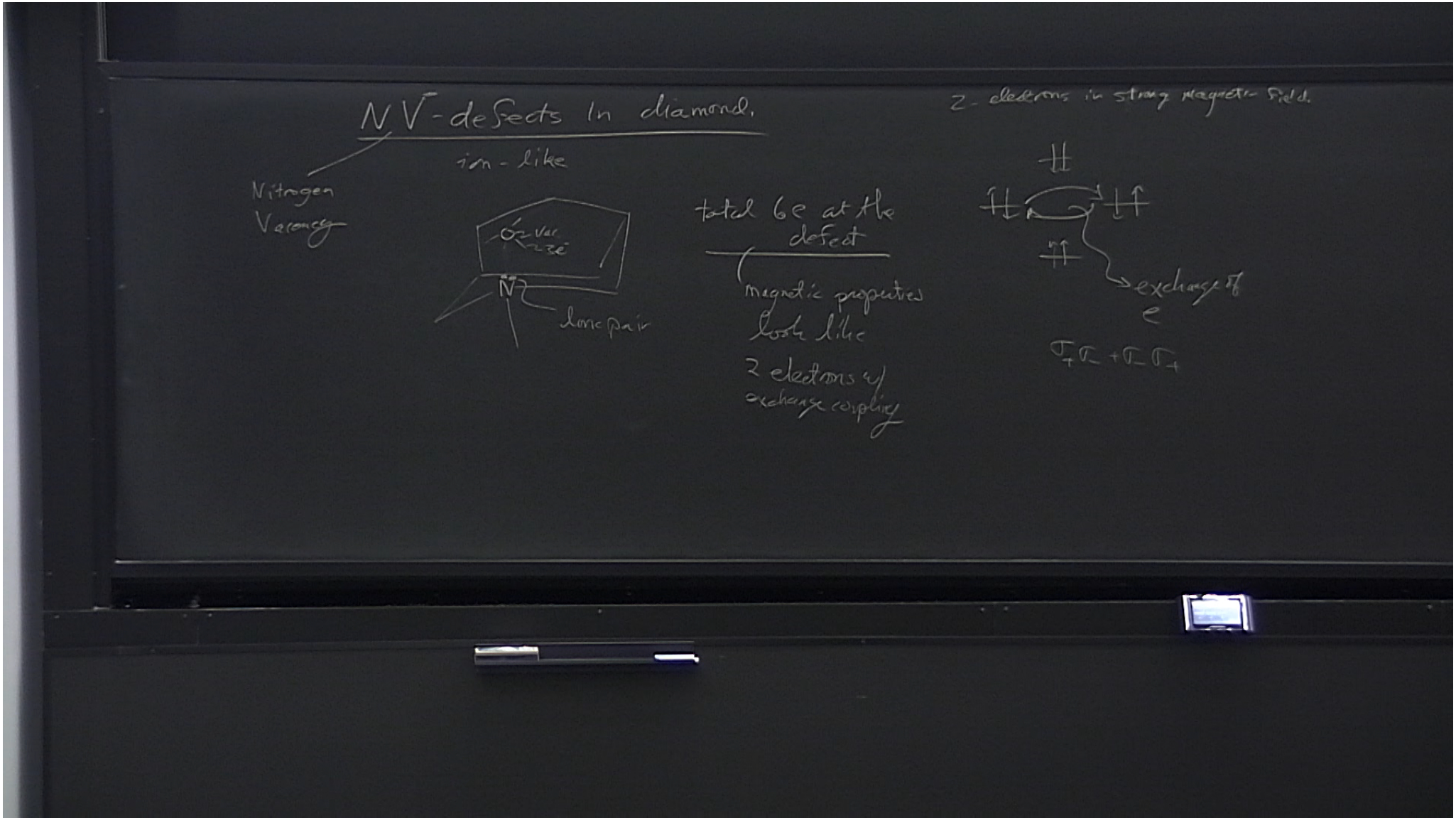
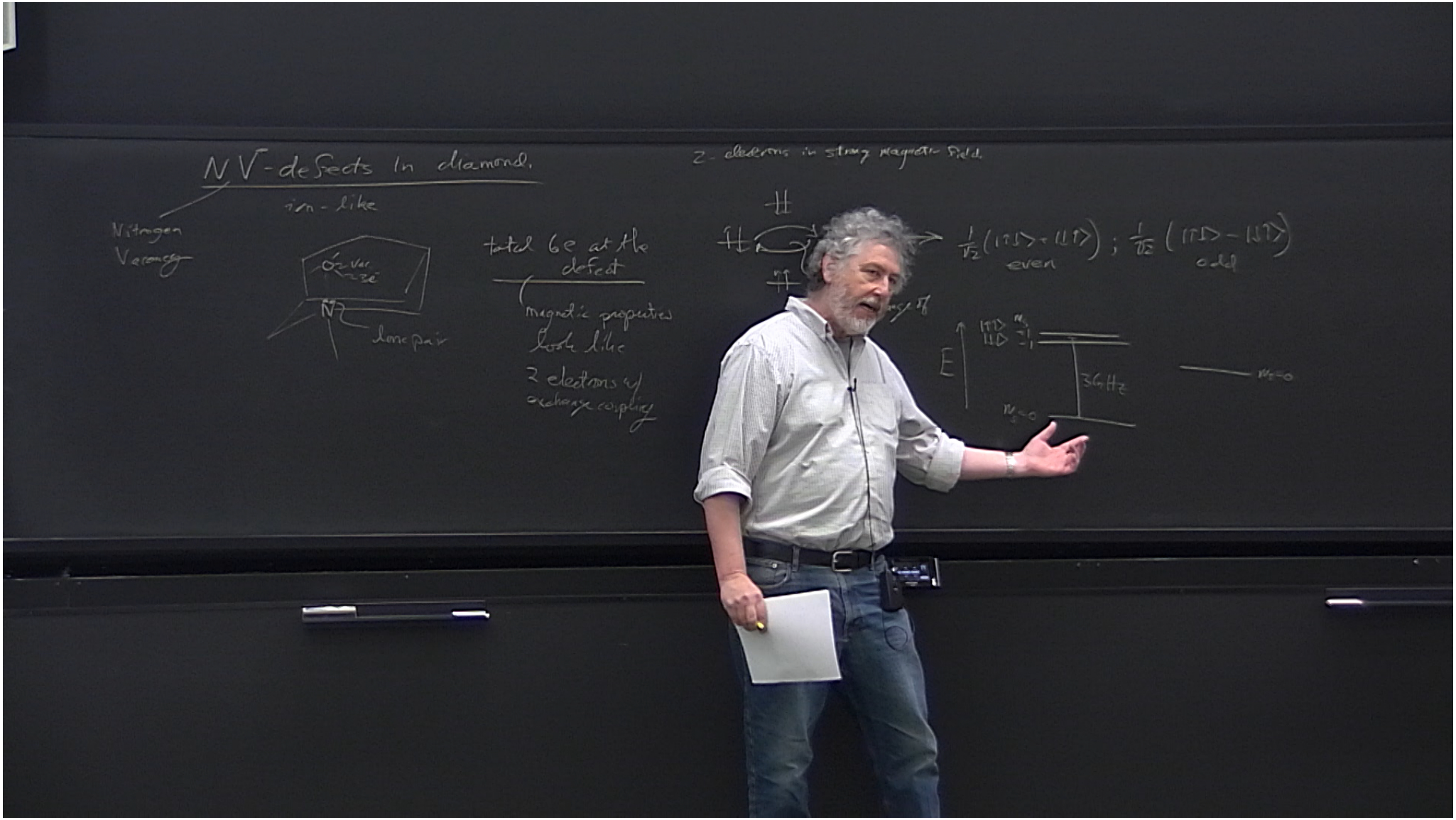
Title: PSI 2016/2017 Explorations in Quantum Information - Lecture 7

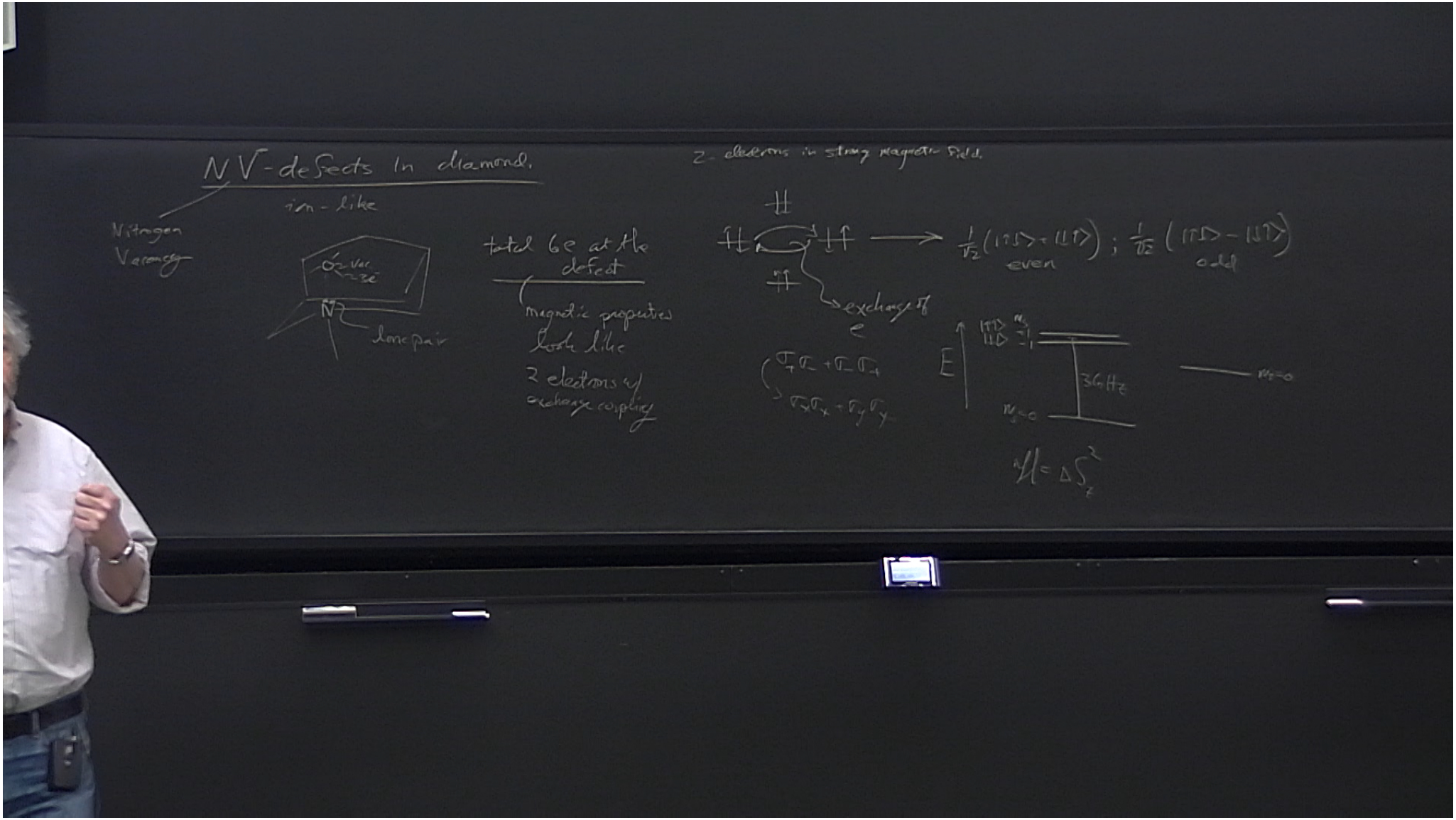
Date: Mar 28, 2017 09:00 AM

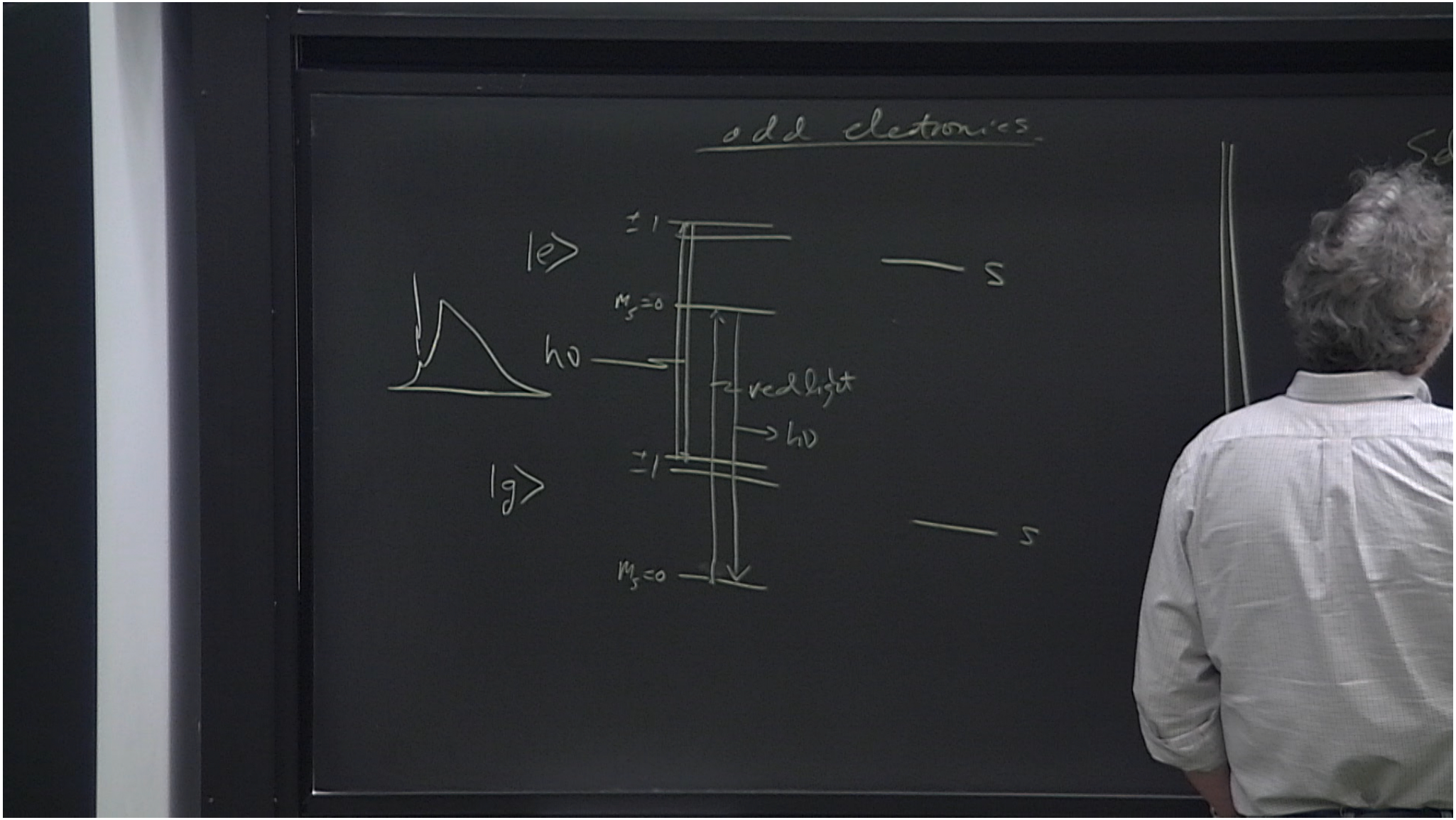
URL: http://pirsa.org/17030064

Abstract:


NV-defects in diamond.
ion-like
Nitrogen
Vacancy
O2 Vac
N
lone pair
total 6e at the defect
magnetic properties look like
2 electrons w/ exchange coupling
2-electrons in strong magnetic field.
exchange of e


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2- electrons in strong magnetic field.
ion-like
Nitrogen
Vacancy
Vac
N
lone pair
total 6e at the defect
magnetic properties look like
2 electrons w/ exchange coupling
E
36 GHz


NV-defects in diamond.
2- electrons in strong magnetic field.
Nitrogen
Vacancy
N
lone pair
total 6e at the defect
magnetic properties
2 electrons w/
exchange coupling
exchange of e
even
odd
E
36 GHz
$m_s=0$
$m_s=0$
$\mathcal{H} = \Delta S_z^2$


odd electronics
|e>
|g>
hν
red light
hν
S
S

$\mathcal{H} = \Delta S_z$

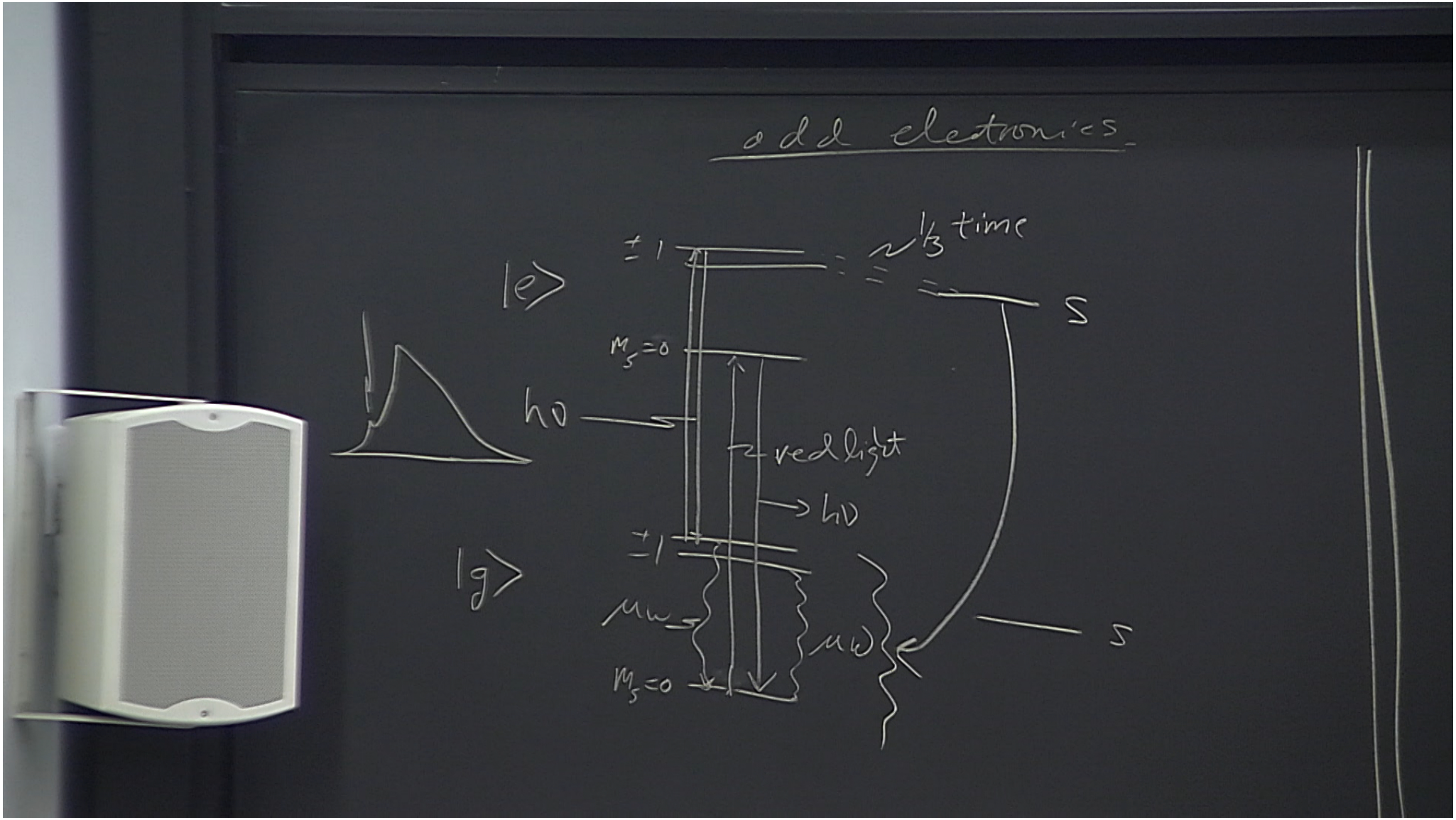
Selection rule
operator dipole
$\sigma_x^A \otimes \mathbb{1} + \mathbb{1} \otimes \sigma_x^B$

$\left| \langle \uparrow\uparrow | \sigma_x^A + \sigma_x^B \left(\frac{|\uparrow\downarrow\rangle + |\downarrow\uparrow\rangle}{\sqrt{2}} \right) \right|^2 \neq 0$ is allowed

$\left| \langle \uparrow\uparrow | \sigma_x^A + \sigma_x^B |\downarrow\downarrow\rangle \right|^2 = 0$

$\left| \langle \uparrow\uparrow | \sigma_x^A + \sigma_x^B \left(\frac{|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle}{\sqrt{2}} \right) \right|^2$

$\langle \uparrow\uparrow | \uparrow\uparrow \rangle - \langle \uparrow\uparrow | \uparrow\uparrow \rangle = 0$


odd electronics
±1
1/3 time
|e>
S
$m_s=0$
hν
red light
hν
±1
|g>
MW
MW
S
$m_s=0$

Selection rule

operator dipole

$\sigma_x^A \otimes \mathbb{1} + \mathbb{1} \otimes \sigma_x^B$

$$\left| \langle \uparrow\uparrow | \sigma_x^A + \sigma_x^B \left(\frac{|\uparrow\downarrow\rangle + |\downarrow\uparrow\rangle}{\sqrt{2}} \right) \right|^2 \neq 0 \quad \text{is allowed}$$

$$\left| \langle \uparrow\uparrow | \sigma_x^A + \sigma_x^B | \downarrow\downarrow \rangle \right|^2 = 0$$

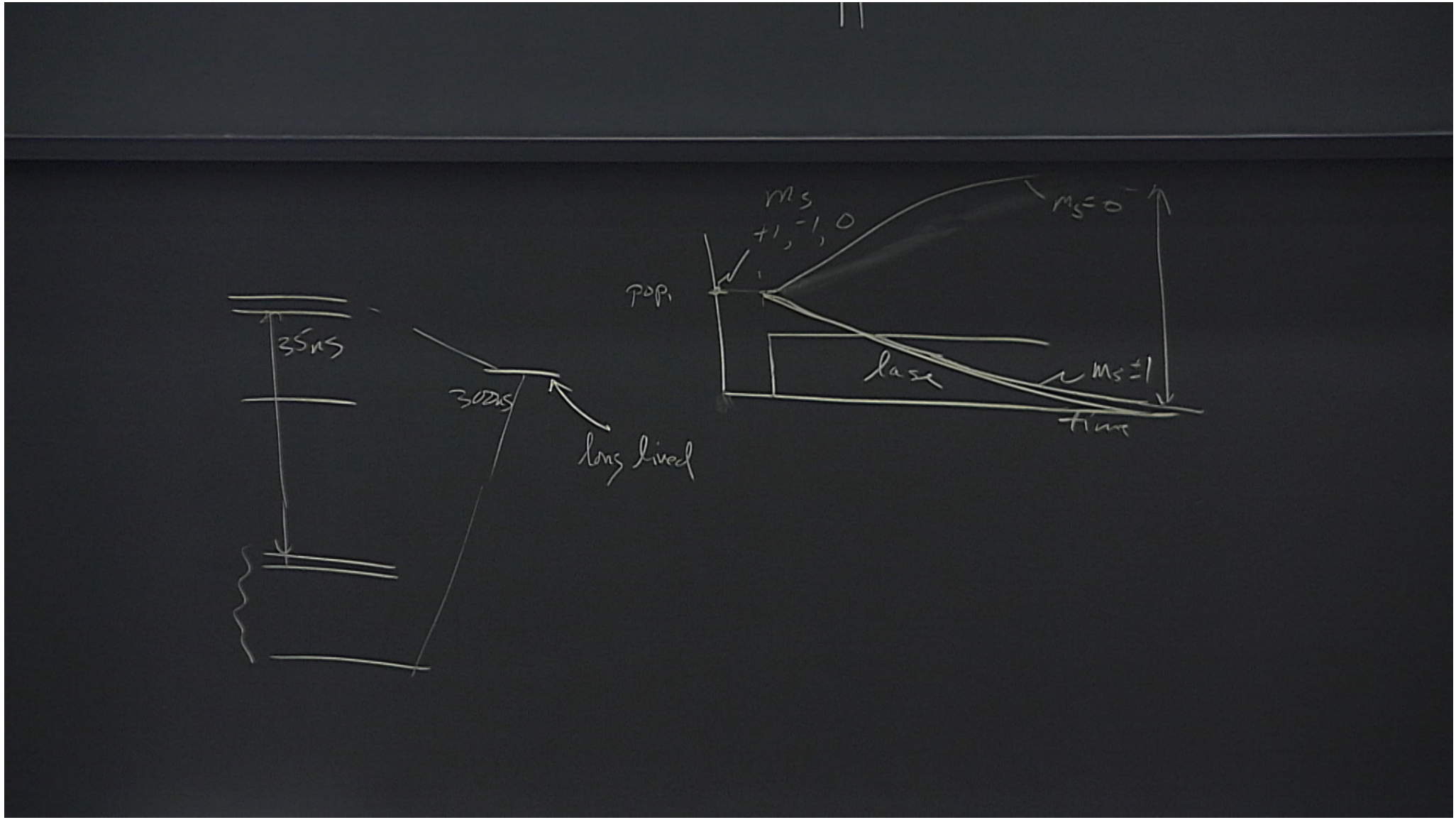
$$\left| \langle \uparrow\uparrow | \sigma_x^A + \sigma_x^B \left(\frac{|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle}{\sqrt{2}} \right) \right|^2$$

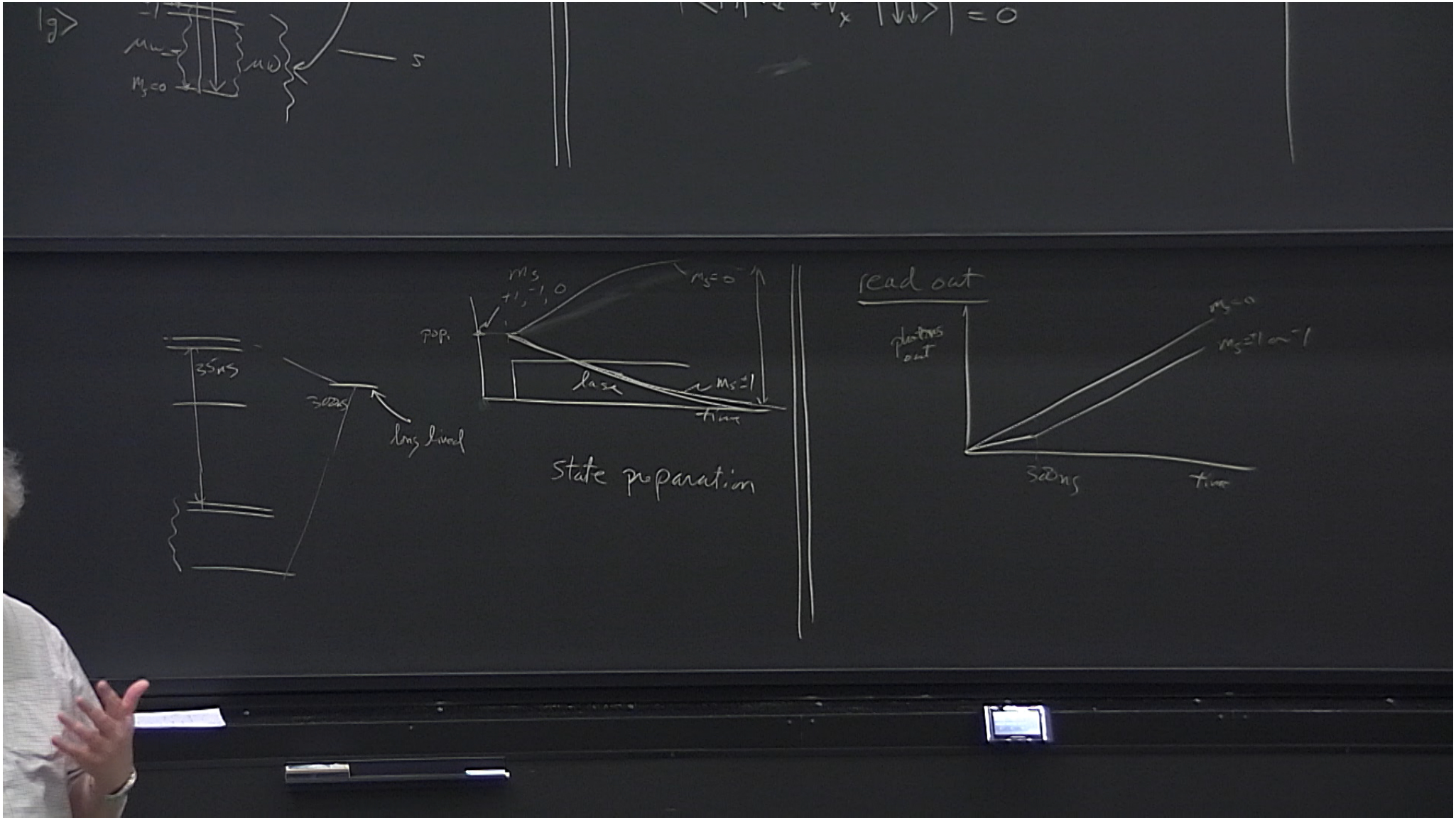
$$\langle \uparrow\uparrow | \uparrow\uparrow \rangle - \langle \uparrow\uparrow | \uparrow\uparrow \rangle = 0$$

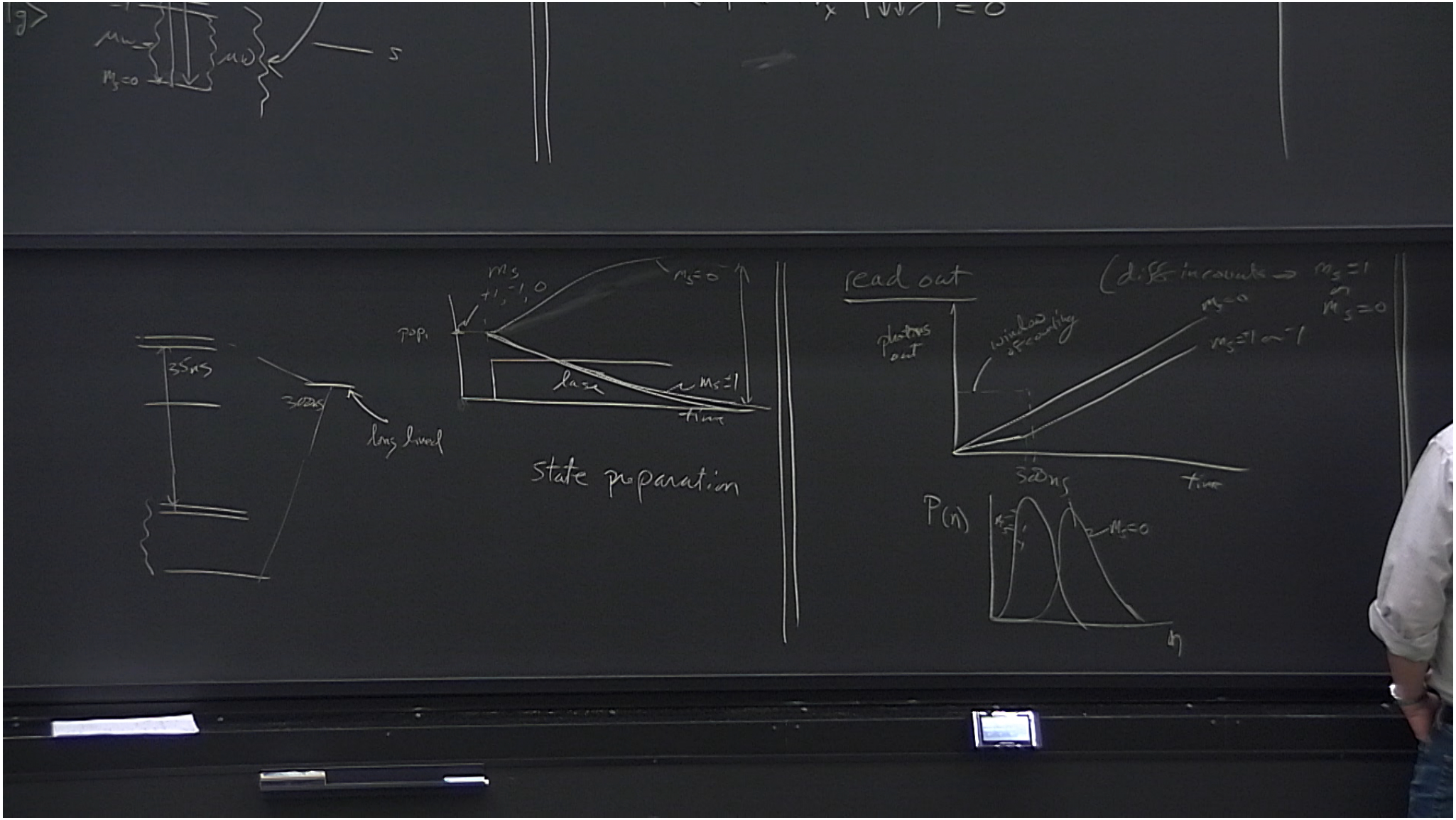
$$\alpha \sigma_x^A + \beta \sigma_x^B \quad ; \quad \alpha, \beta \sim 1$$

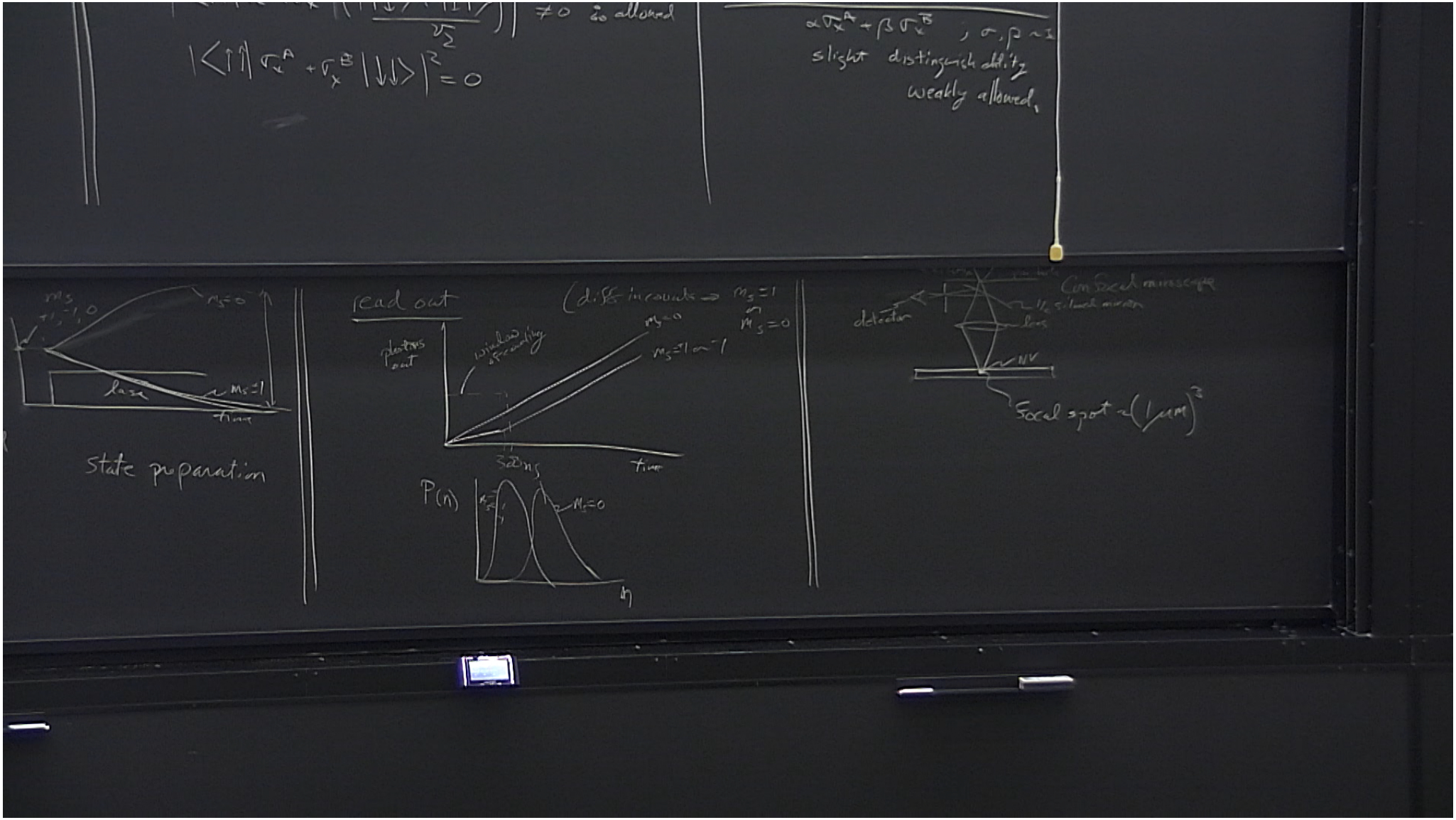
slight distinguishability

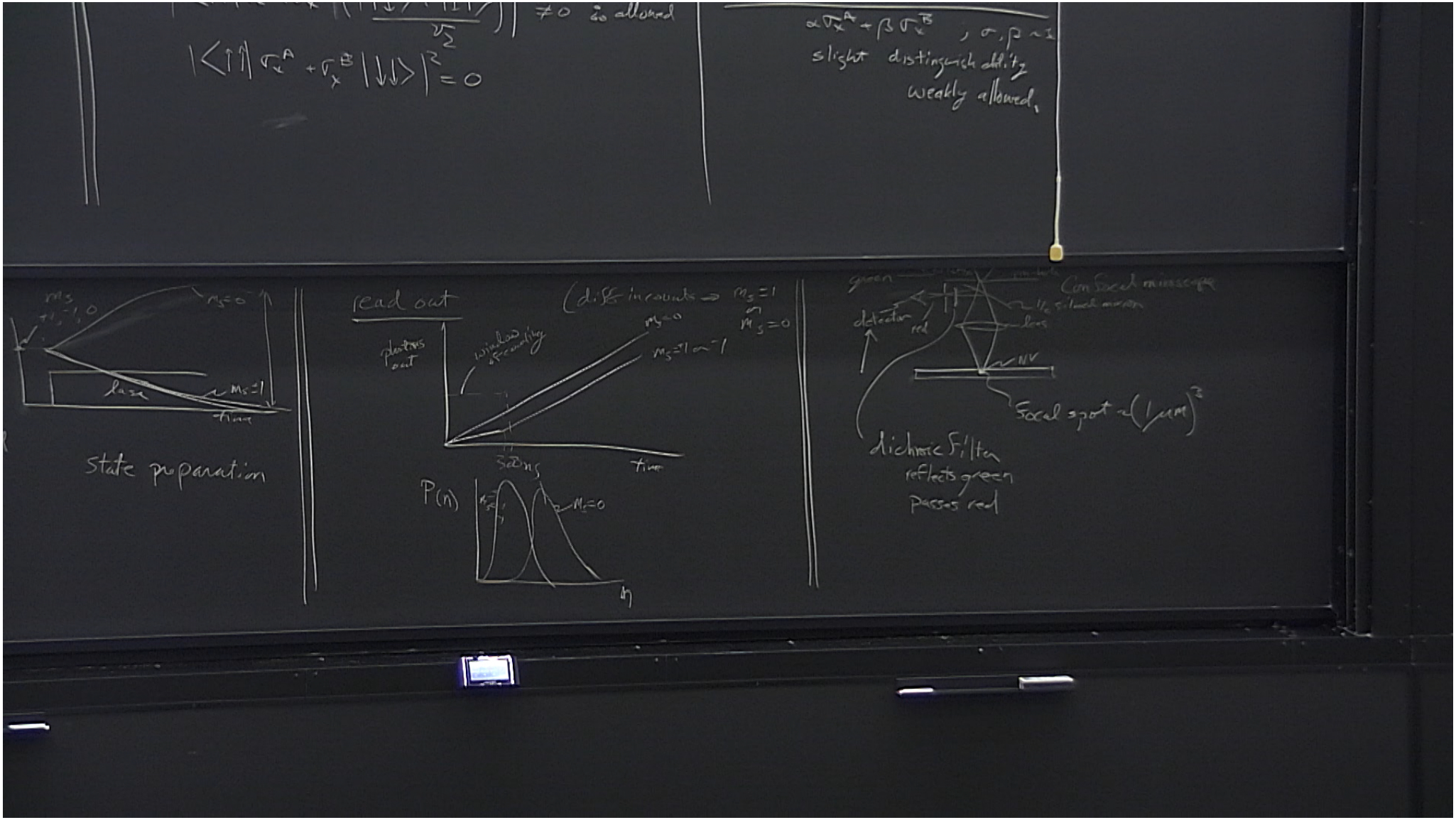
weakly allowed.

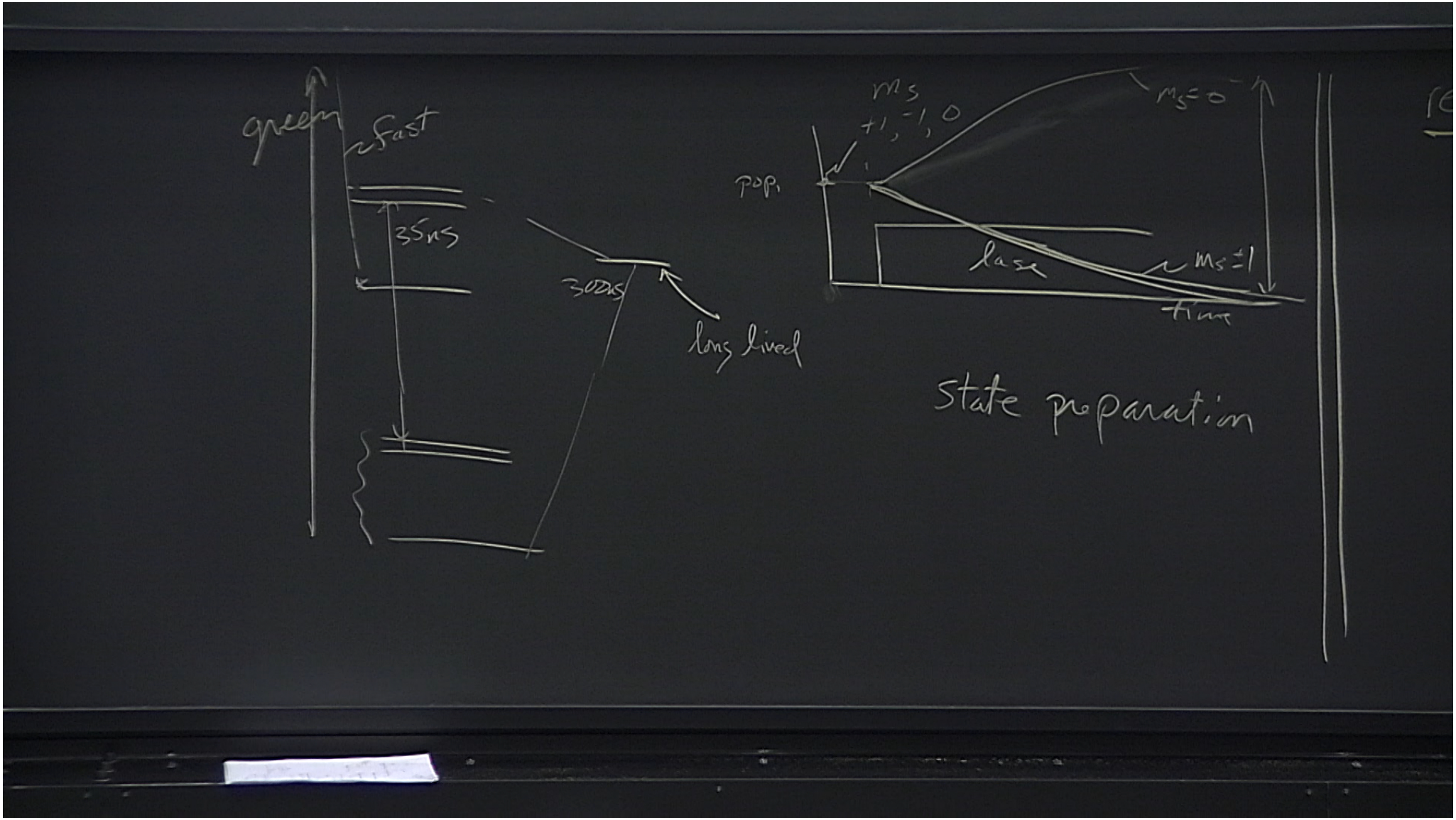

35ns
300ns
long lived
ms
+1, -1, 0
pop.
ms=0
laser
ms=±1
time

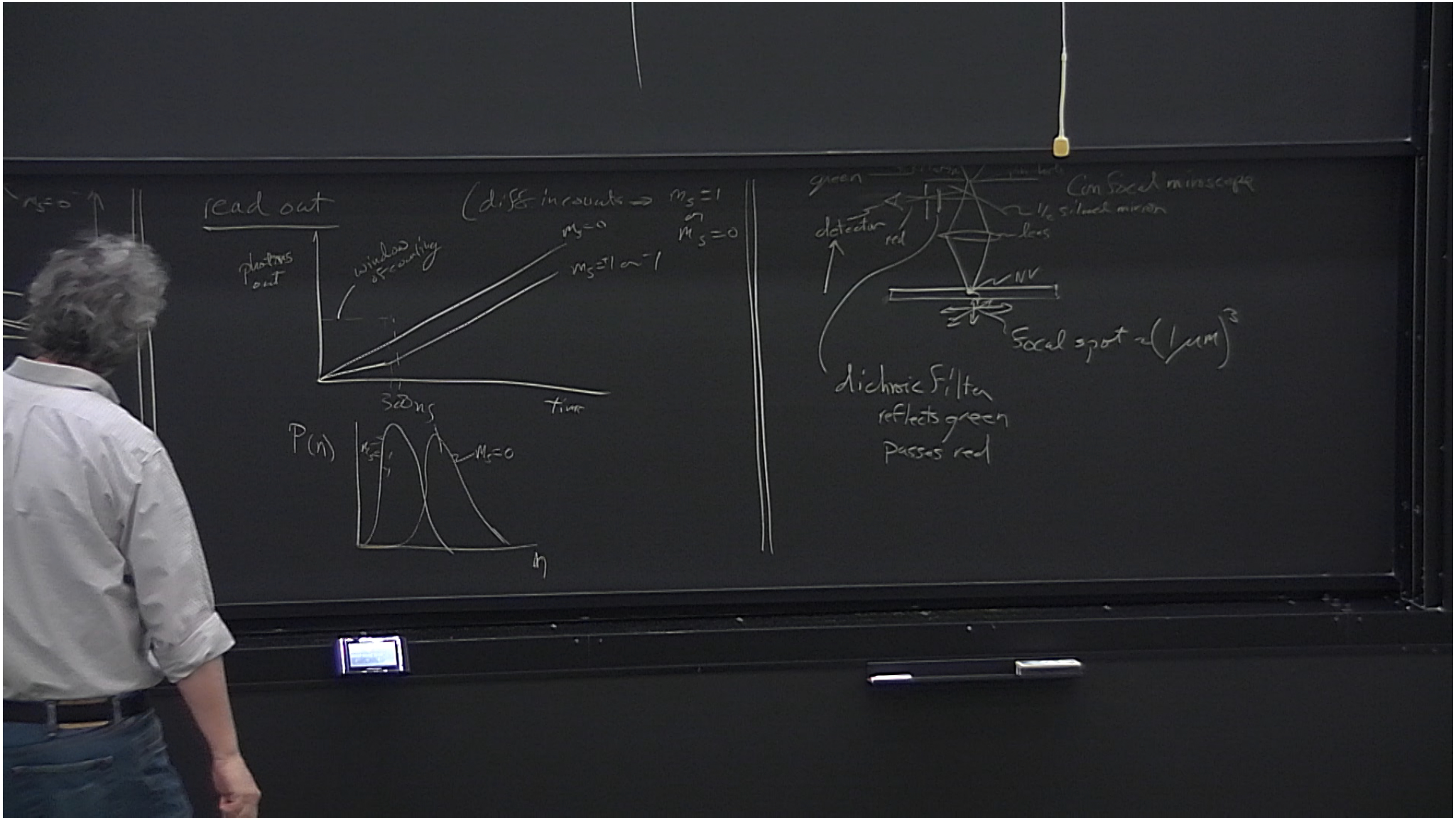

|g>
mw
ms=0
mw
s
ms
+1, -1, 0
pop.
ms=0
laser
ms=±1
time
state preparation
read out
photons out
ms=0
ms=±1 or -1
seconds
time

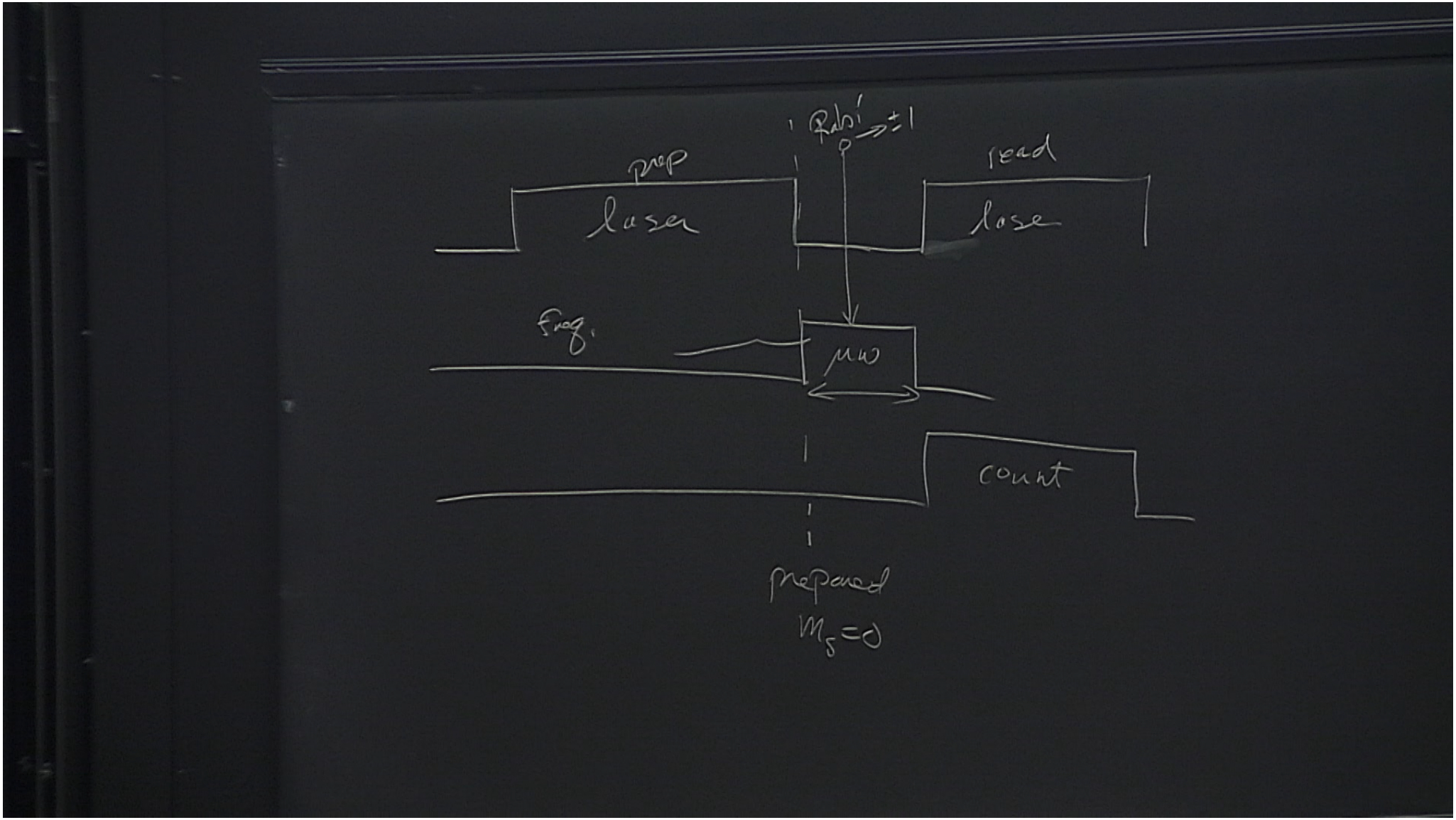

$m_s = 0$
MW
MW
5
$|g\rangle$
m_s +1, -1, 0
$m_s = 0$
Pop.
laser
$m_s = \pm 1$
time
state preparation
355 ns
300 ns
long lived
read out
photons out
(diff in counts → $m_s = 1$ or $m_s = 0$)
$m_s = 0$
$m_s = \pm 1$ or -1
time
300 ns
P(n)
n

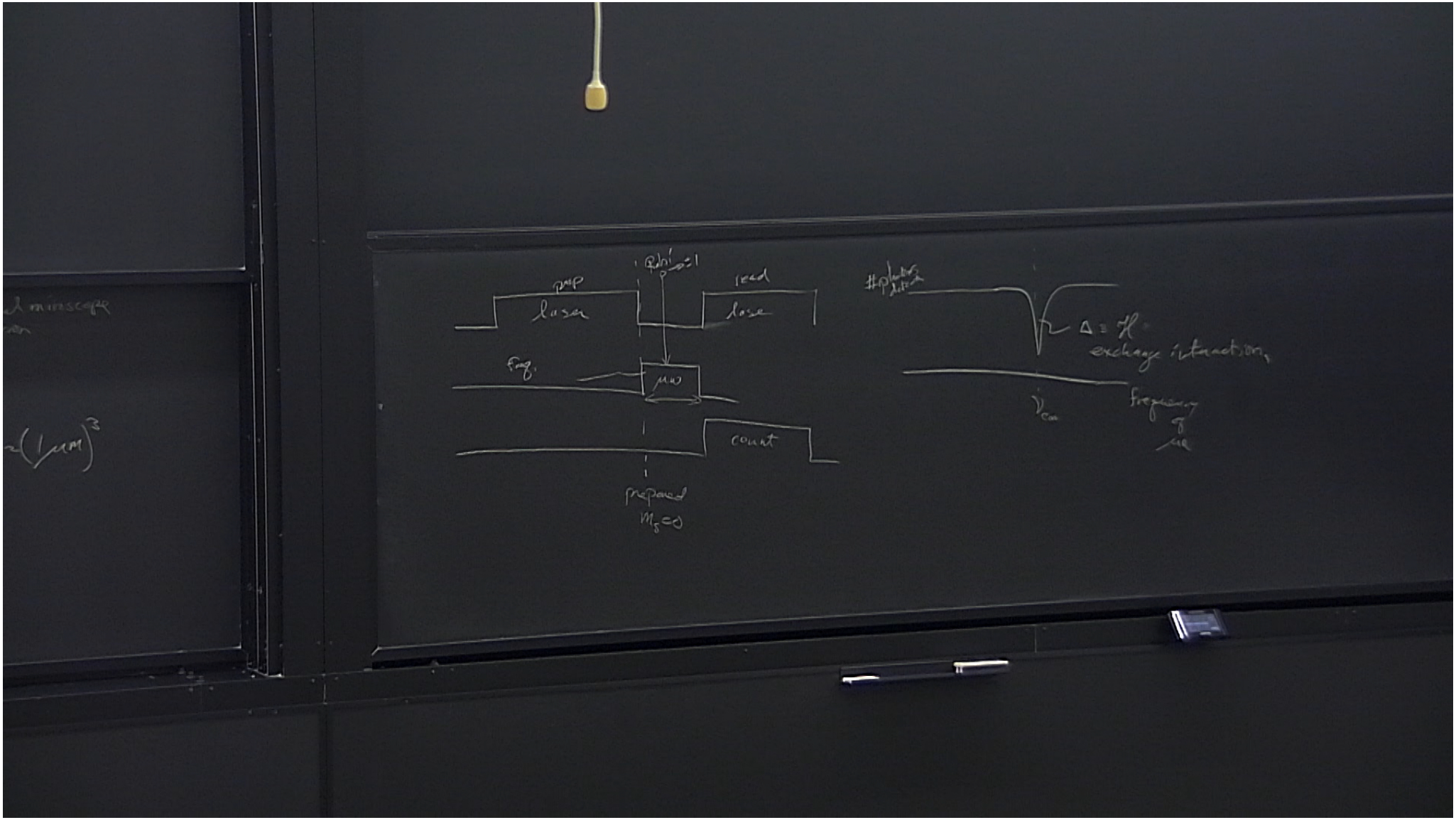

$\neq 0$ ∴ allowed
$|\langle\uparrow\uparrow|\sigma_x^A + \sigma_x^B|\downarrow\downarrow\rangle|^2 = 0$
$\alpha\sigma_x^A + \beta\sigma_x^B$; $\alpha, \beta \sim 1$
slight distinguishability
weakly allowed
m_s
$m_s=0$
$m_s=1$
laser
time
state preparation
read out
photons out
initialization & recording
$m_s=0$
$m_s=1$ or -1
$m_s=1$ or $m_s=0$
300 ns
time
P(n)
$m_s=1$
$m_s=0$
n
detection
Con focal microscope
½ silvered mirror
lens
NV
focal spot ~ (1 μm)³


$\neq 0$ ∴ allowed
$|\langle\uparrow\uparrow| \sigma_x^A + \sigma_x^B |\downarrow\downarrow\rangle|^2 = 0$
$\alpha\sigma_x^A + \beta\sigma_x^B$, $\alpha, \beta \sim 1$
slight distinguishability
weakly allowed
m_s
$m_s=0$
laser
$m_s=1$
time
state preparation
read out
(diff in counts ⇒ $m_s=1$ or $m_s=0$
photons out
initialization & recording
$m_s=0$
$m_s=1$ or -1
300ns
time
P(n)
$m_s=1$
$m_s=0$
n
green
Con Focal microscope
detector
red
lens
NV
focal spot ~ $(1\mu m)^2$
dichroic filter
reflects green
passes red


green
fast
35ns
300ns
long lived
pop.
m_s
+1, -1, 0
$m_s = 0$
laser
$m_s = \pm 1$
time
State preparation


read out
photons out
window of counting
$m_s=0$
$m_s=1$ or -1
300 ns
time
P(n)
$m_s=1$
$m_s=0$
n
green
detector
red
NV
dichroic filter
reflects green
passes red


prep
laser
Rabi
read
laser
freq.
MW
count
prepared
$m_s = 0$


pump
laser
read
laser
freq.
μw
count
prepared
$m_s = 0$
exchange interaction
frequency