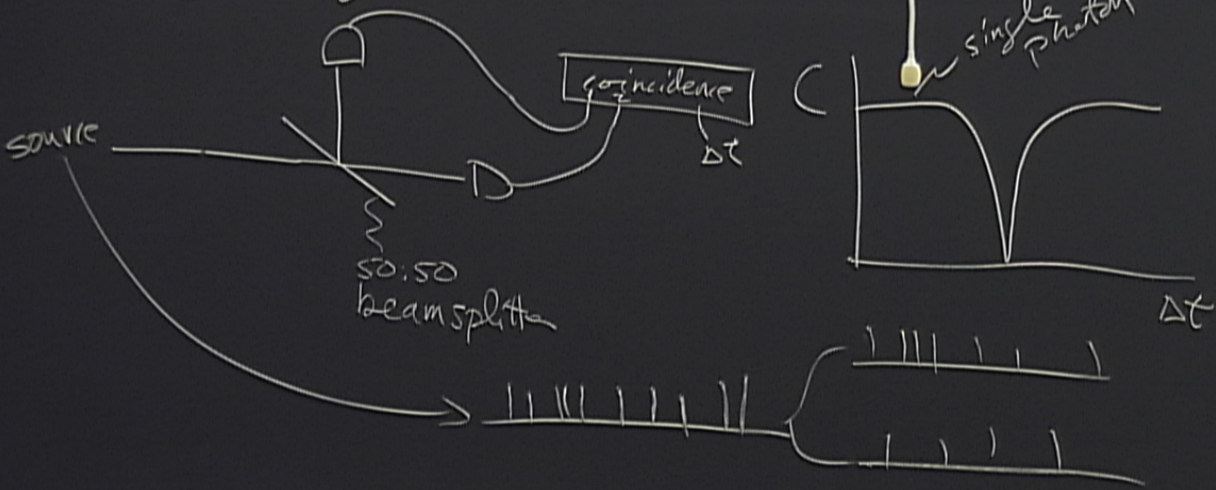
Hanbury Brown Twiss



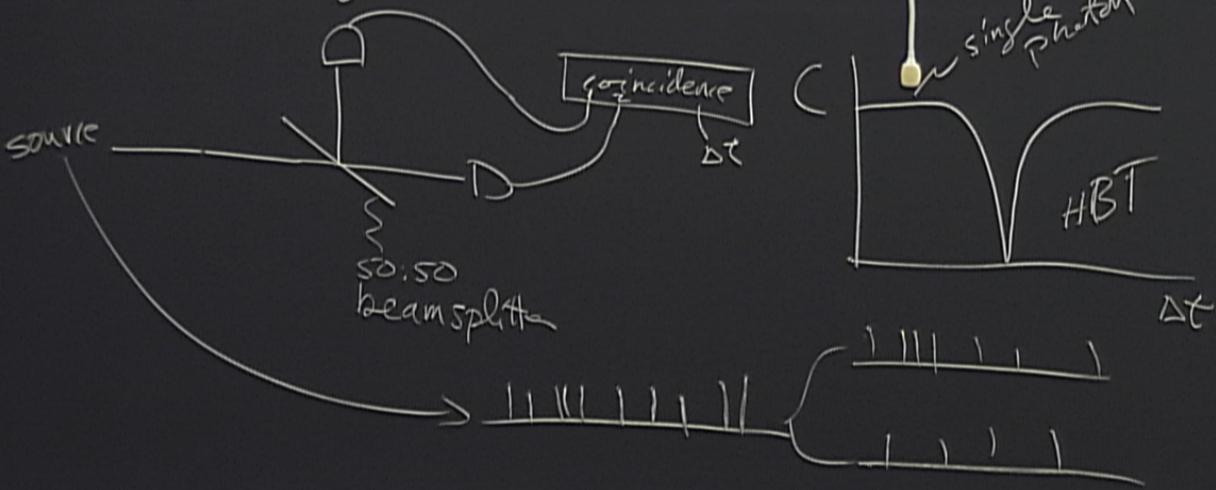
Hanbury Brown Tass



Hanbury Brown Tass



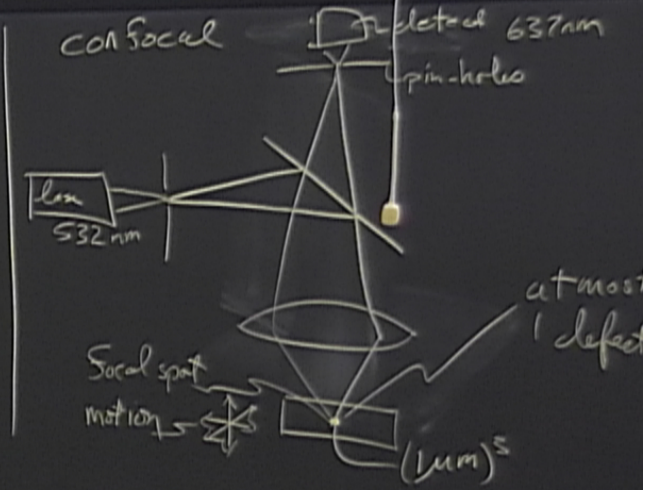
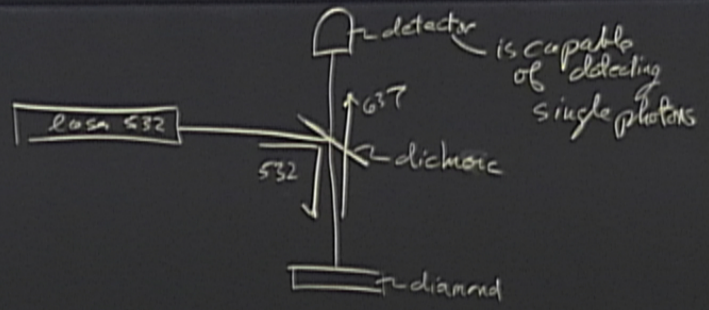
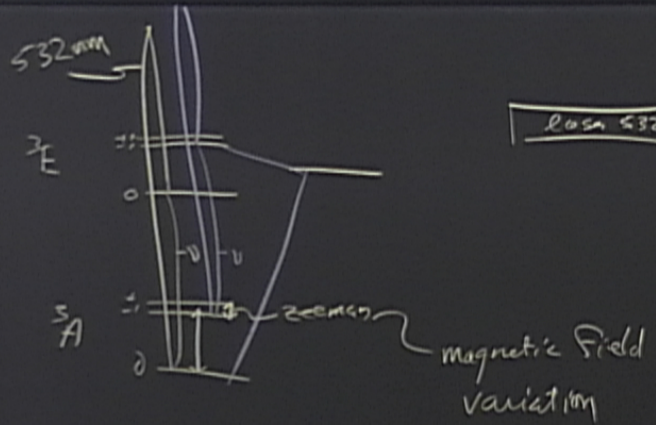
Hanbury Brown Tass



1. scalable map to qubits

$\mathcal{F}(lum)^2$

- Ψ (lum)²
1. scalable map to qubits
 - ✓ 2. initialize
 - ✓ 3. universal control
 - ✓ 4. qubit specific measurement



S_1 noise