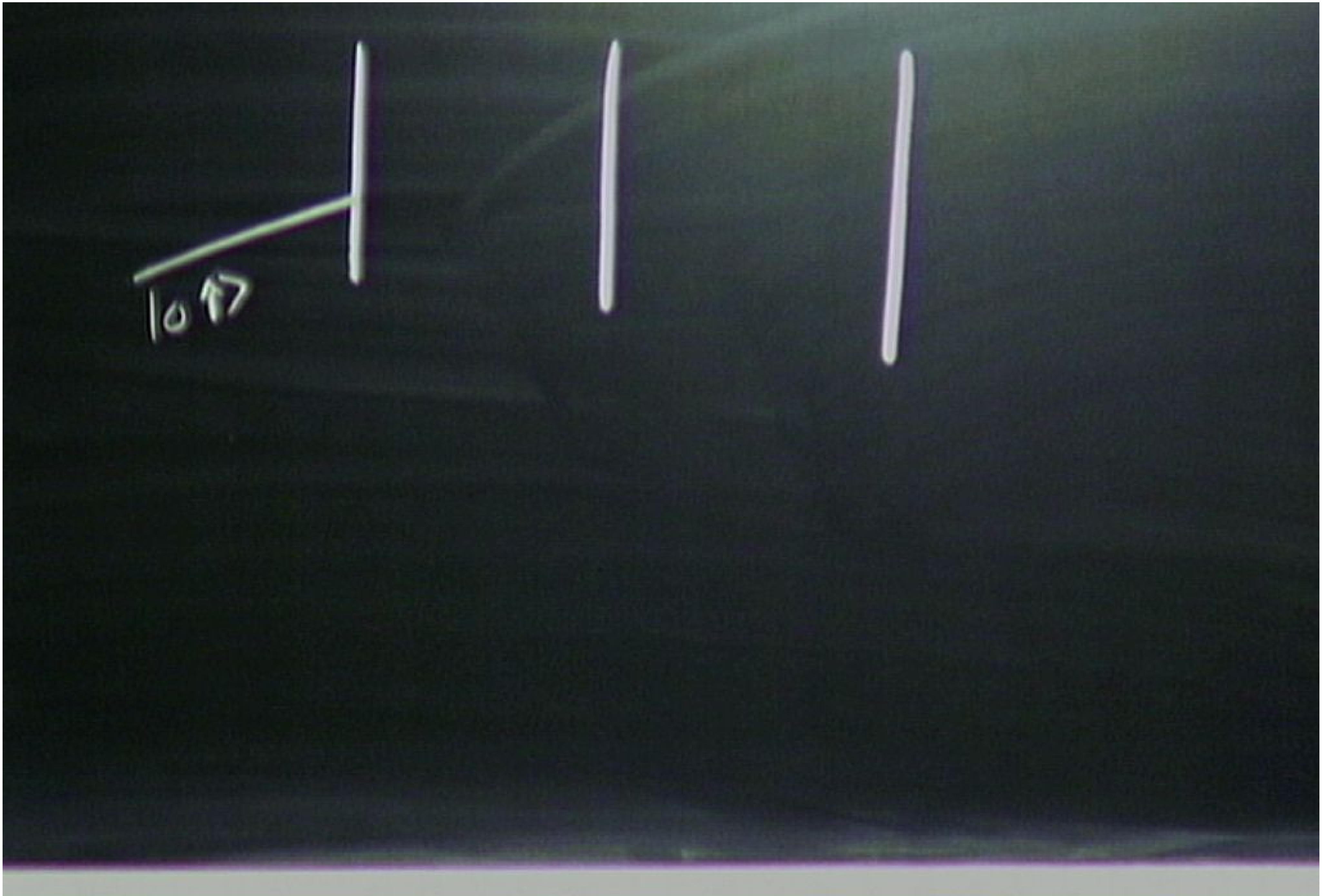
Title: Explorations in Quantum Information - Lecture 6

Date: Mar 22, 2011 09:00 AM

URL: http://pirsa.org/11030019

Abstract: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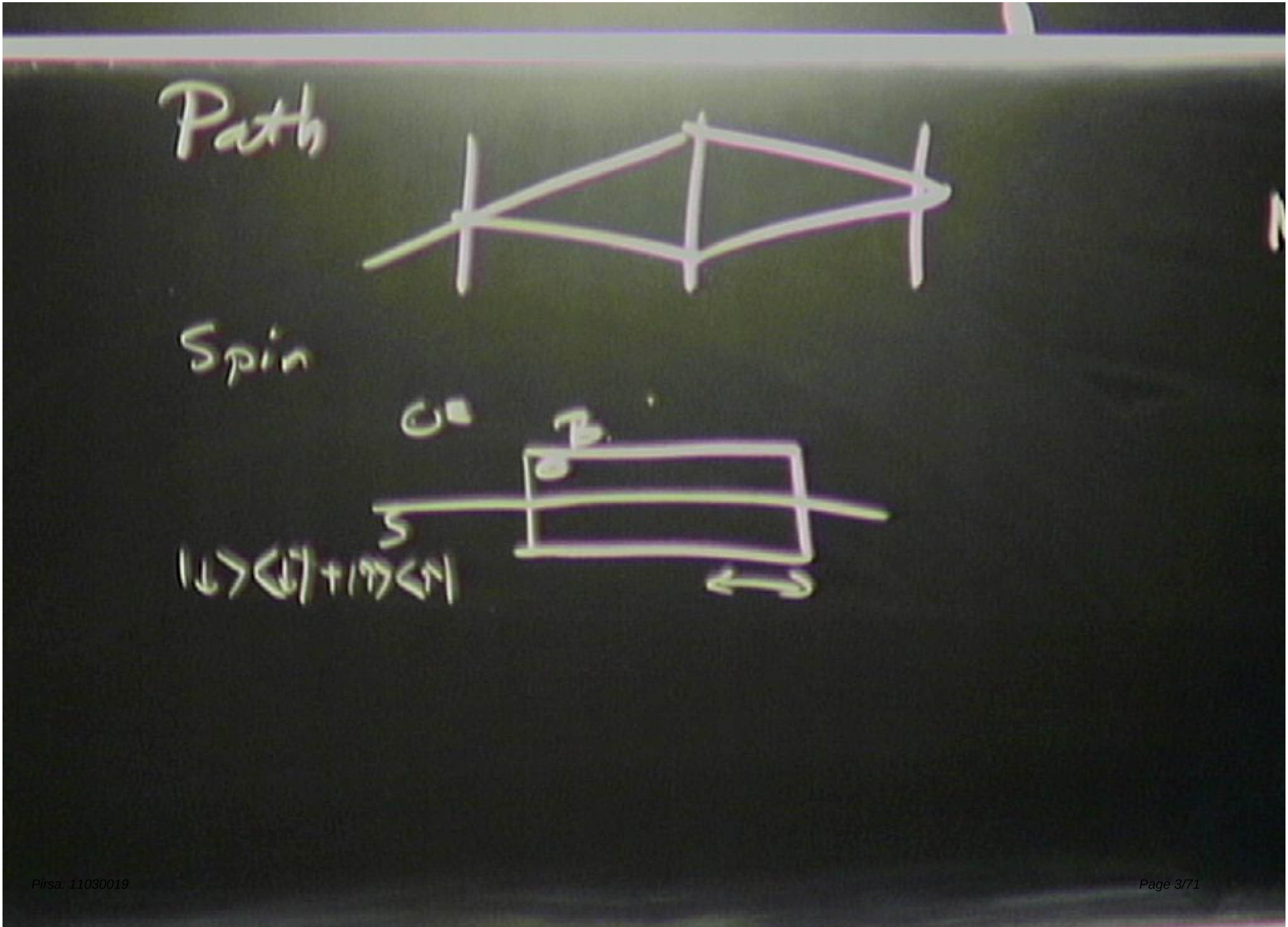
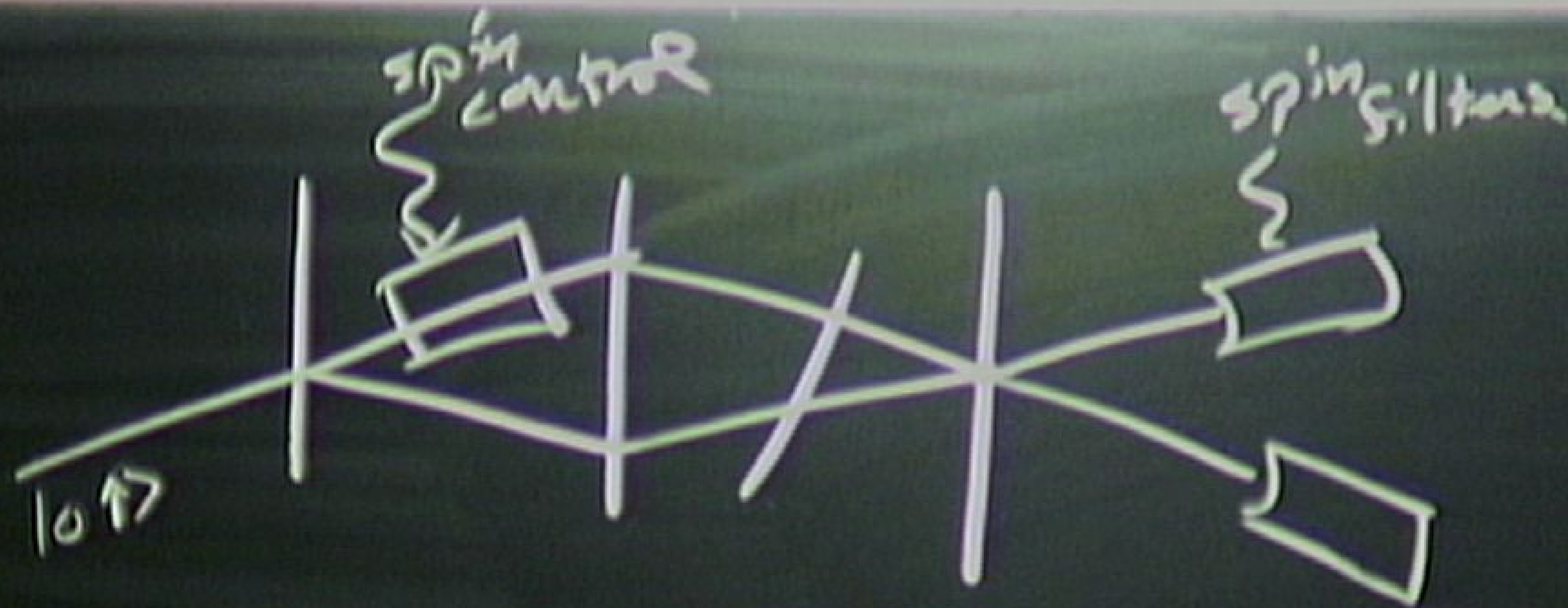
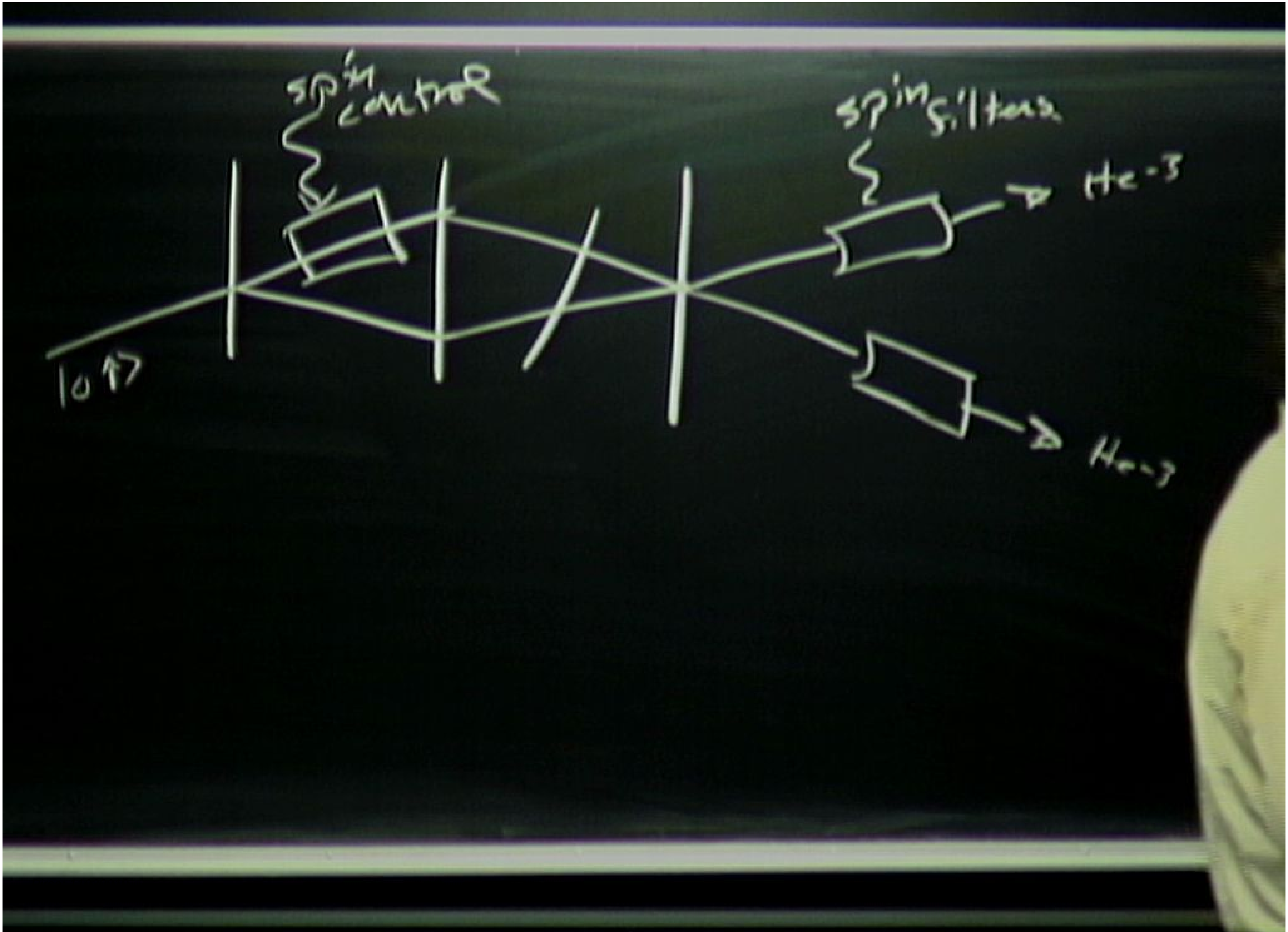
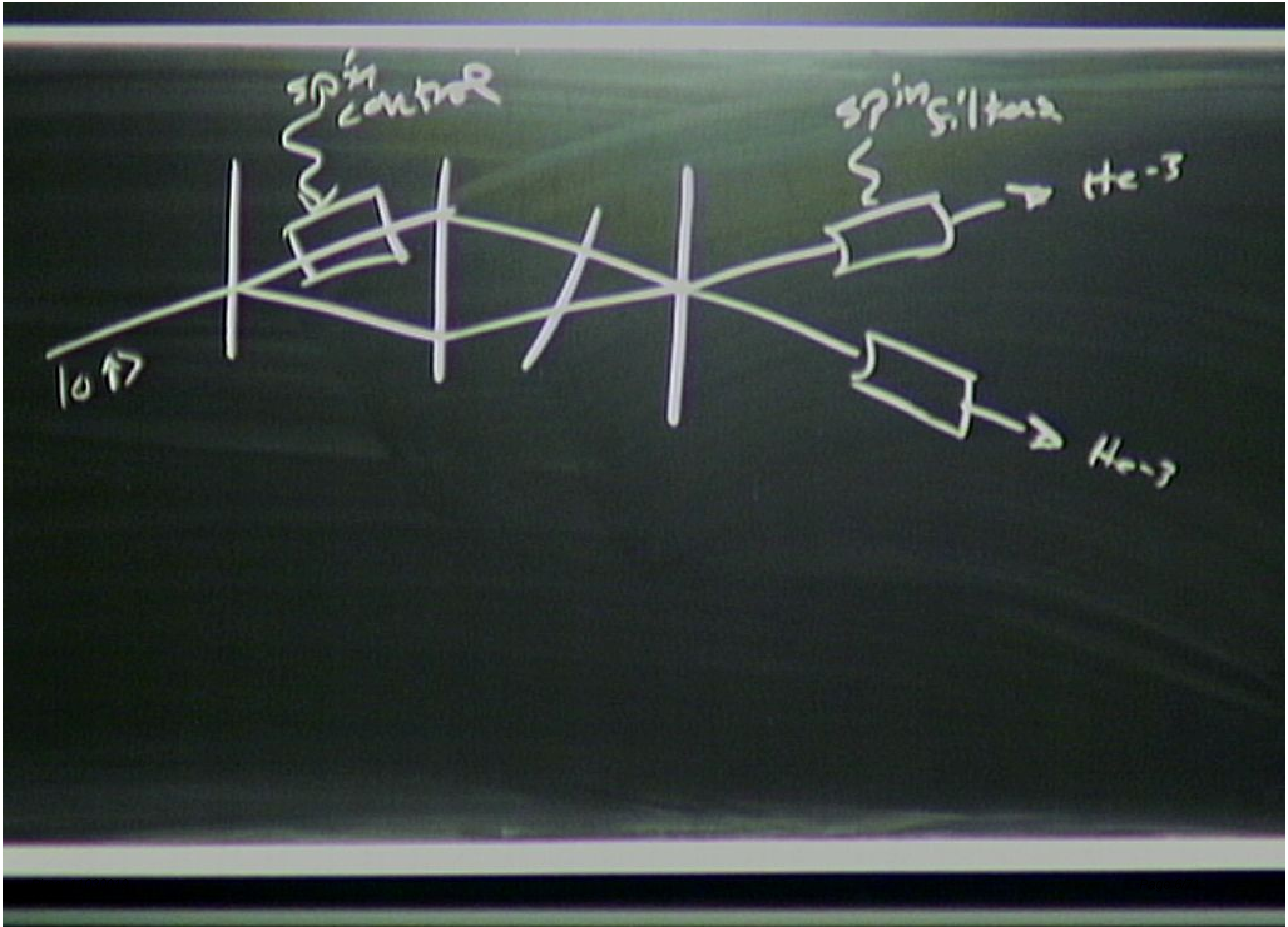
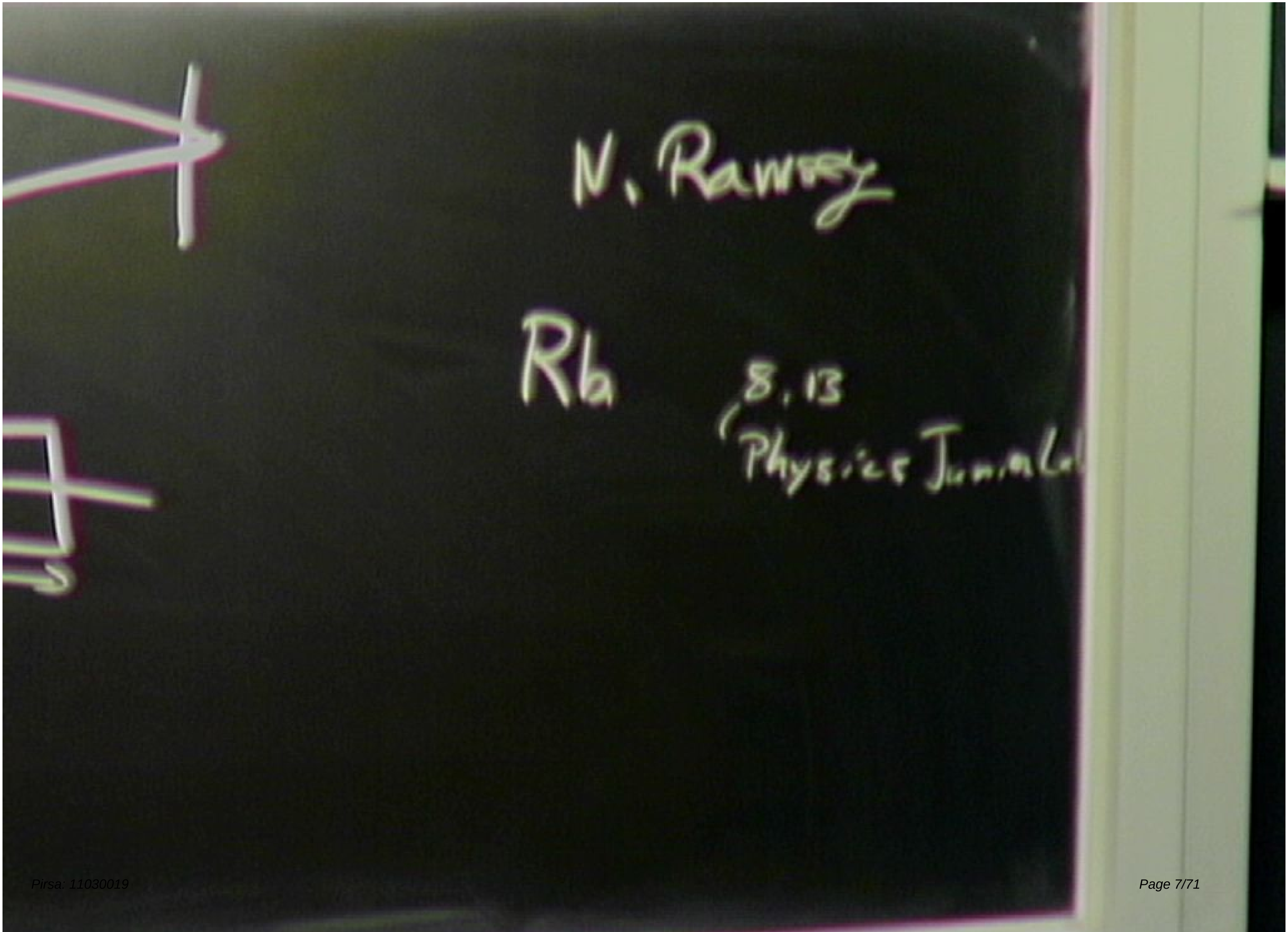


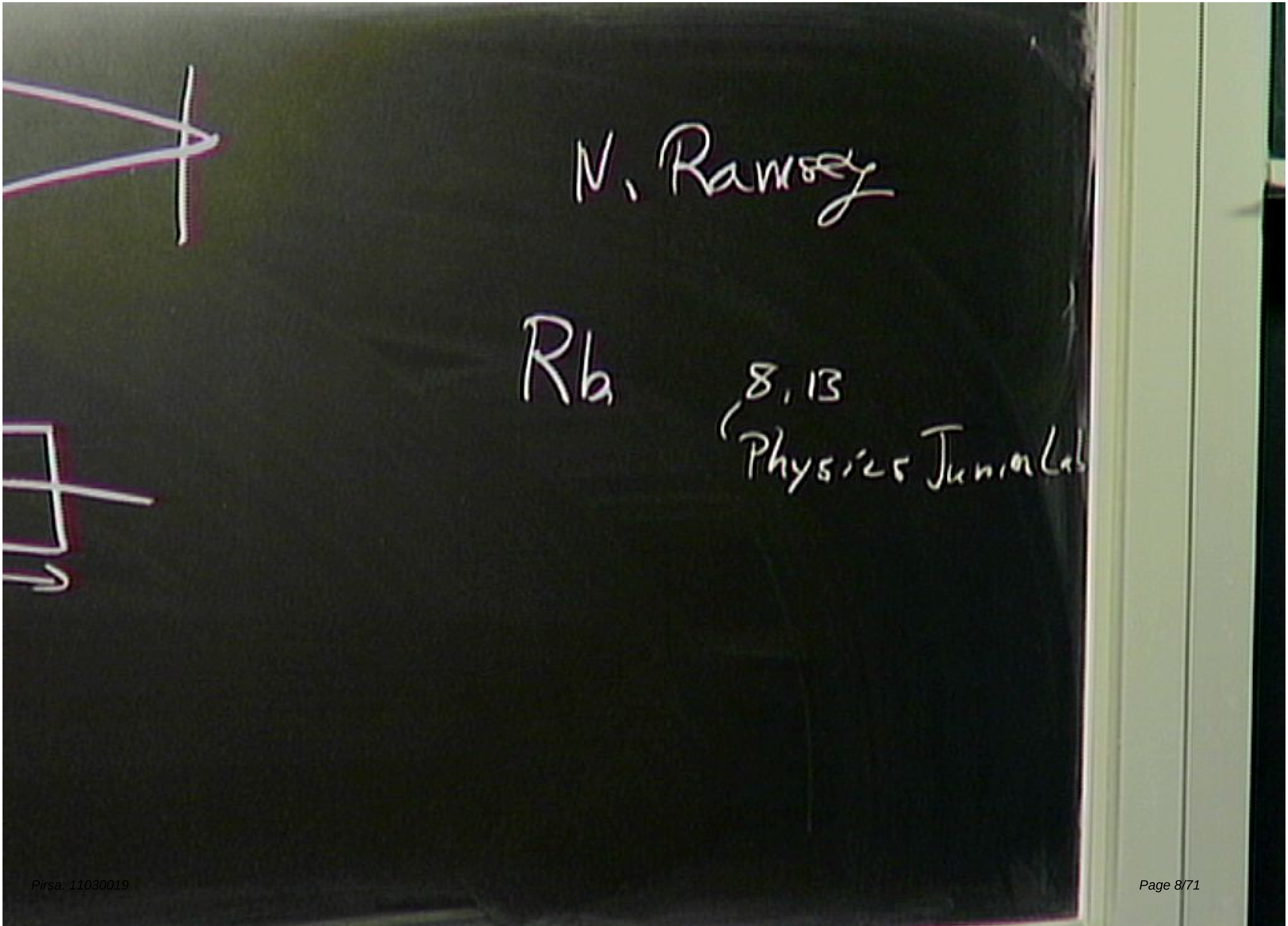
Path
Spin

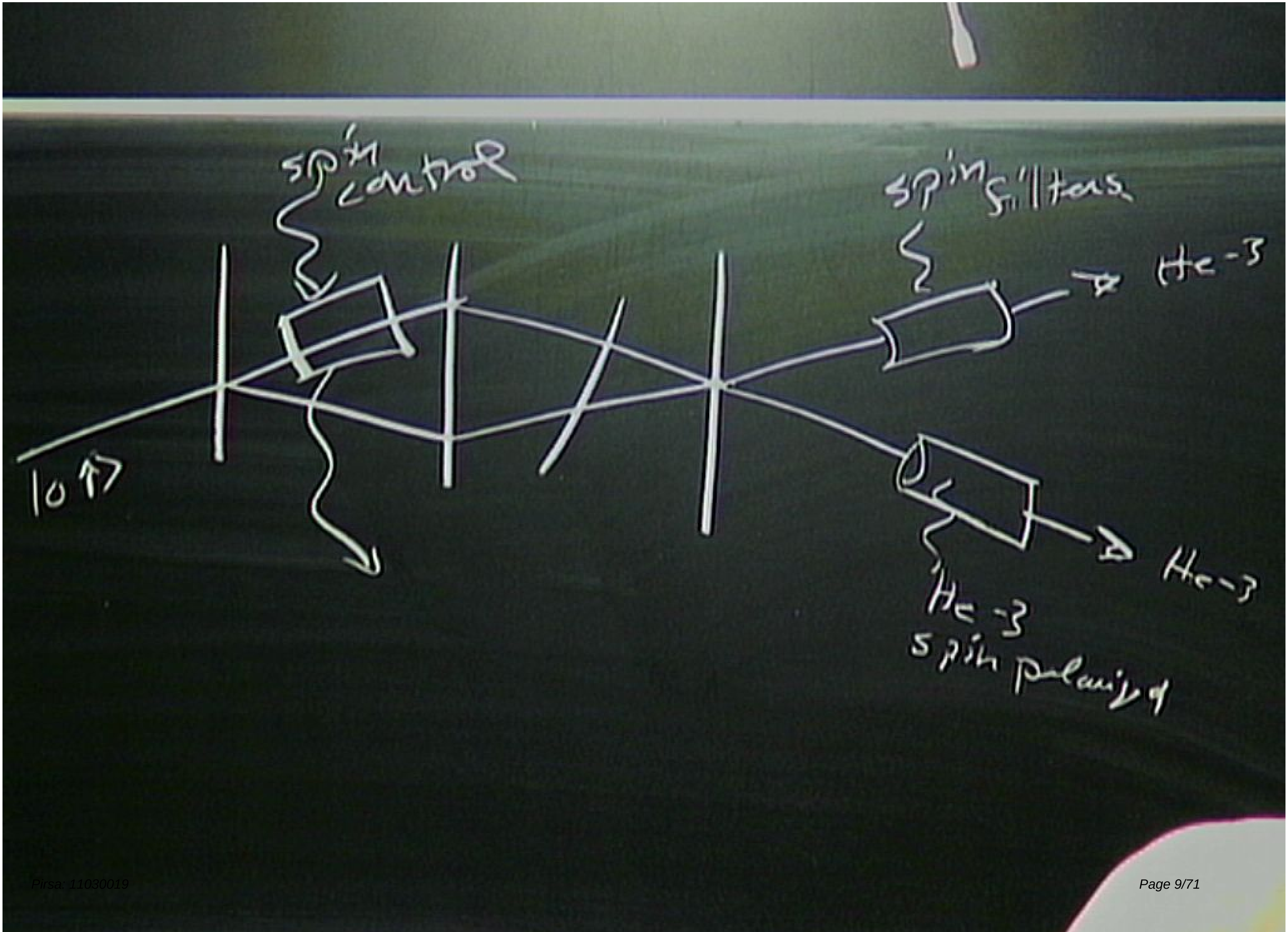

spin control
spin filter
|0↑>

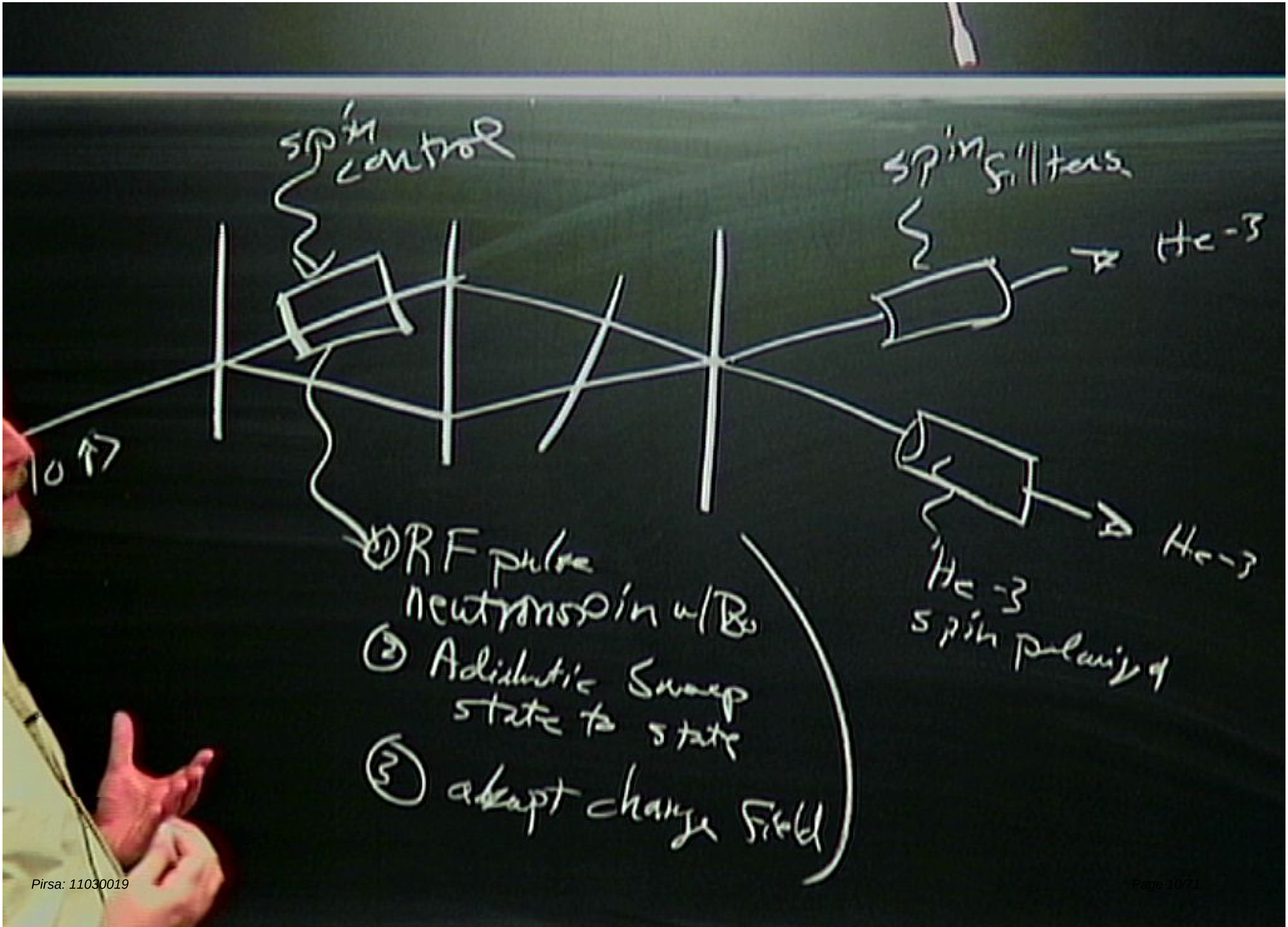

spin control
spin filters
He-3
He-3
|0↑⟩

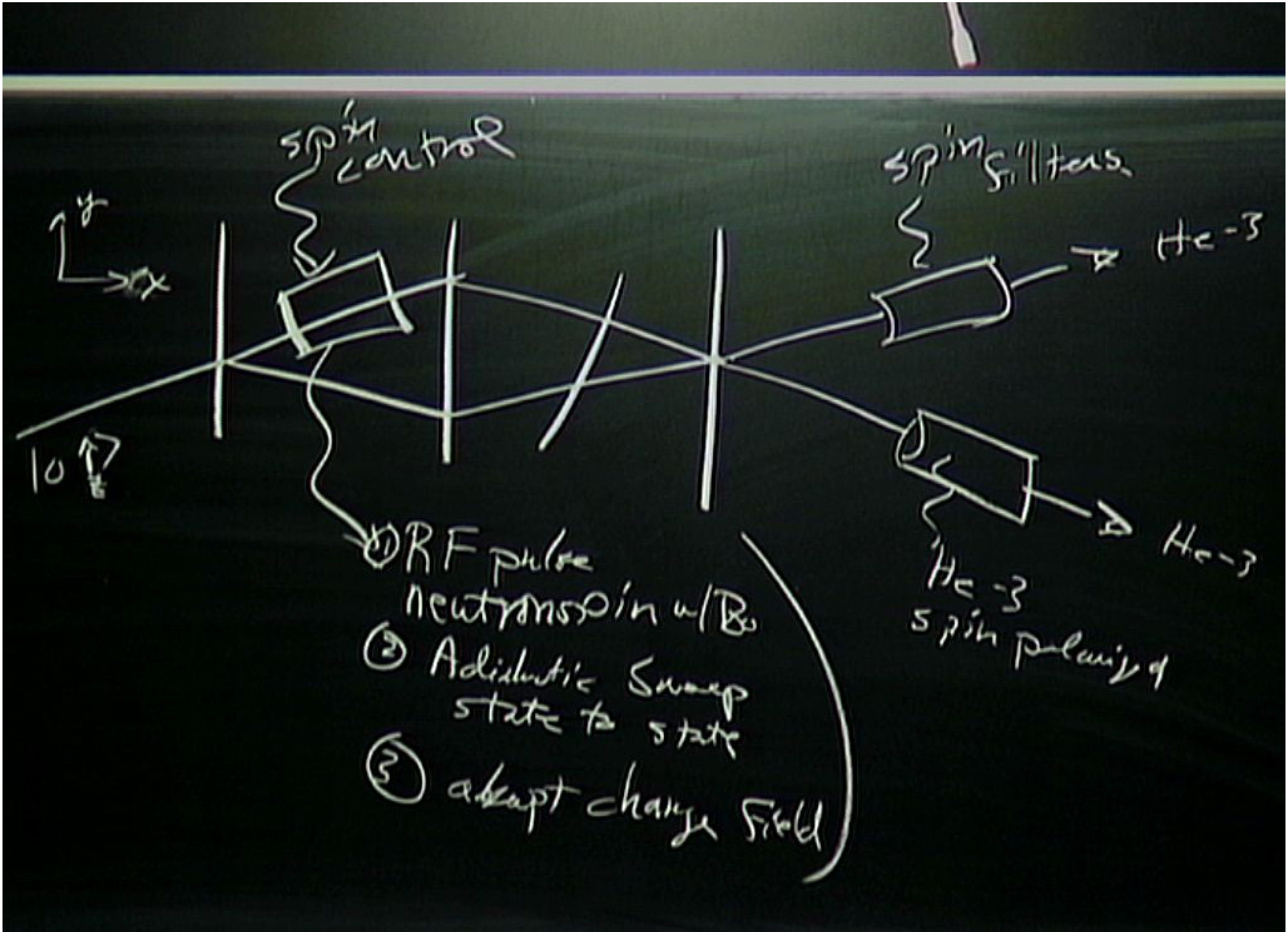

spin
spin
He-3
He-3
|0↑⟩


N. Ramsey
Rb
8,13

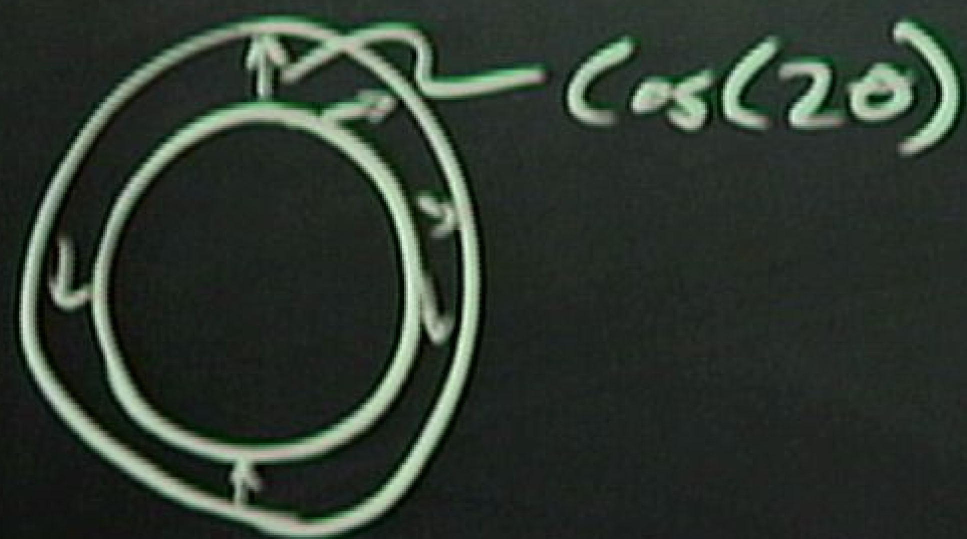

N. Ramsey
Rb
8, 13
Physics Junior Lab


spin control
spin filters
He-3
He-3
He-3
spin polarized
|0↑⟩

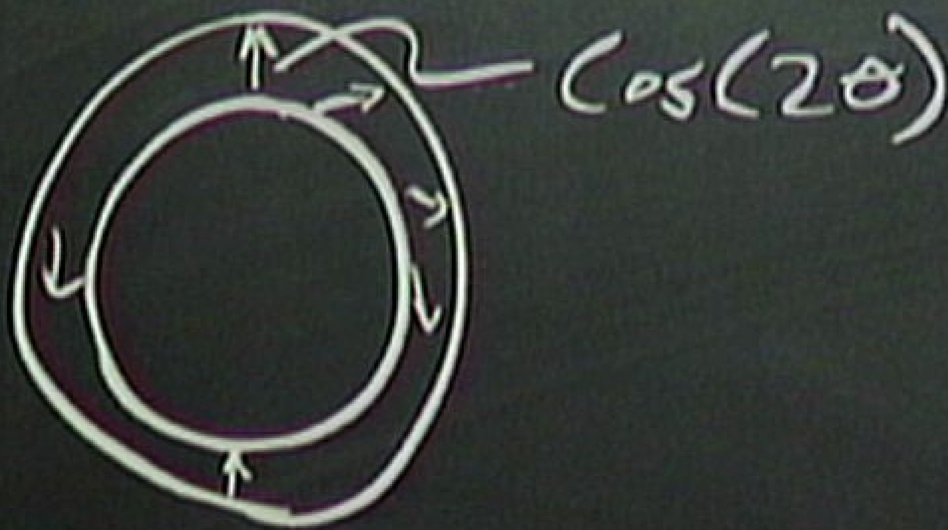

spin control
spin filters
He-3
He-3
① RF pulse
neutron spin w/ B_0
② Adiabatic Sweep
state to state
③ abrupt change field
He-3
spin polarized


spin control
spin filters
y
x
He-3
He-3
He-3
spin polarized
① RF pulse
neutron spin w/ B_0
② Adiabatic Sweep
state to state
③ abrupt change field

Halbach magnetics

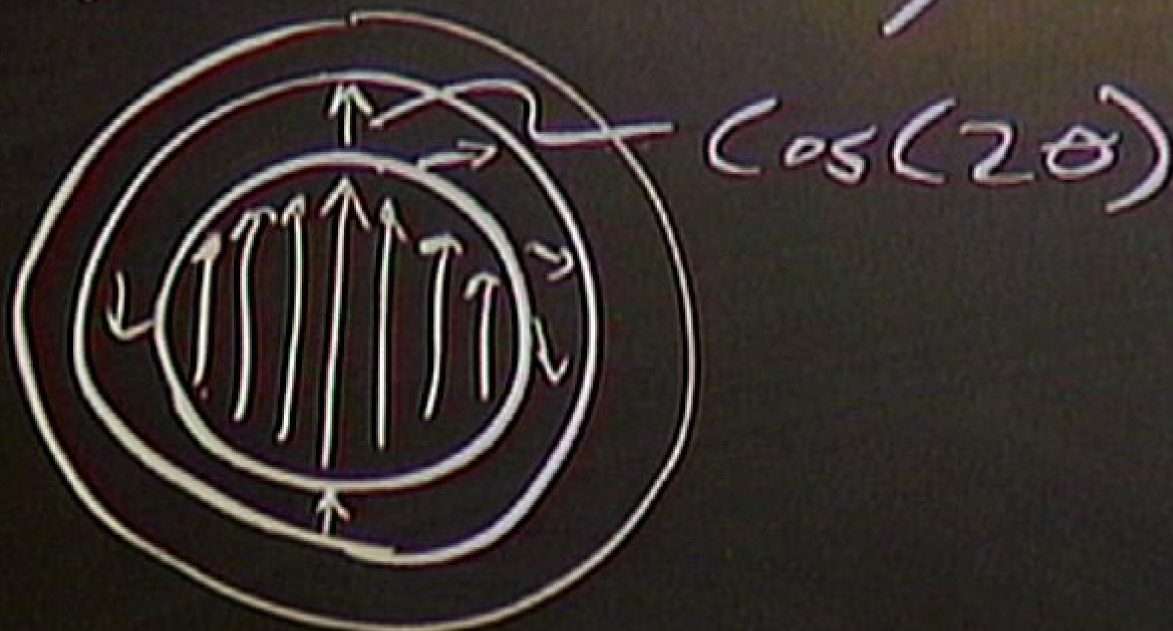


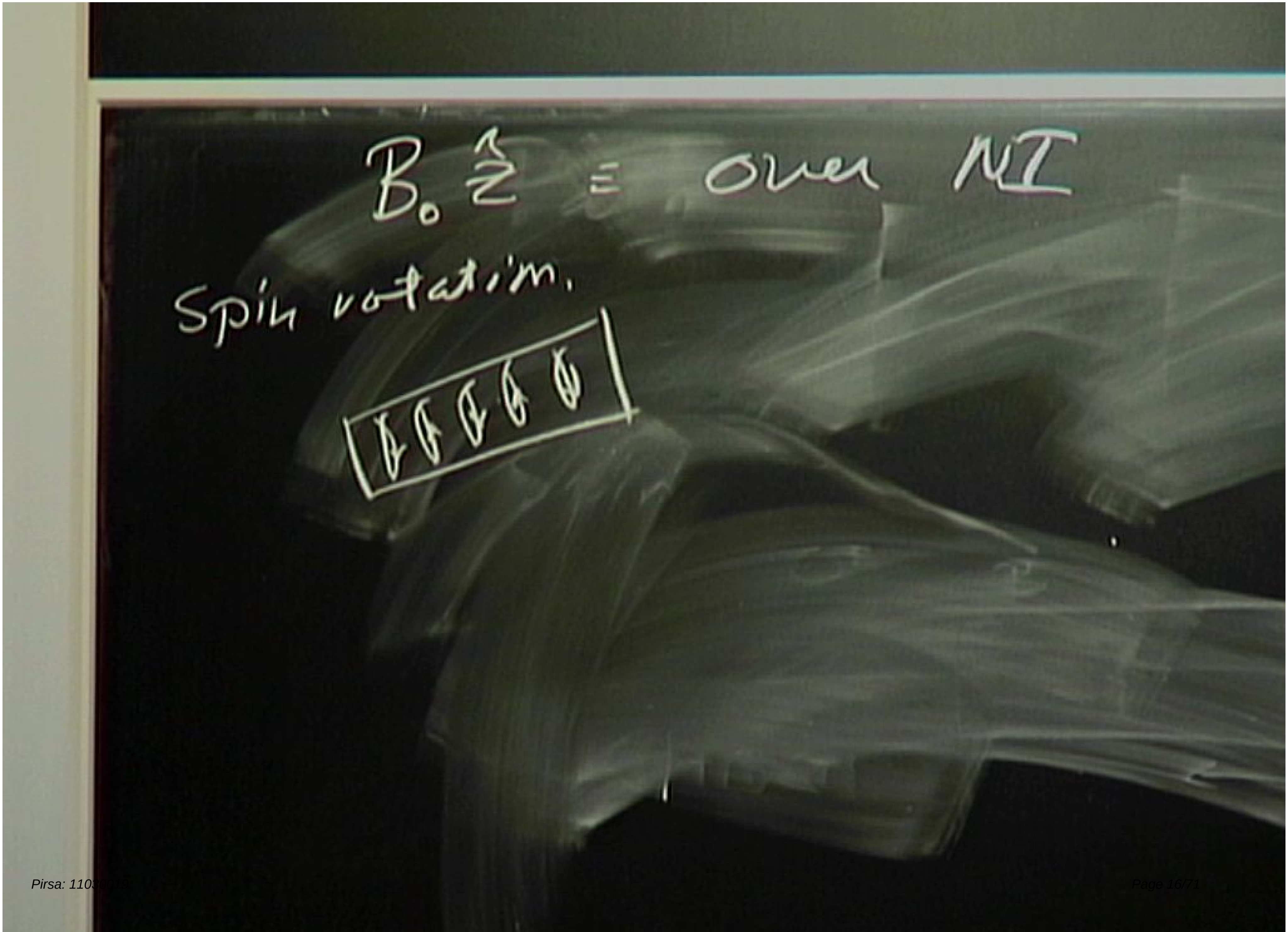
Halbach magnetics

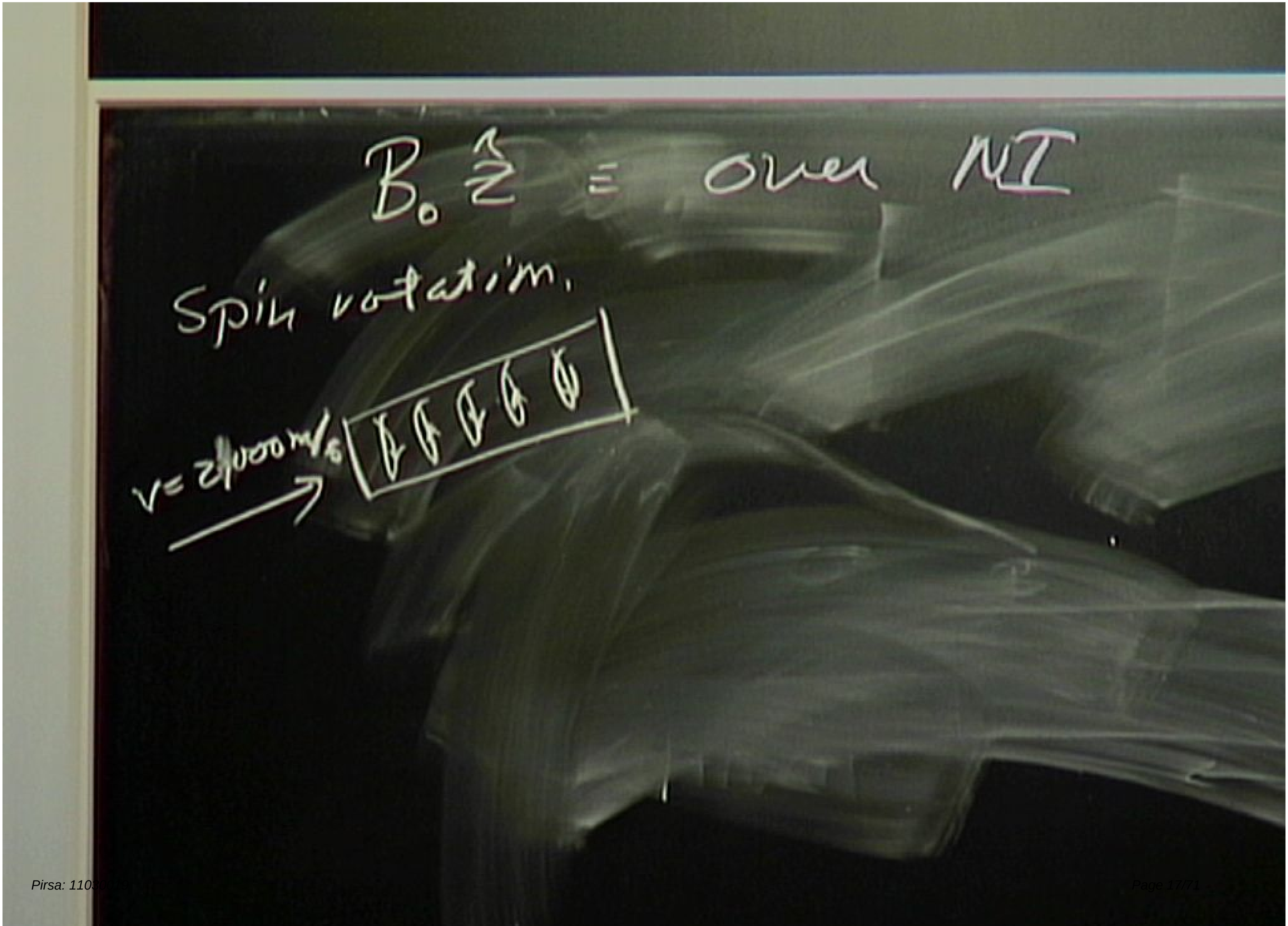


Halbach magnetics

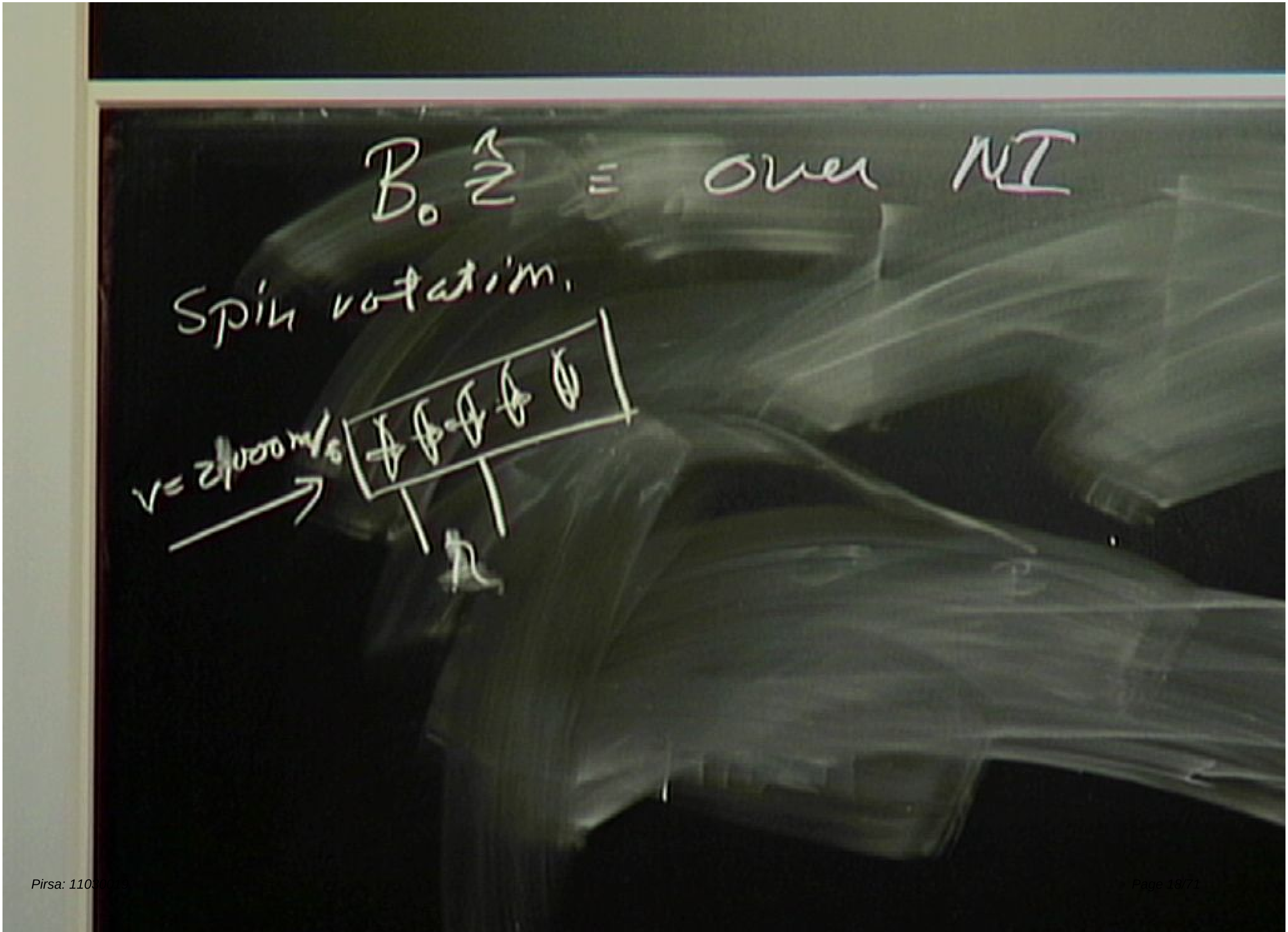
Halbach magnetics




$B_0 \hat{z}$ = over NI
Spin rotation.



B₀ ẑ ≡ over NI
Spin rotation.
v=2400m/s

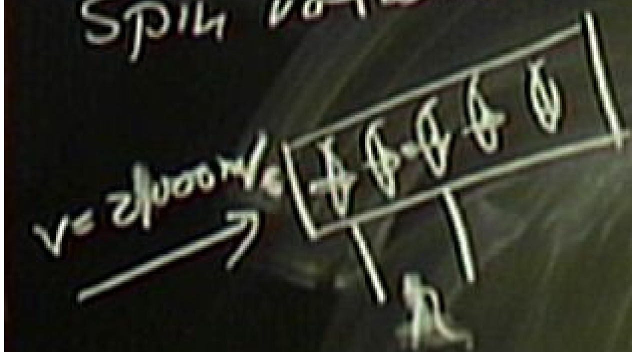

$B_0 \hat{z}$ = over NI
Spin rotation.
v = 2000 m/s

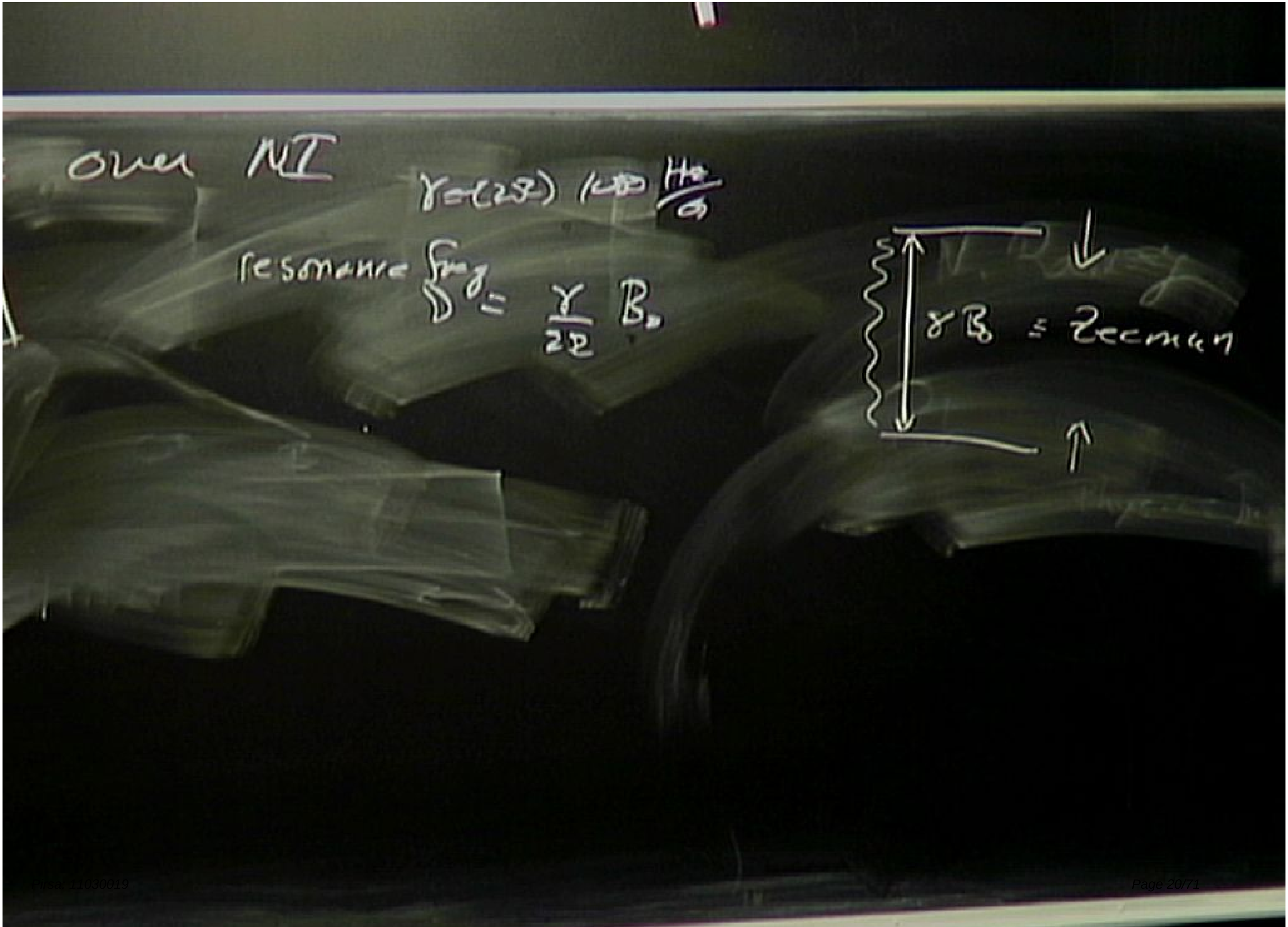
$B_0 \hat{z}$ = over NI

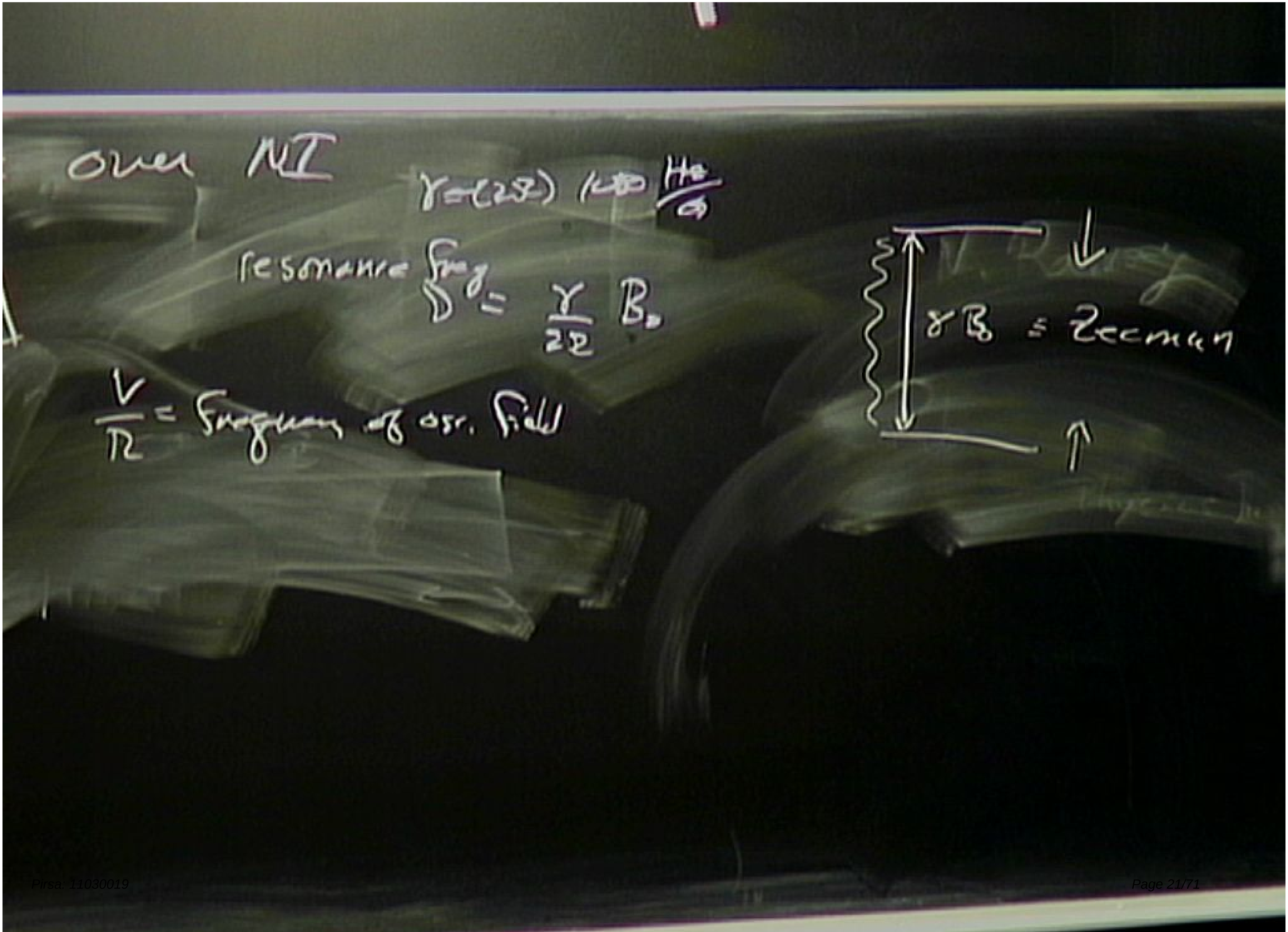
$\gamma = (2\pi)\ 4200\ \frac{Hz}{G}$

Spin rotation.

resonance freq. $\nu = \frac{\gamma}{2\pi} B_0$




over NI
resonance freq
ν = γ/2π B₀
γB₀ = Zeeman


over
resonance freq
ν = γ/2π B₀
V/R = frequency of osc. field
γB₀ = Zeeman

over MI

$\gamma = (2\pi)\ 42\ \frac{\text{MHz}}{\text{T}}$

resonance freq.

$$\nu_0 = \frac{\gamma}{2\pi} B_0$$

$$\gamma B_0 = \text{Zeeman}$$

$$\nu = \frac{V}{h} = \text{frequency of osc. field}$$

$$\left[\frac{V}{h} = \frac{\gamma}{2\pi} B_0\right]$$

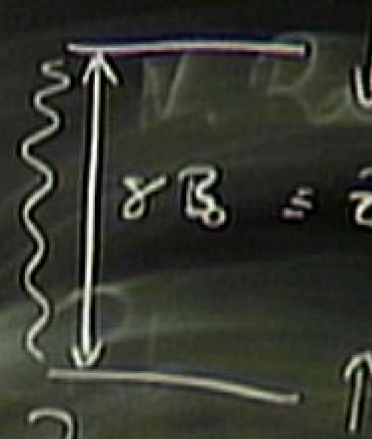
over NI

$\gamma = (2\pi)\ 1.40\ \frac{Hz}{G}$

resonance freq

$\nu_0 = \frac{\gamma}{2\pi} B_0$

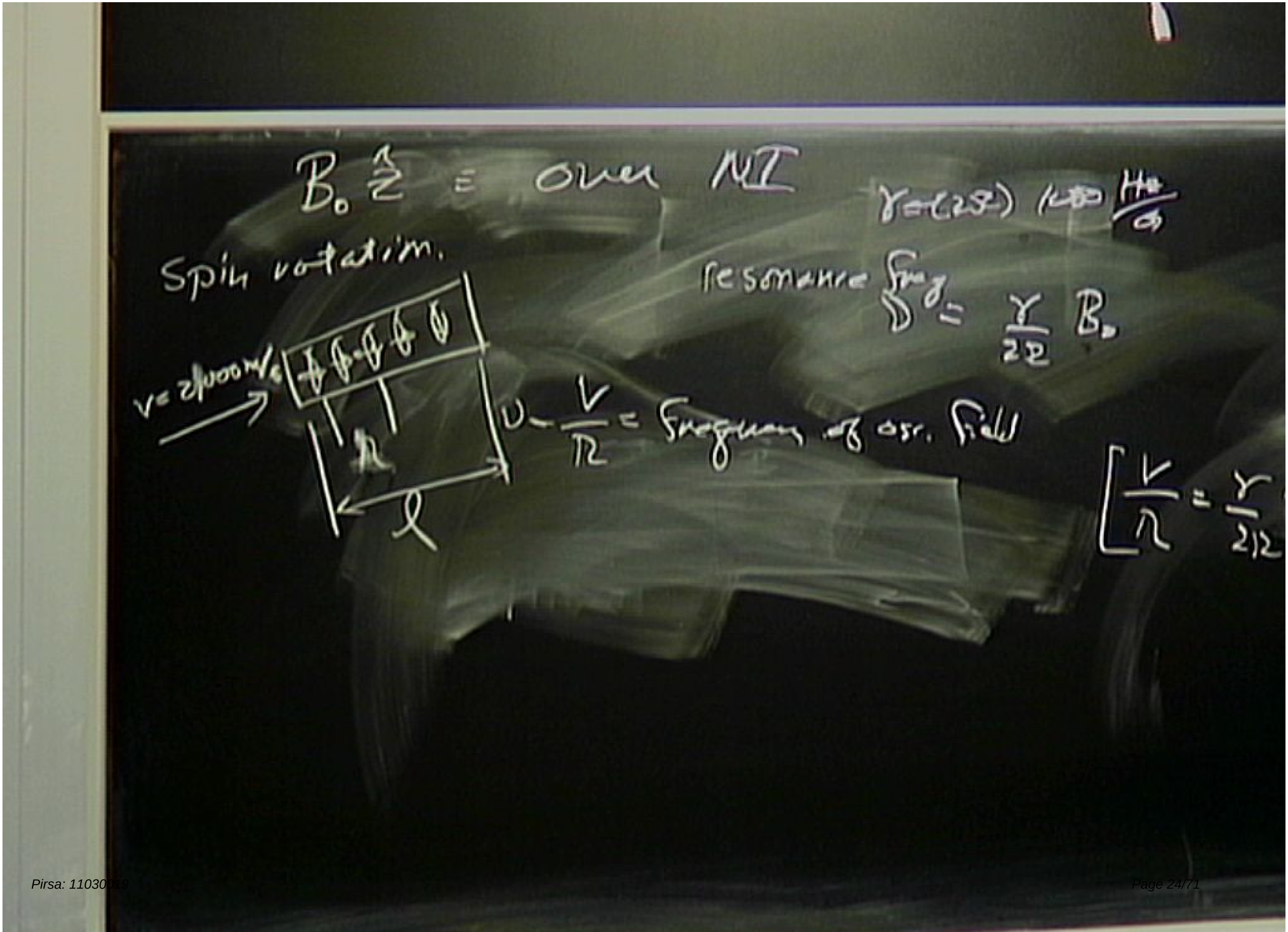
$\nu = \frac{v}{\lambda}$ = frequency of osc. field

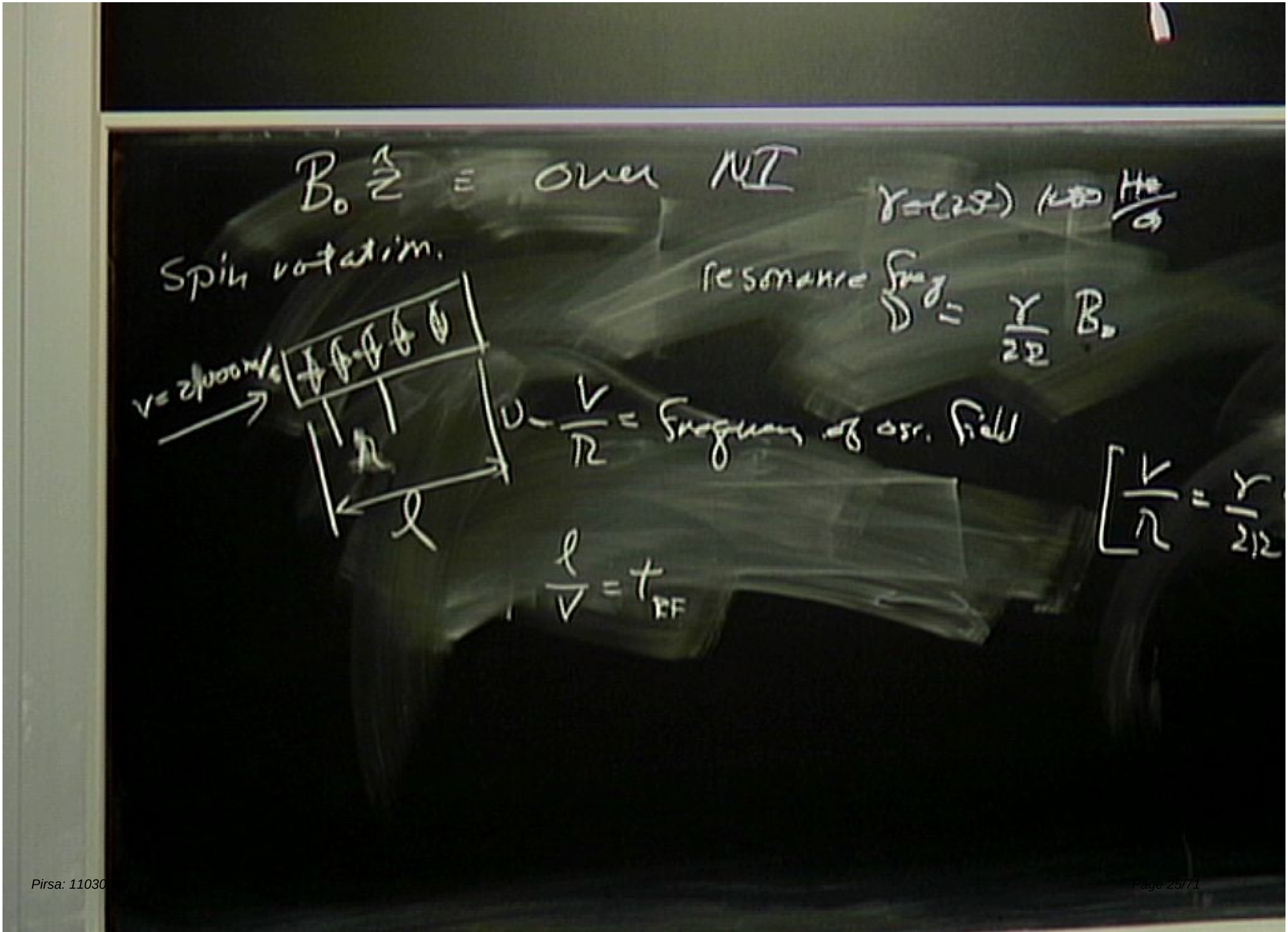


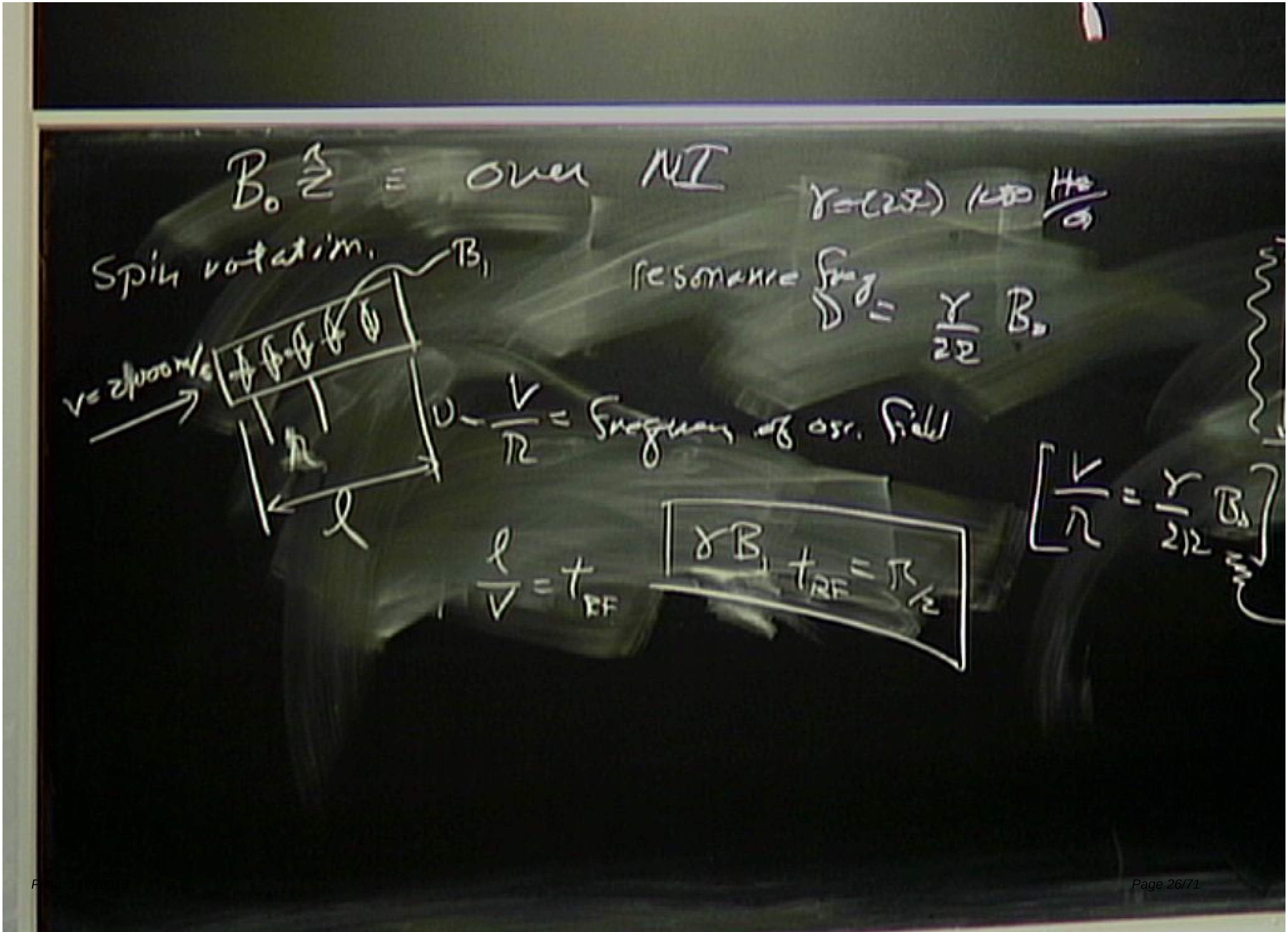
γB_0 = Zeeman

$\left[\frac{v}{\lambda} = \frac{\gamma}{2\pi} B_0\right]$

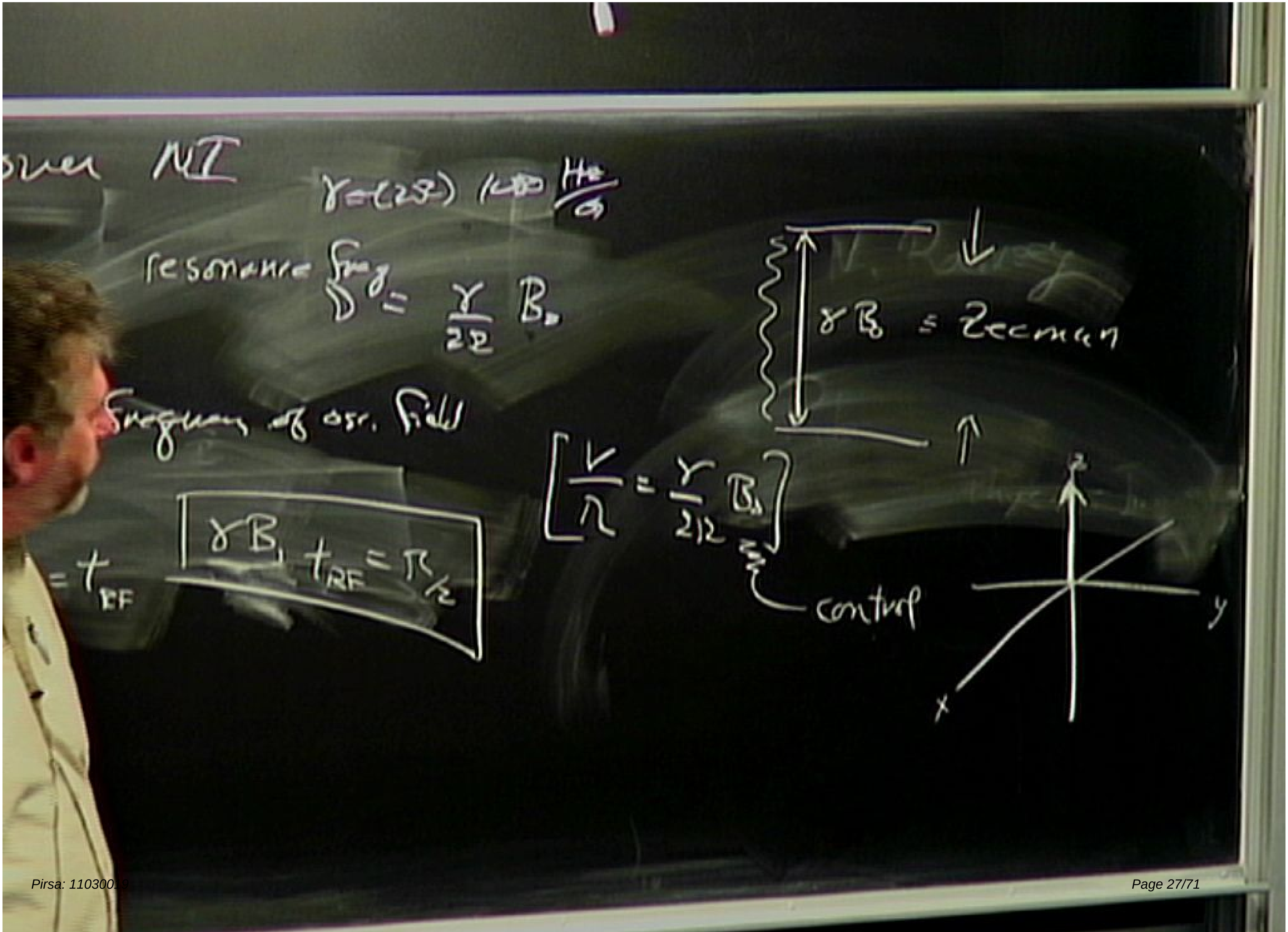
control

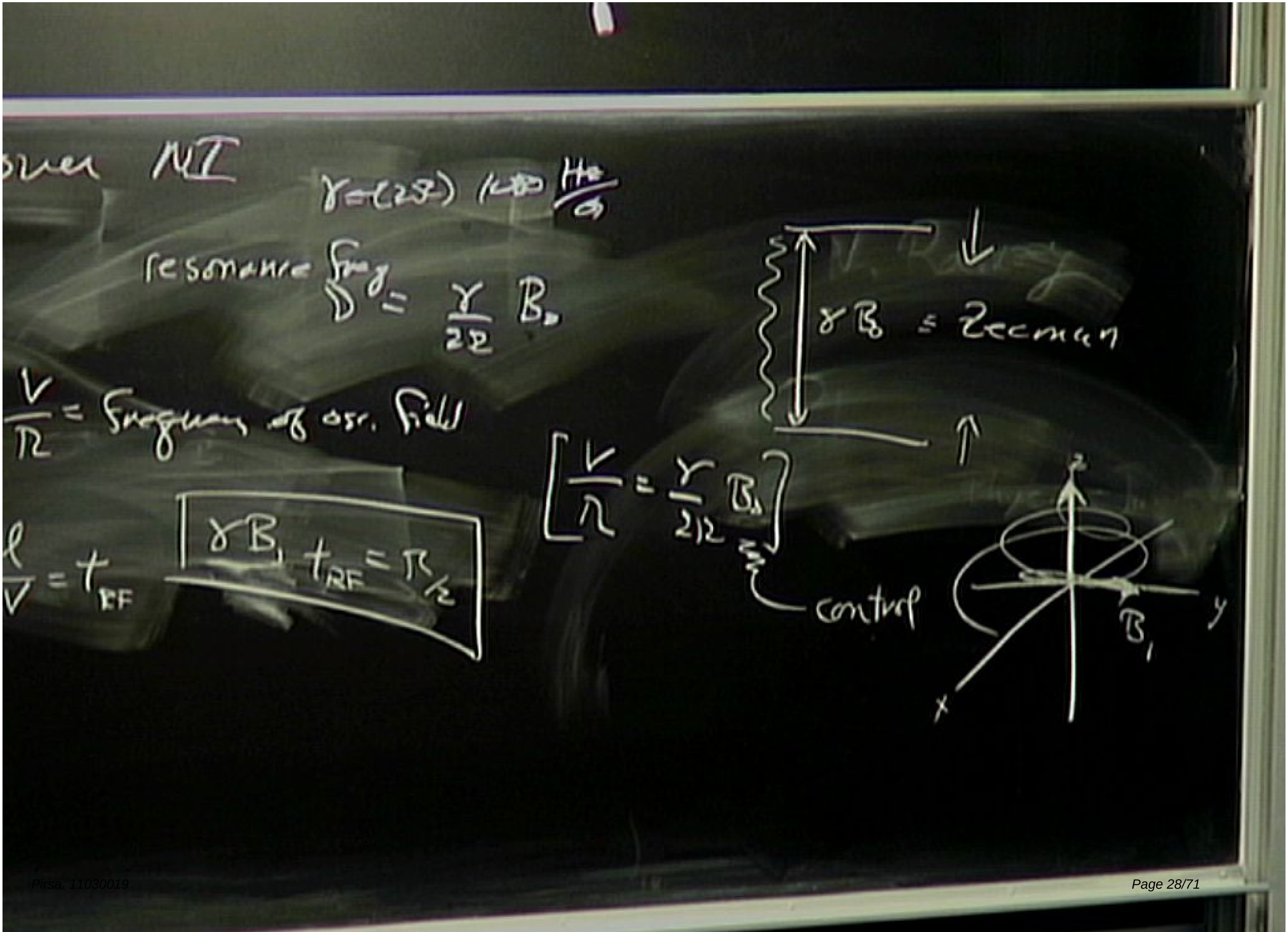

B0 ẑ = over MI
Spin rotation.
resonance freq
f0 = γ/2π B0
ν = v/λ = frequency of osc. field
λ
l

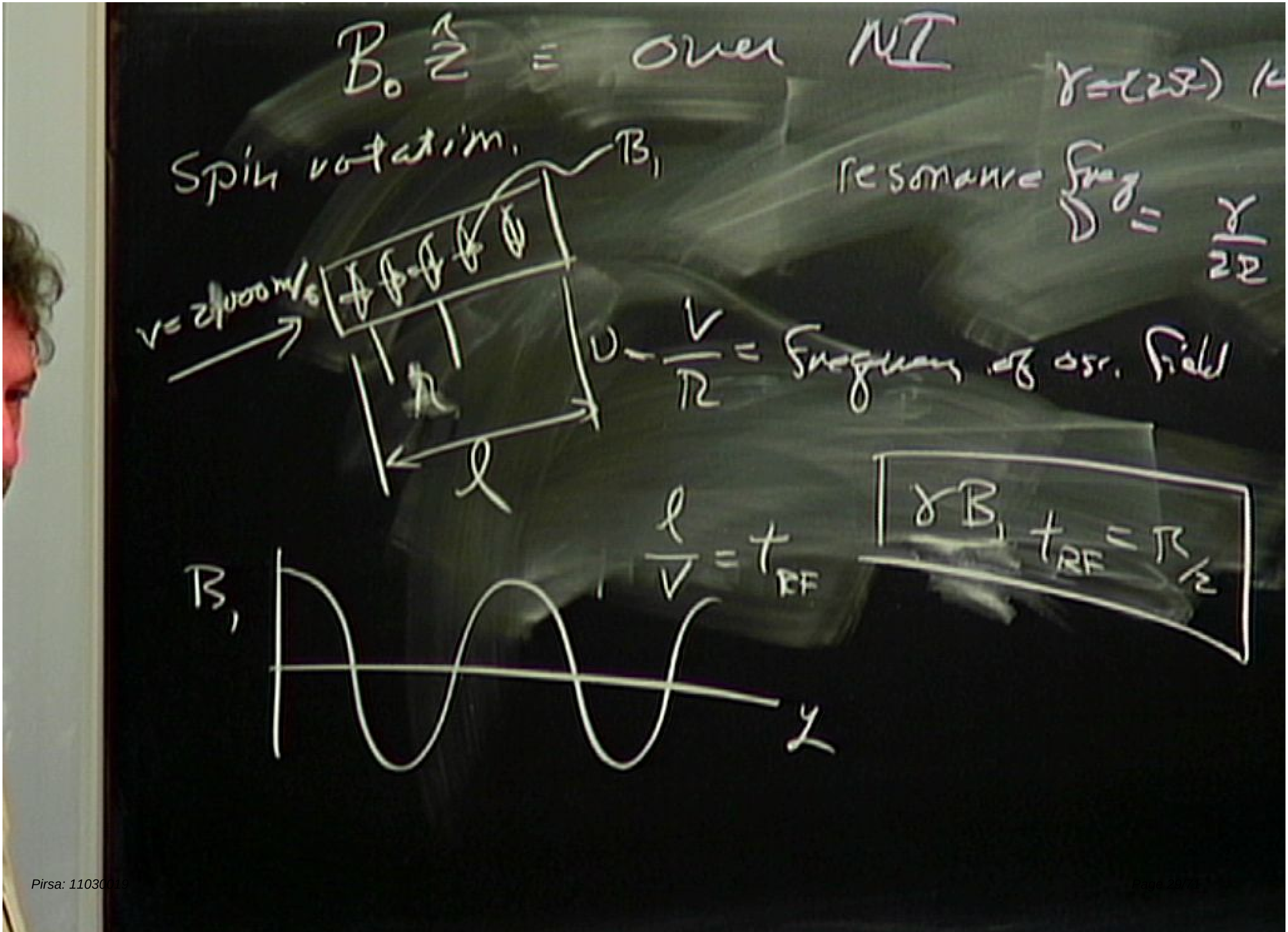

Spin rotation.
resonance freq
frequency of osc. field

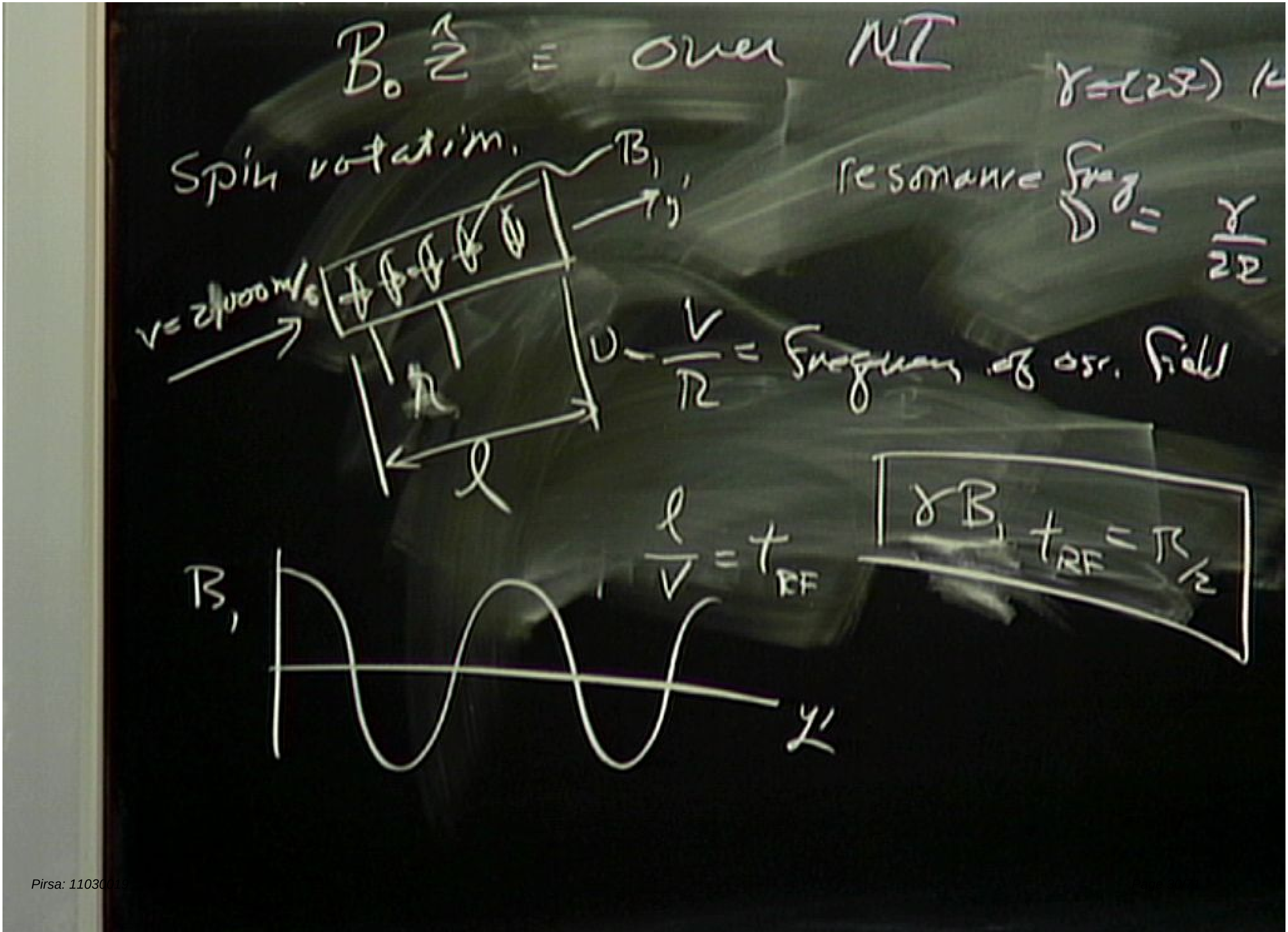


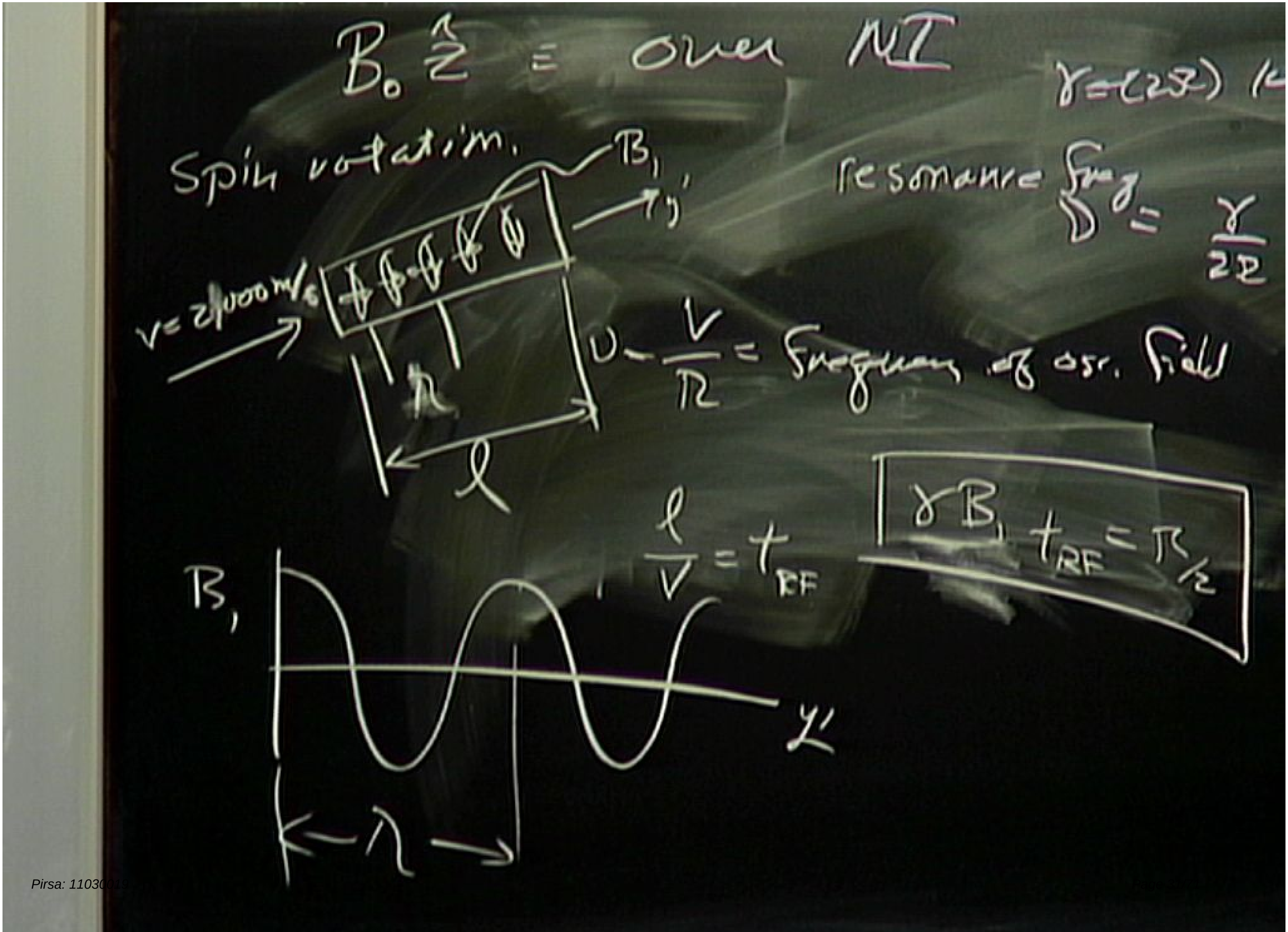
B₀ ẑ = over NI
γ = (2π) 4200 Hz/G
Spin rotation.
B₁
resonance freq
ν₀ = γ/2π B₀
v = 2000 m/s
ν ~ v/λ = frequency of osc. field
λ
l
[v/λ = γ/2π B₀]
l/v = t_RF
γB₁ t_RF = π/2

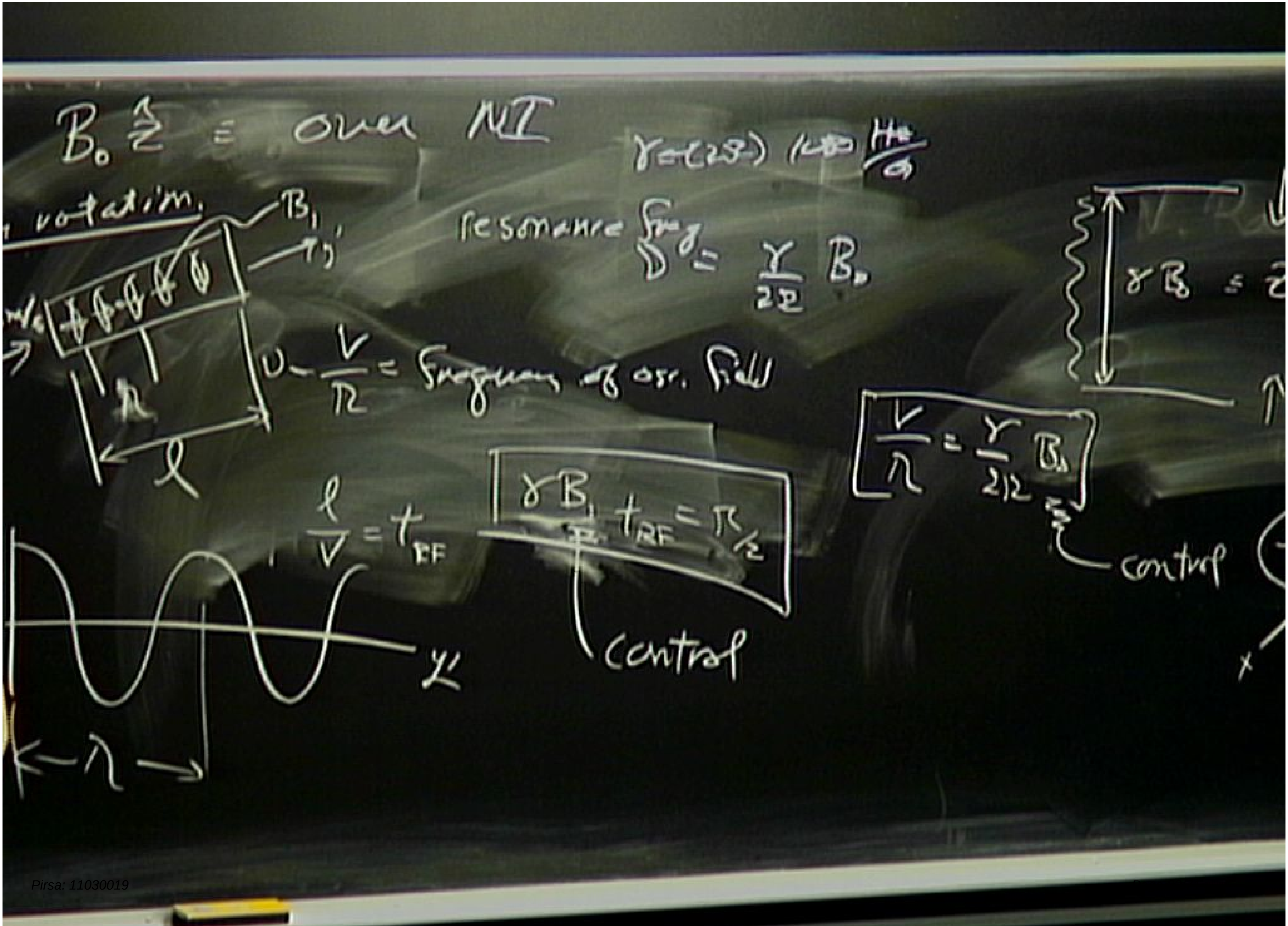

resonance freq
frequency of osc. field
γB = Zeeman
control
x
y
z


NI
resonance freq
$\nu_0 = \frac{\gamma}{2\pi} B_0$
$\frac{V}{\lambda}$ = frequency of osc. field
γB_0 = Zeeman
$\left[\frac{V}{\lambda} = \frac{\gamma}{2\pi} B_0\right]$
control
$\frac{l}{V} = t_{RF}$
$\gamma B_1 t_{RF} = \pi/2$
z
y
x
B_1

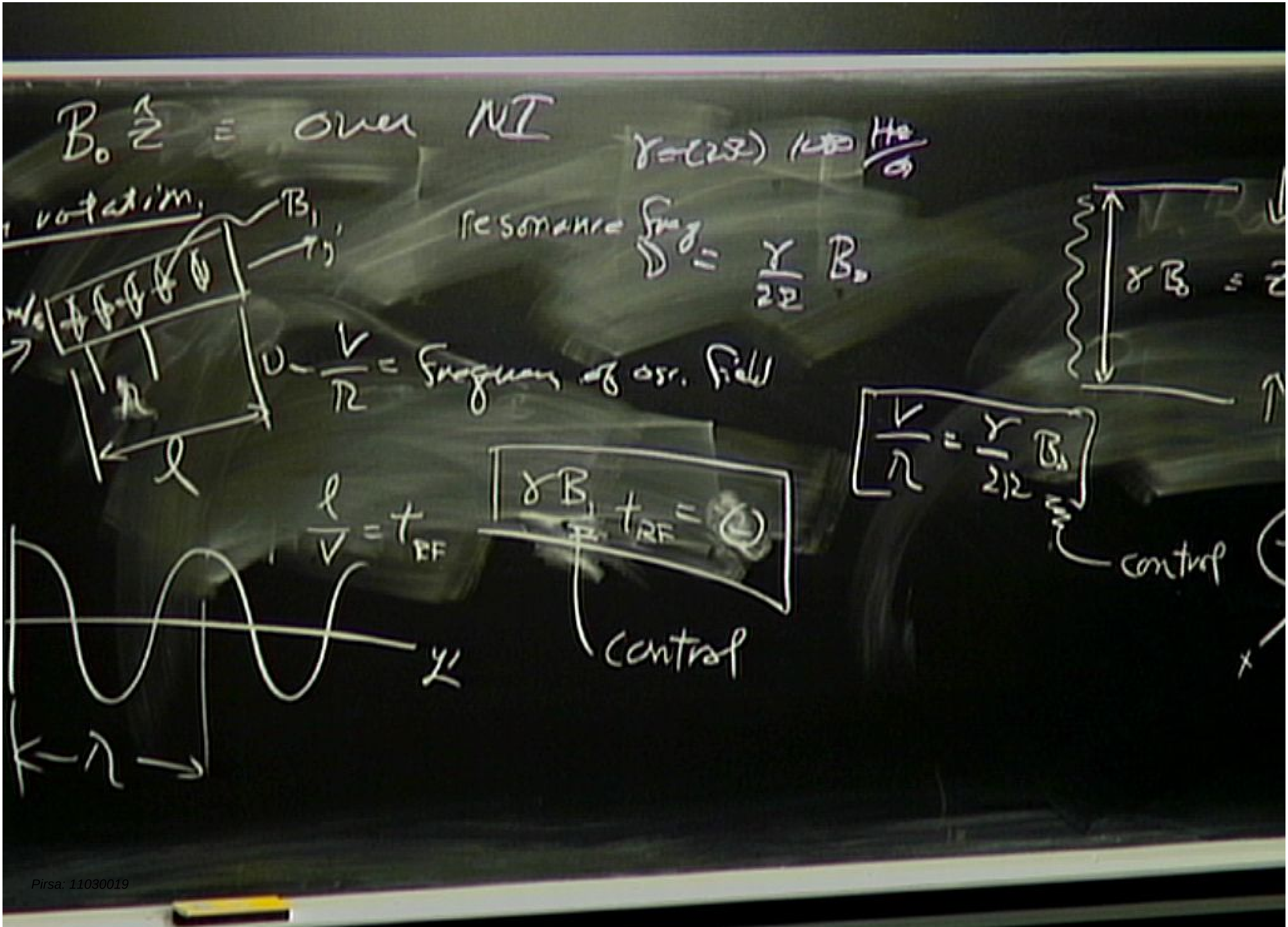

B₀ ẑ = over NI
γ=(2π)
Spin rotation.
B₁
resonance freq
ν₀ = γ/2π
v = 2000 m/s
R
ℓ
ν ~ V/R = frequency of osc. field
ℓ/V = t_RF
γB₁ t_RF = π/2
B₁
z


B₀ ẑ = over NI
Spin rotation.
B₁
resonance freq
ν₀ = γ/2π
ν ~ v/R = frequency of osc. field
l
l/v = t_RF
γB₁ t_RF = π/2
B₁

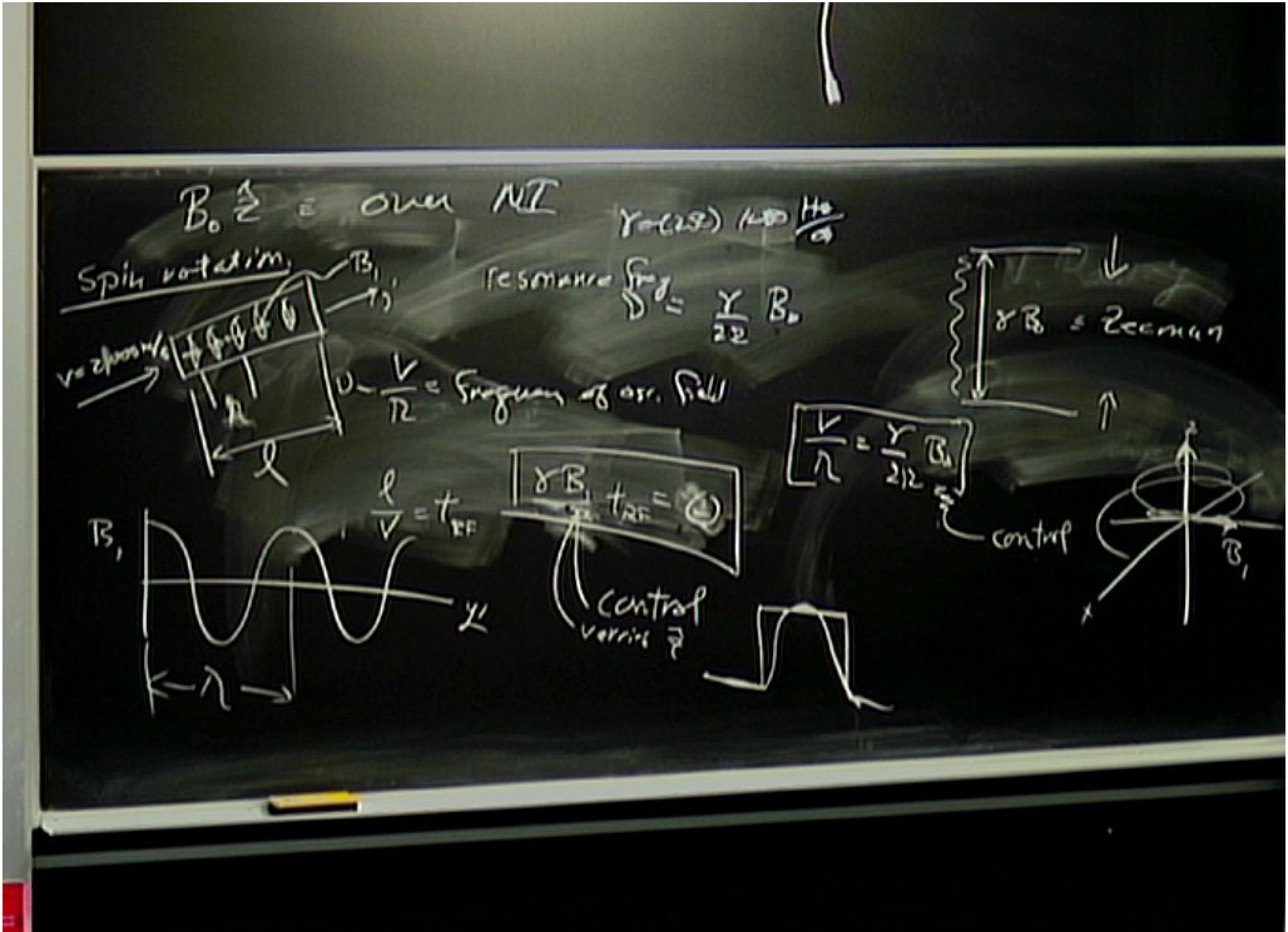

$B_0 \hat{z}$ = oven NI
$\gamma = (2\pi)$
Spin rotation.
B_1
resonance freq
$\nu_0 = \frac{\gamma}{2\pi}$
v = 2,000 m/s
λ
ℓ
$\nu \sim \frac{V}{\lambda}$ = frequency of osc. field
$\frac{\ell}{V} = t_{RF}$
$\gamma B_1 t_{RF} = \pi/2$
B_1
x



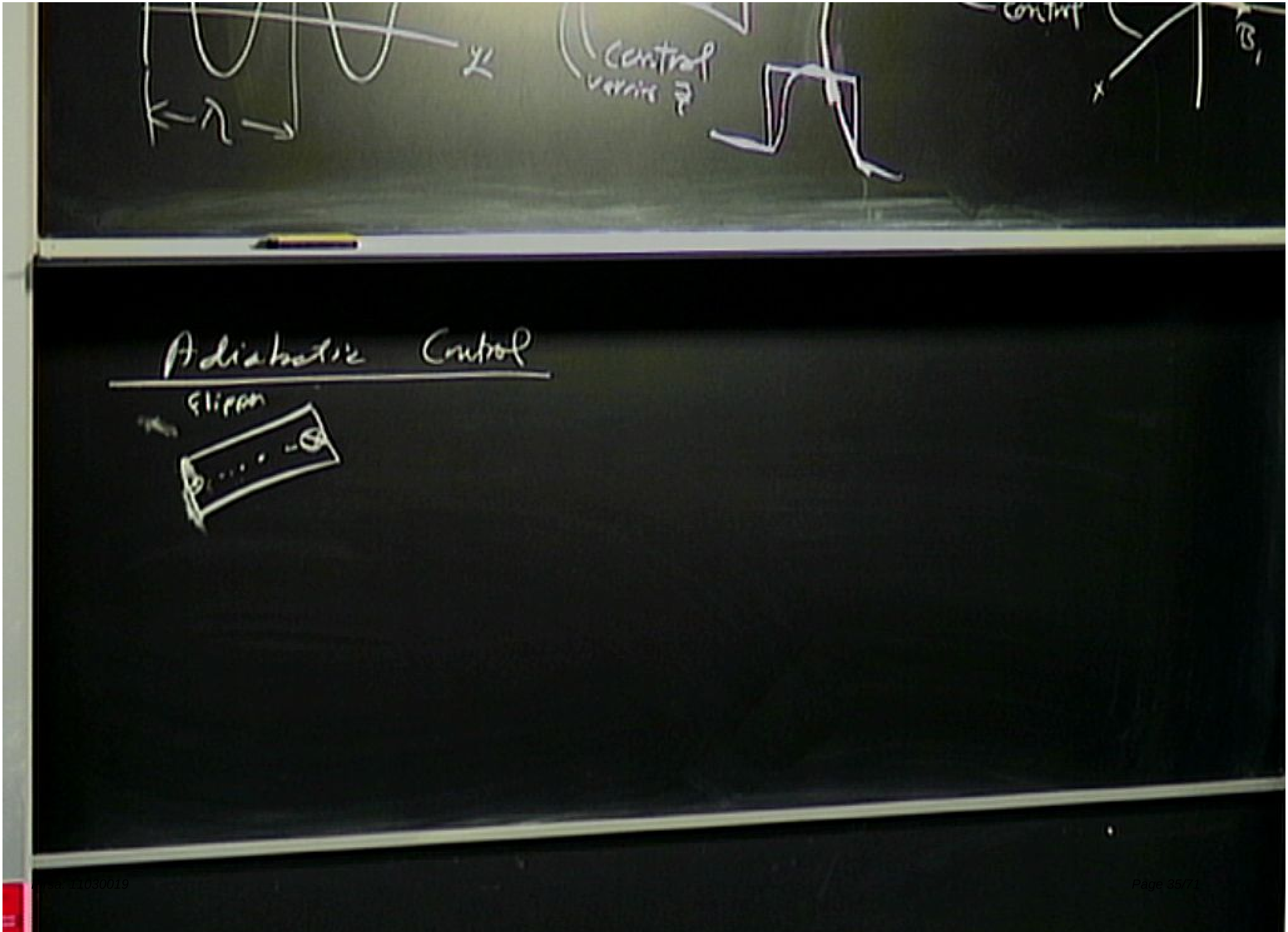
$B_0\hat{z}$ = over NI
$\gamma = (2\pi)(1.5)$ Hz/G
rotation
B_1
resonance freq.
$\nu = \frac{\gamma}{2\pi} B_0$
$\nu \sim \frac{v}{\lambda}$ = frequency of osc. field
ℓ
$\frac{\ell}{v} = t_{RF}$
$\gamma B_1 t_{RF} = \pi/2$
control
$\frac{v}{\lambda} = \frac{\gamma}{2\pi} B_0$
control
γB_0
λ
Pirsa: 11030019



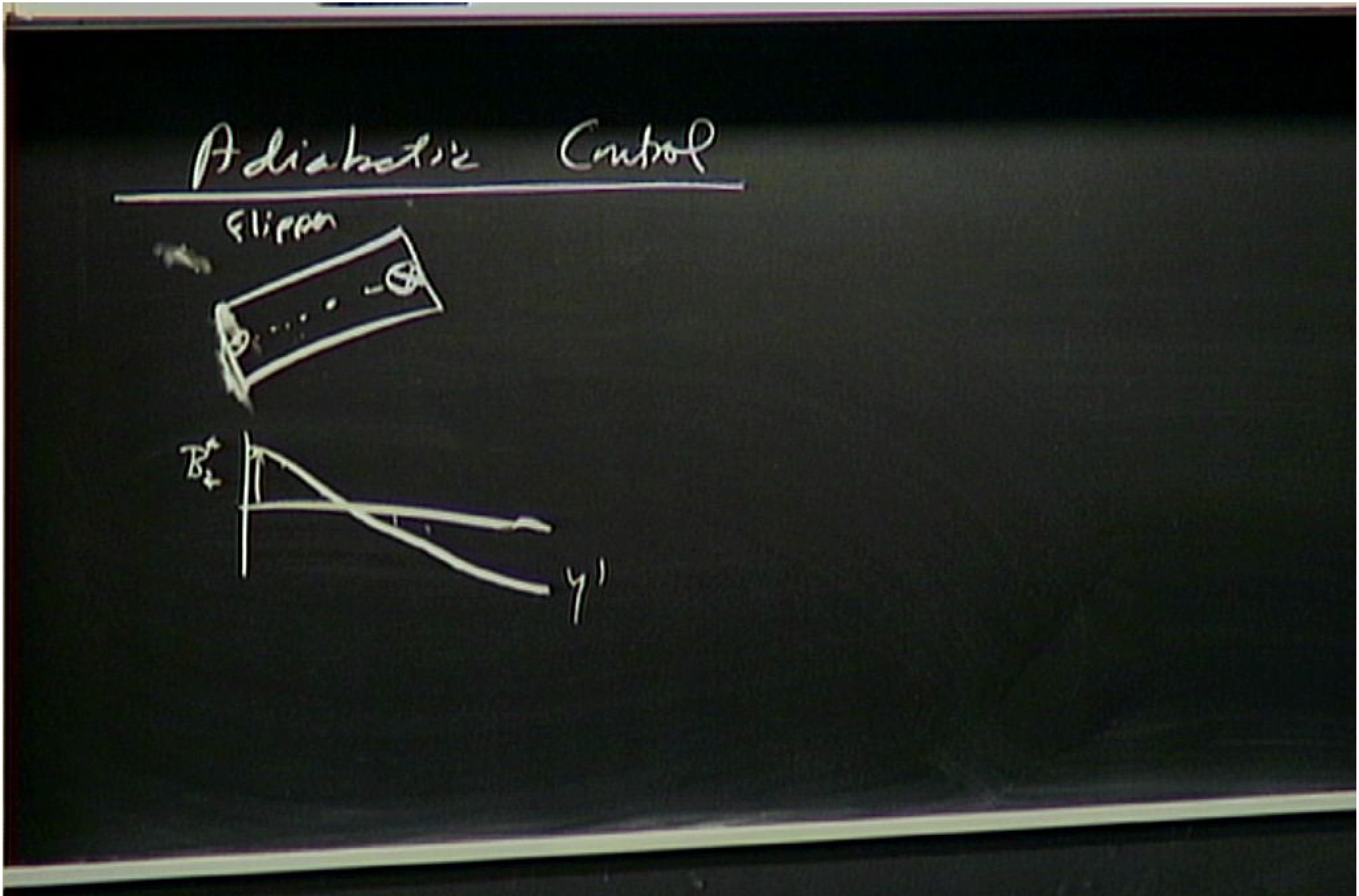
$B_0 \hat{z}$ = over NI
rotation
B_1
resonance freq
$\nu = \frac{\gamma}{2\pi} B_0$
$\nu \sim \frac{v}{\lambda}$ = frequency of osc. field
λ
l
$\frac{l}{v} = t_{RF}$
$\gamma B_1 t_{RF} =$
control
$\frac{v}{\lambda} = \frac{\gamma}{2\pi} B_0$
control
γB_0

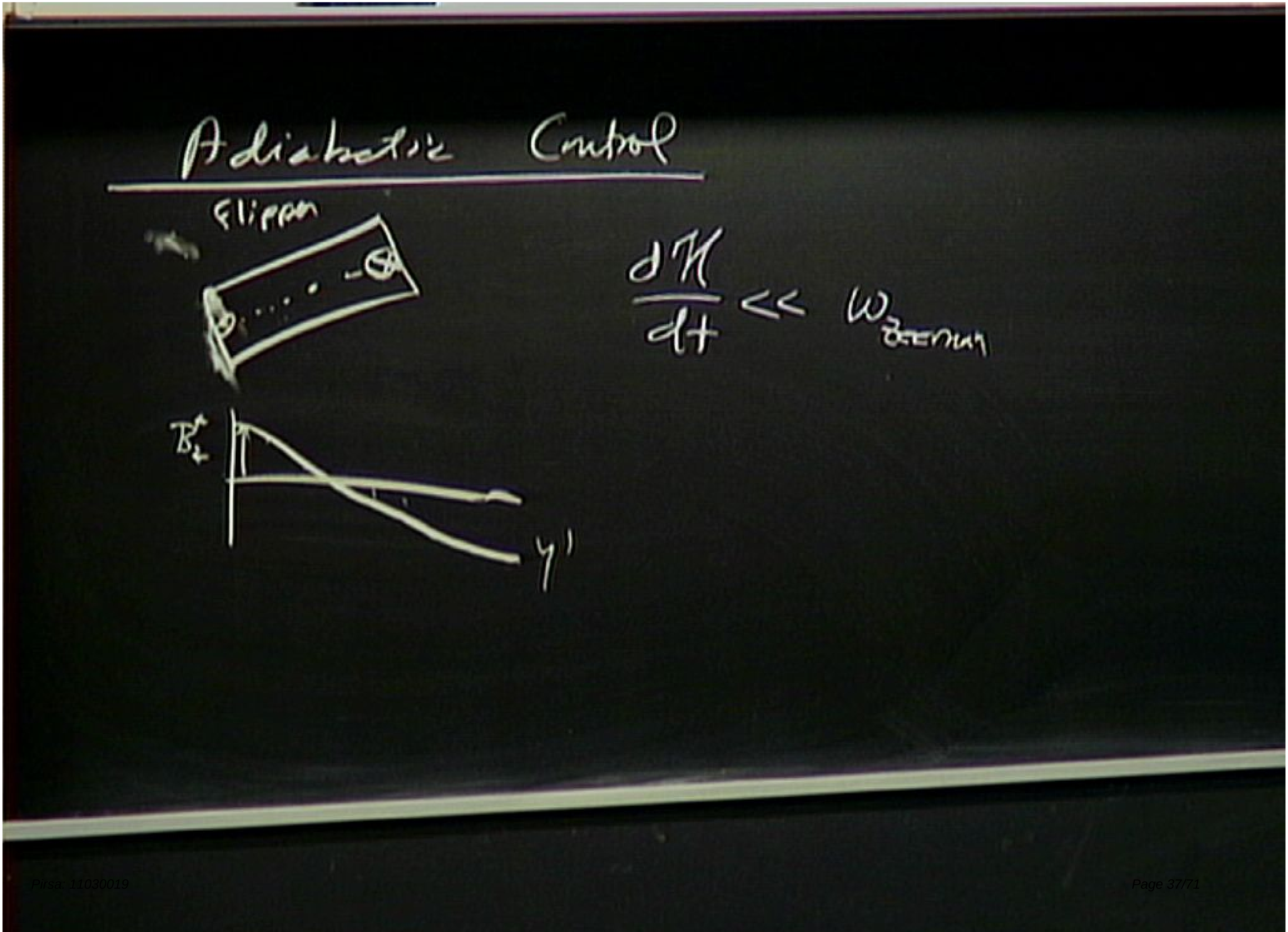


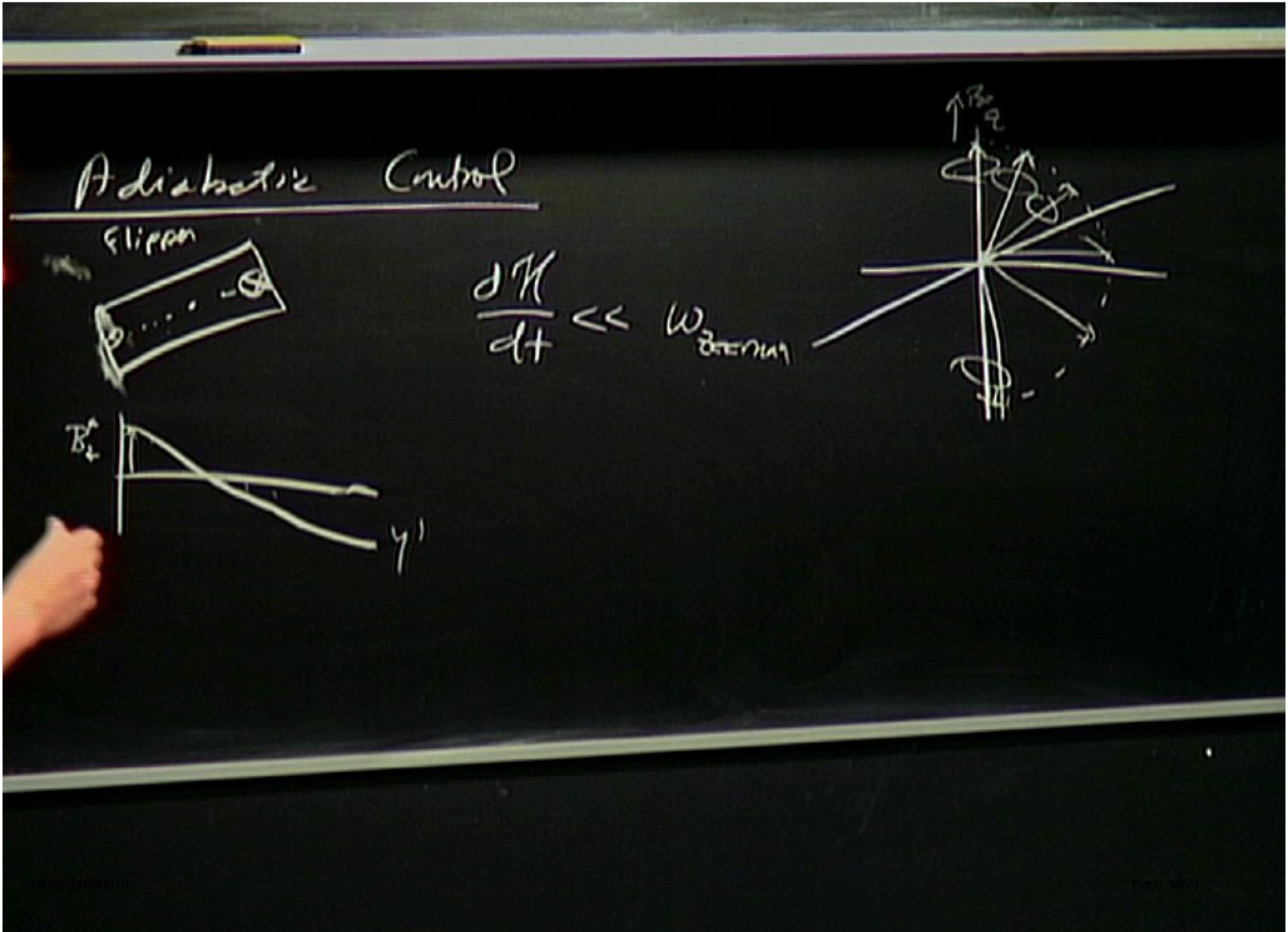
Spin rotation
resonance freq
= frequency of osc. field
= Zeeman
control
control

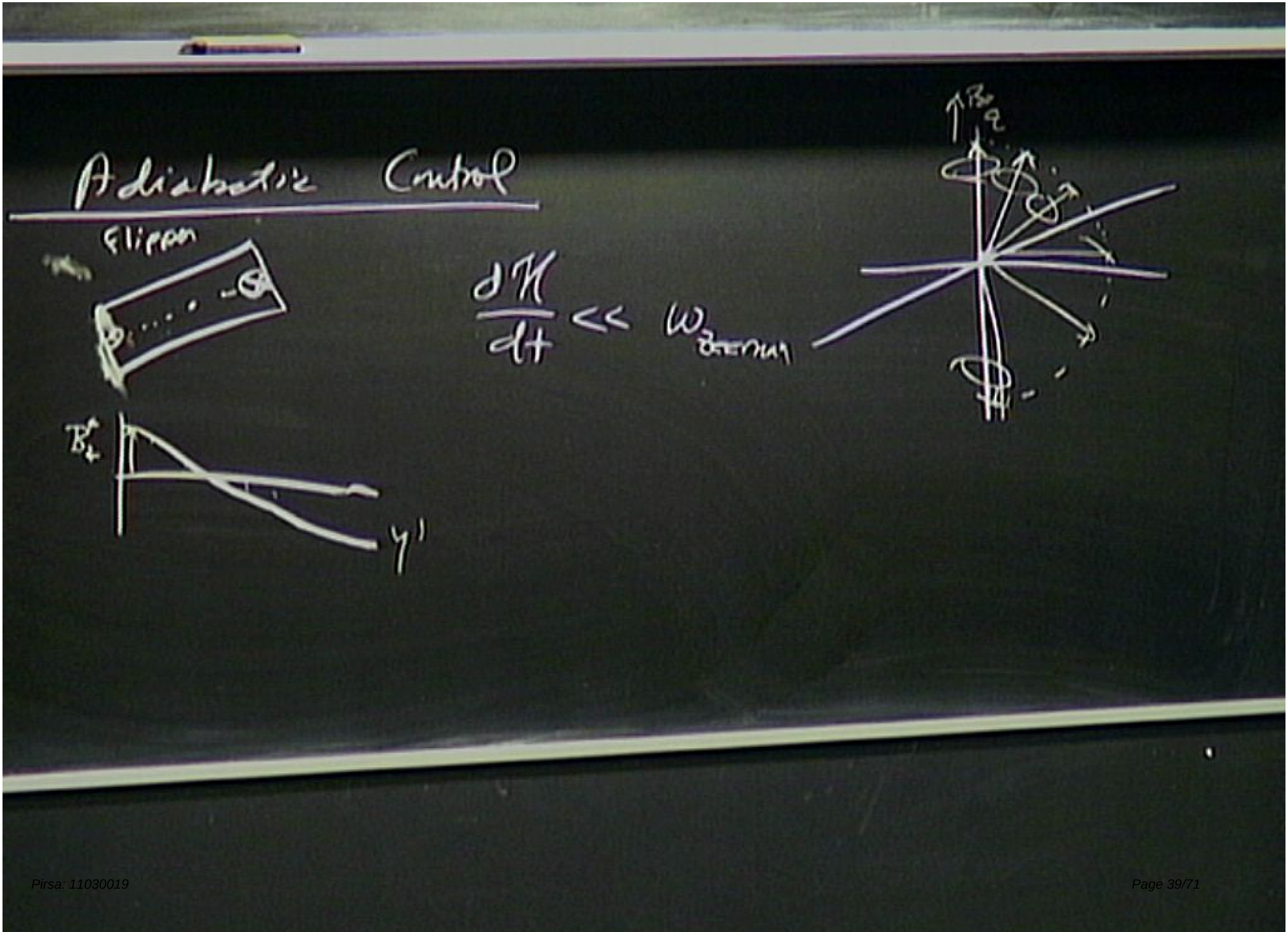


Control
varying
Adiabatic Control
Slippan


Adiabatic Control
flipper
y'

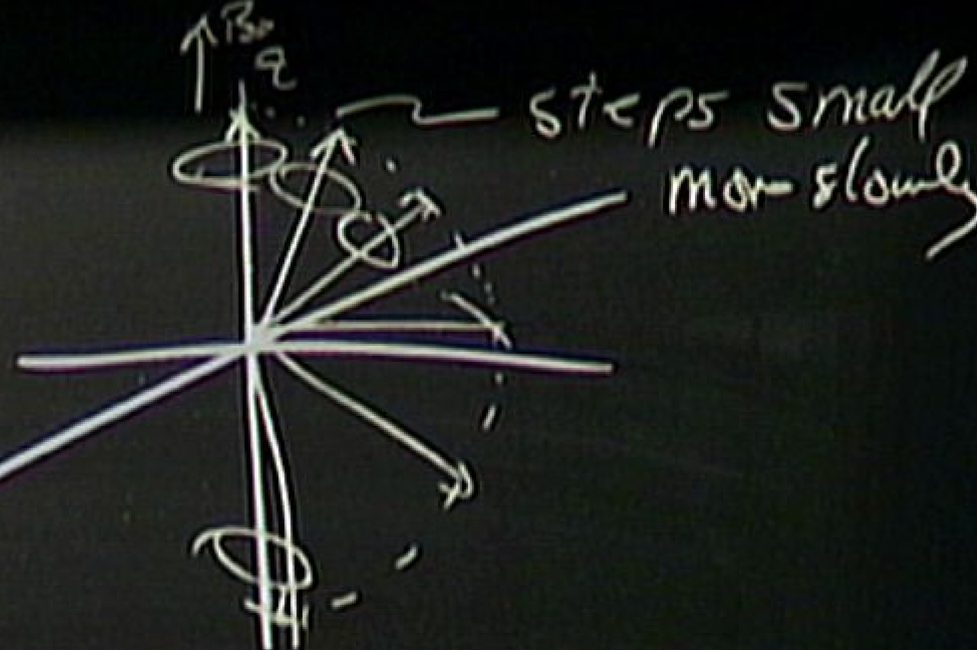

Adiabatic Control
Flipper
dH/dt << ω
y'

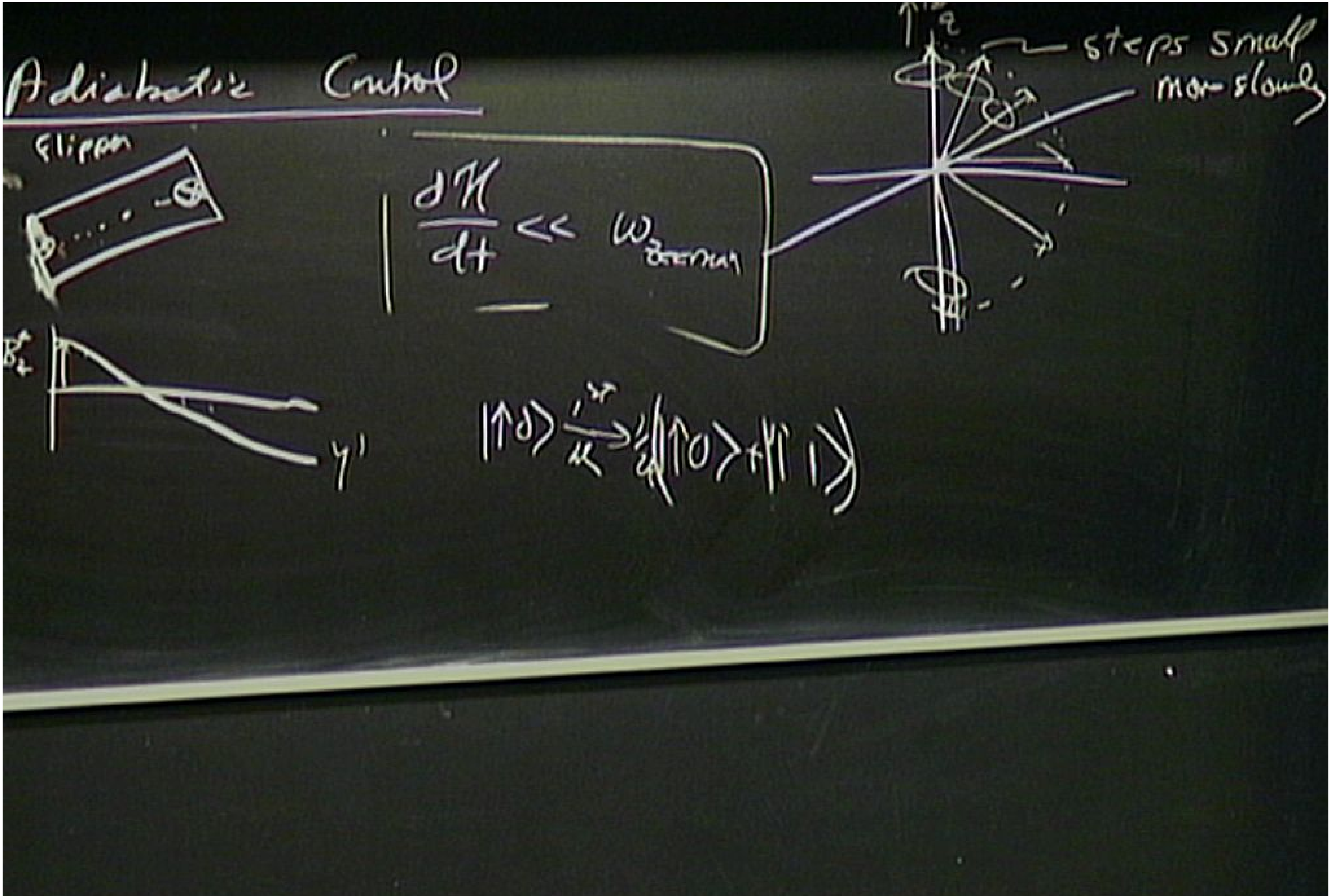

Adiabatic Control
Flipper
$\frac{dH}{dt} << \omega$
y'

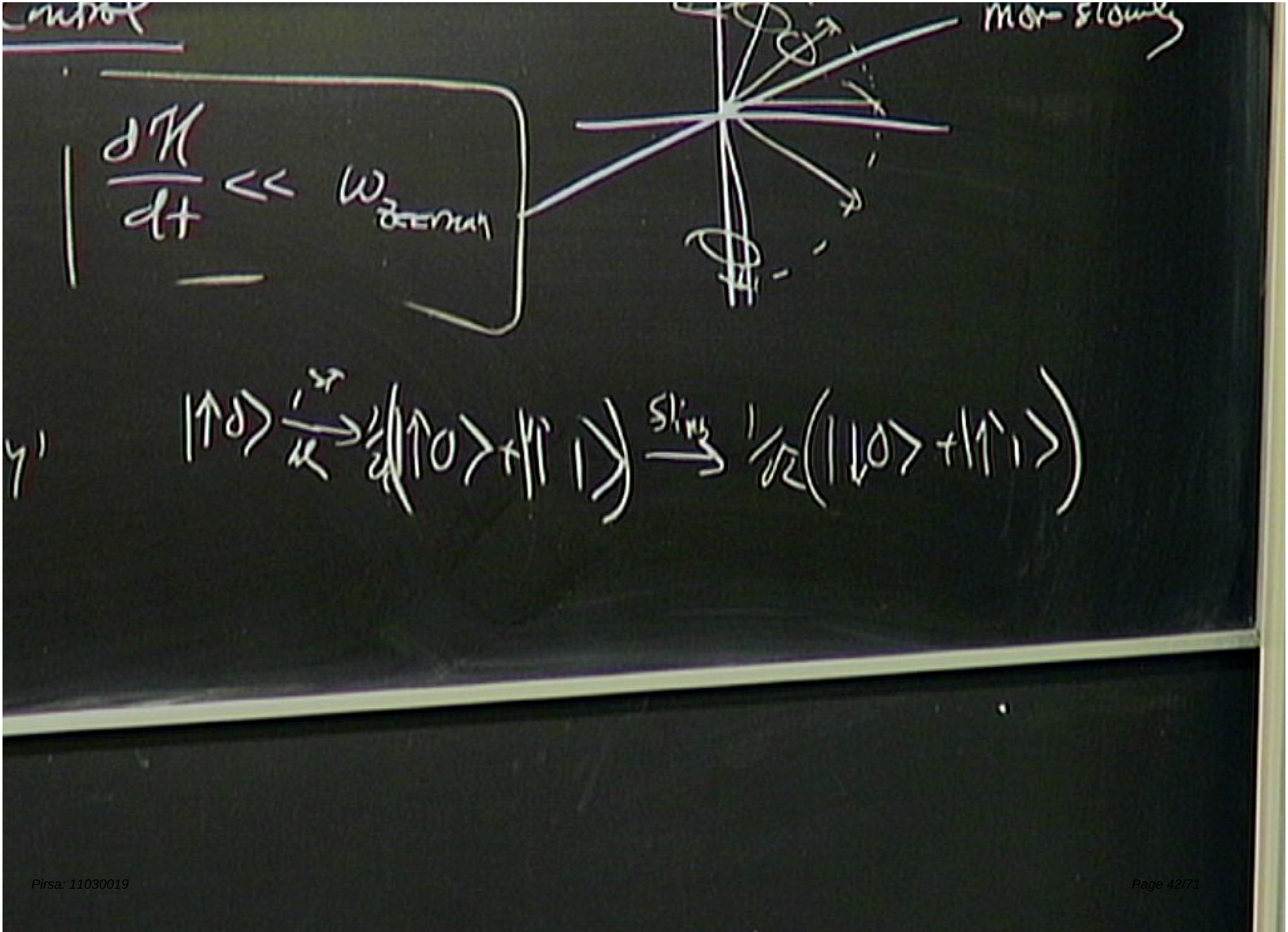

Adiabatic Control
Flipper
$\frac{dH}{dt} << \omega$

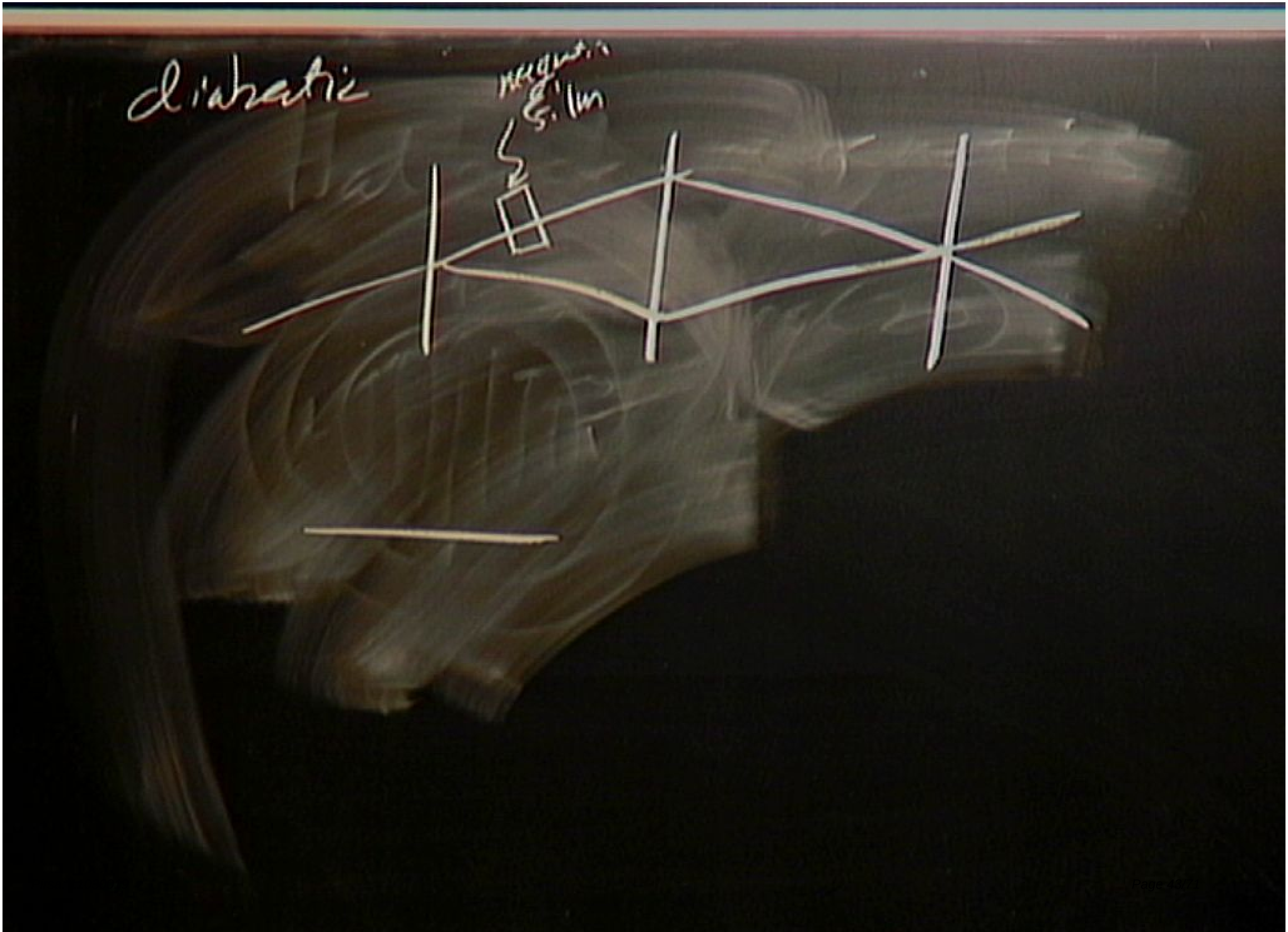
ntrol

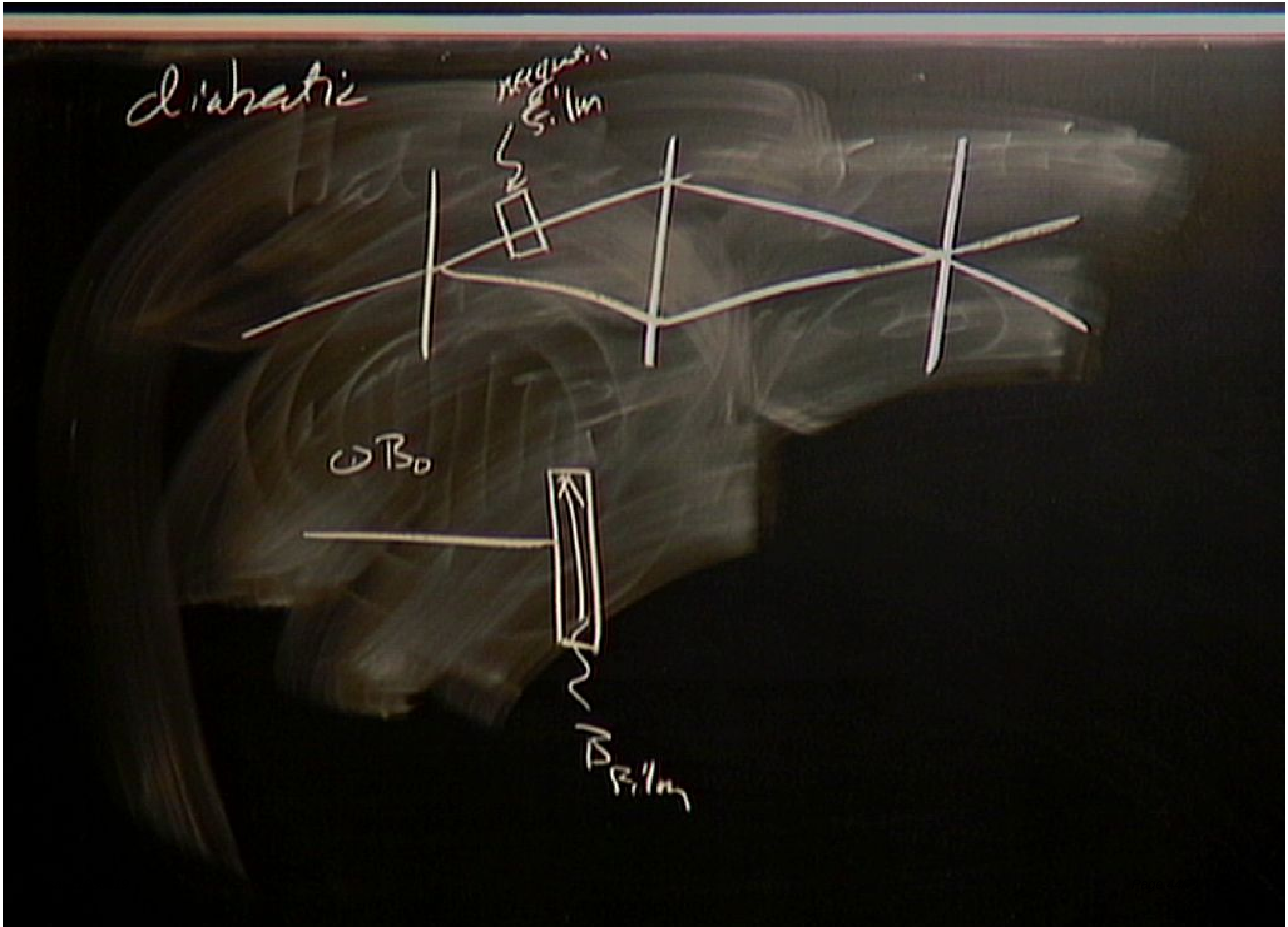
$$\frac{d\mathcal{H}}{dt} \ll \omega_{Zeeman}$$

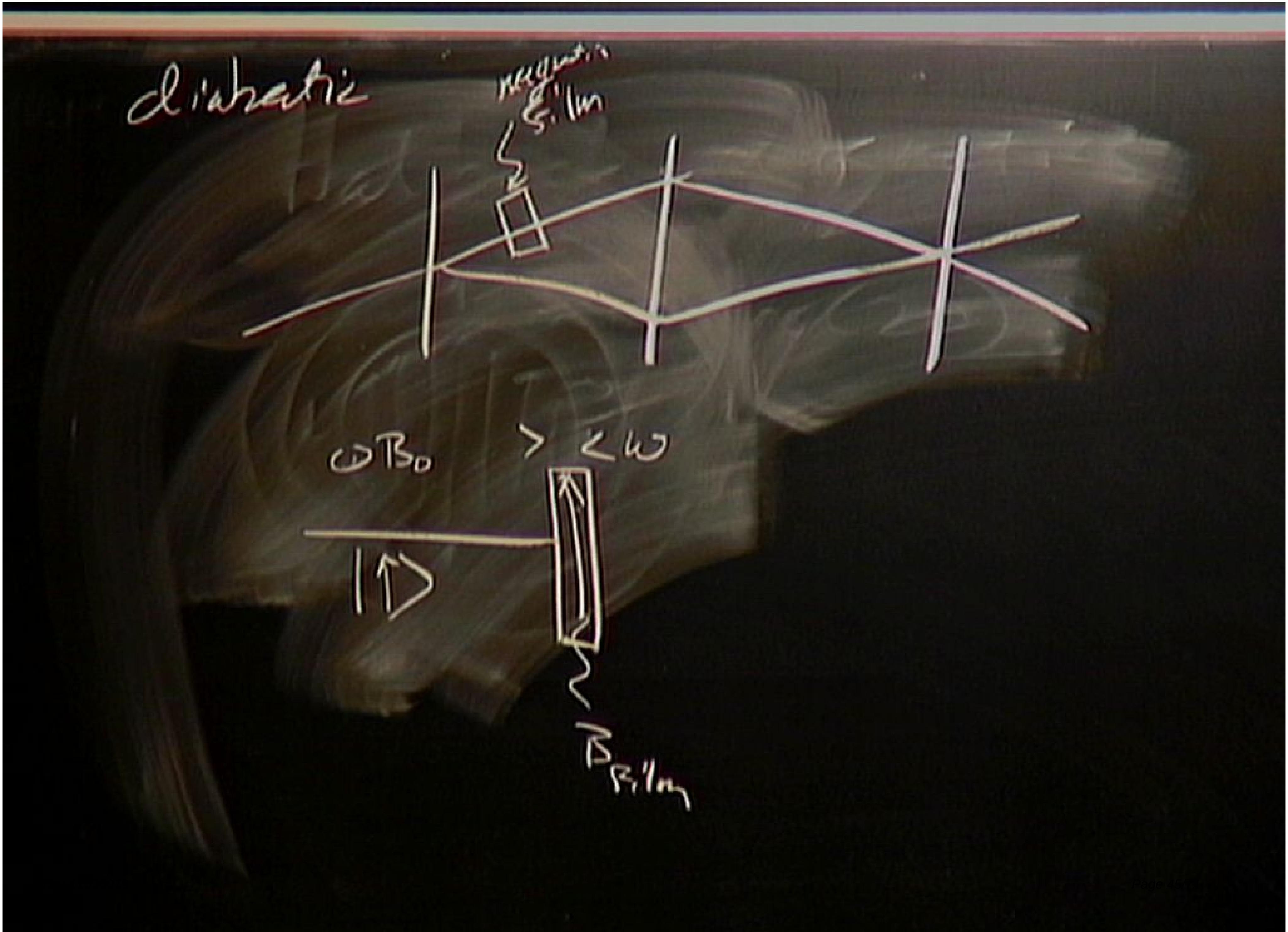


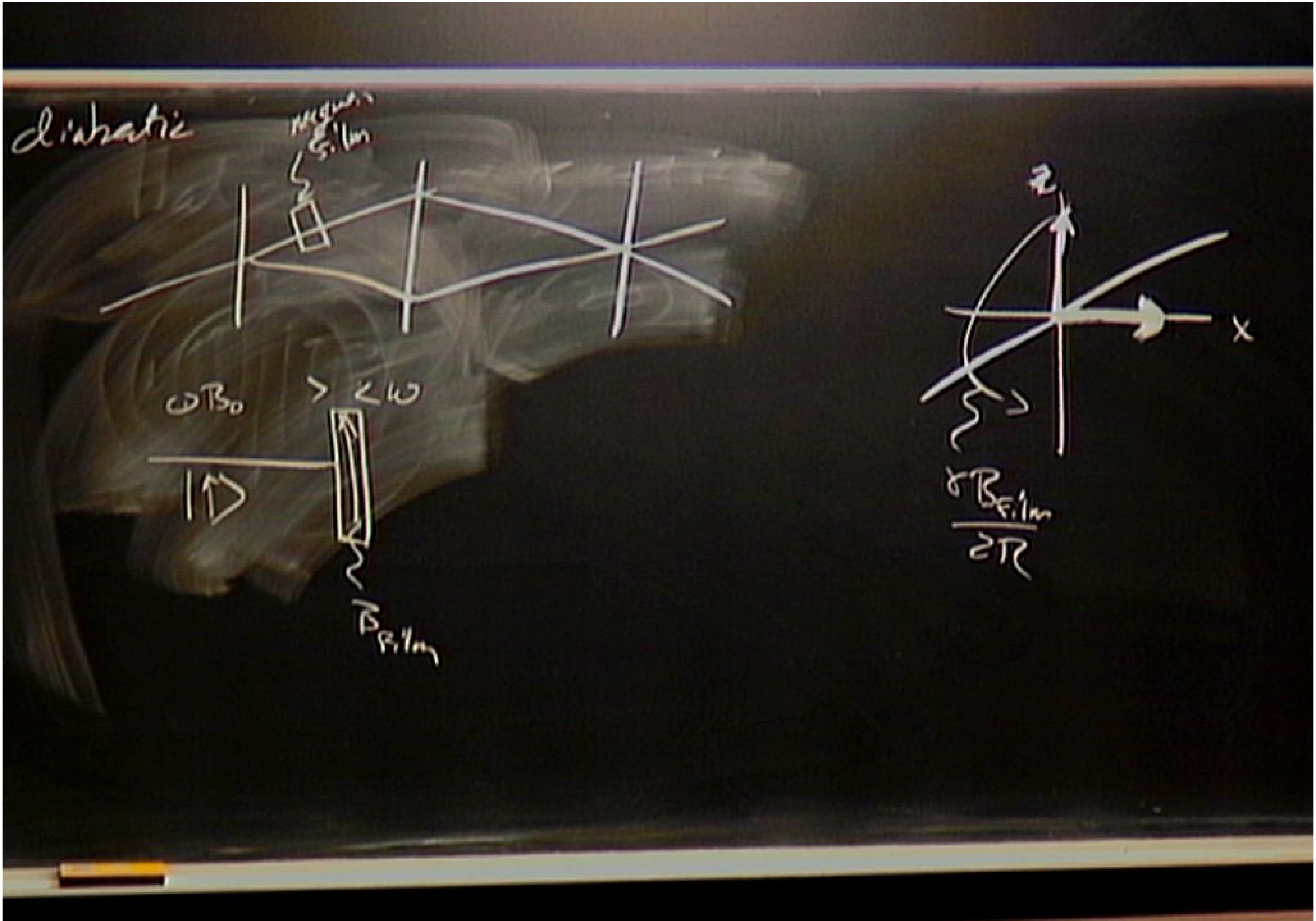

Adiabatic Control
flipper
steps small
move slowly
$\frac{dH}{dt} \ll \omega_{Larmor}$

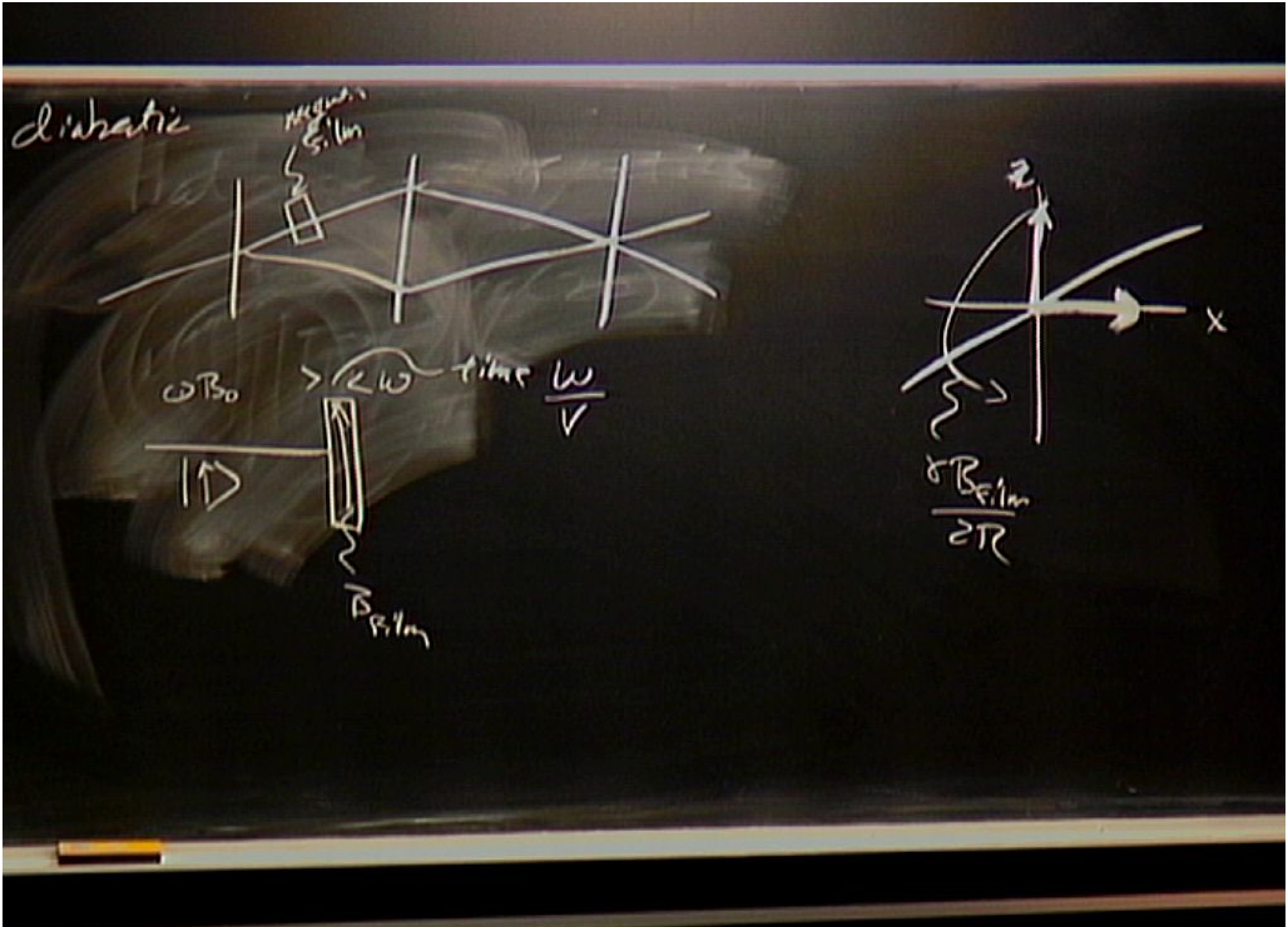

more slowly

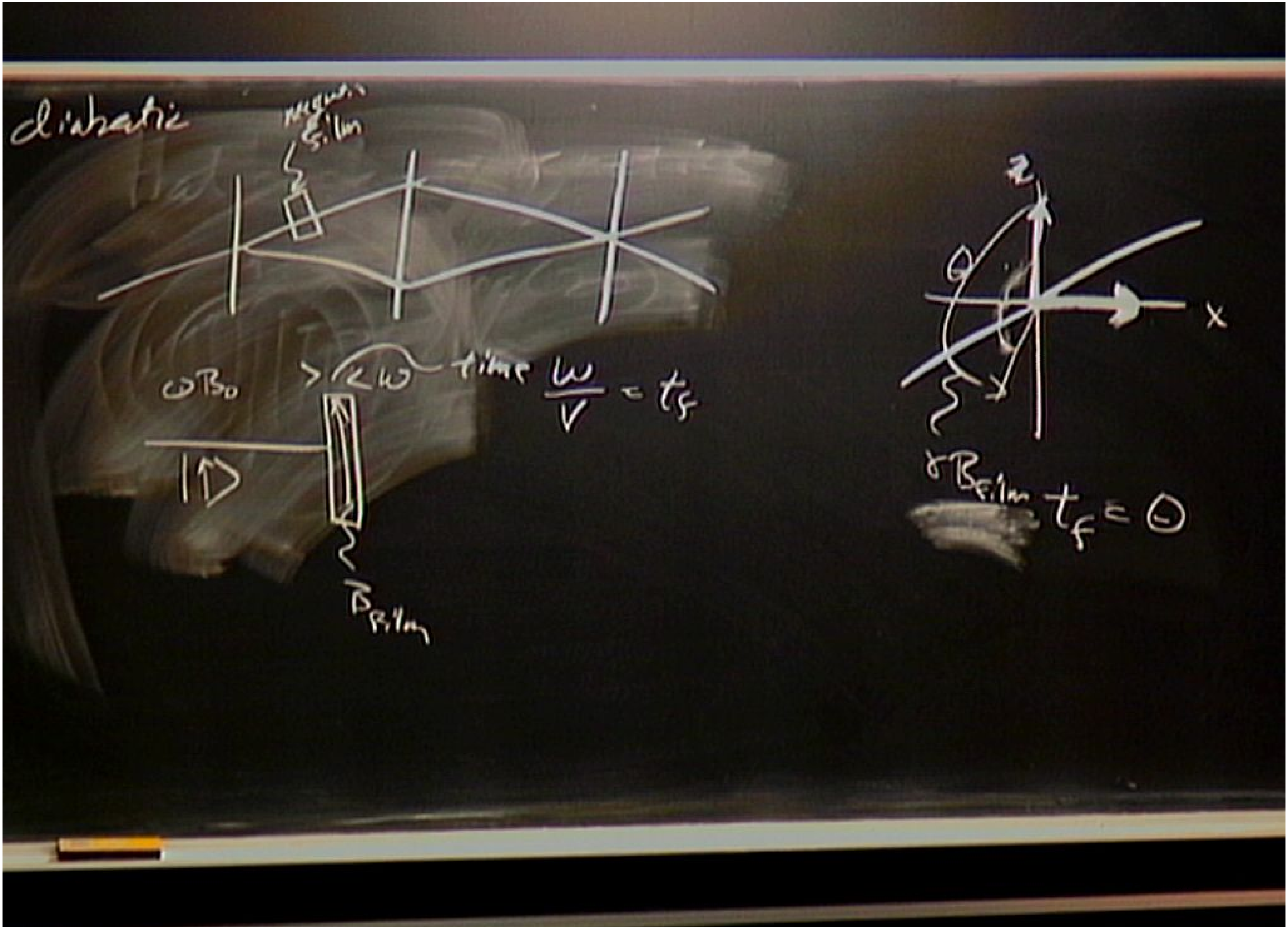

diabatic

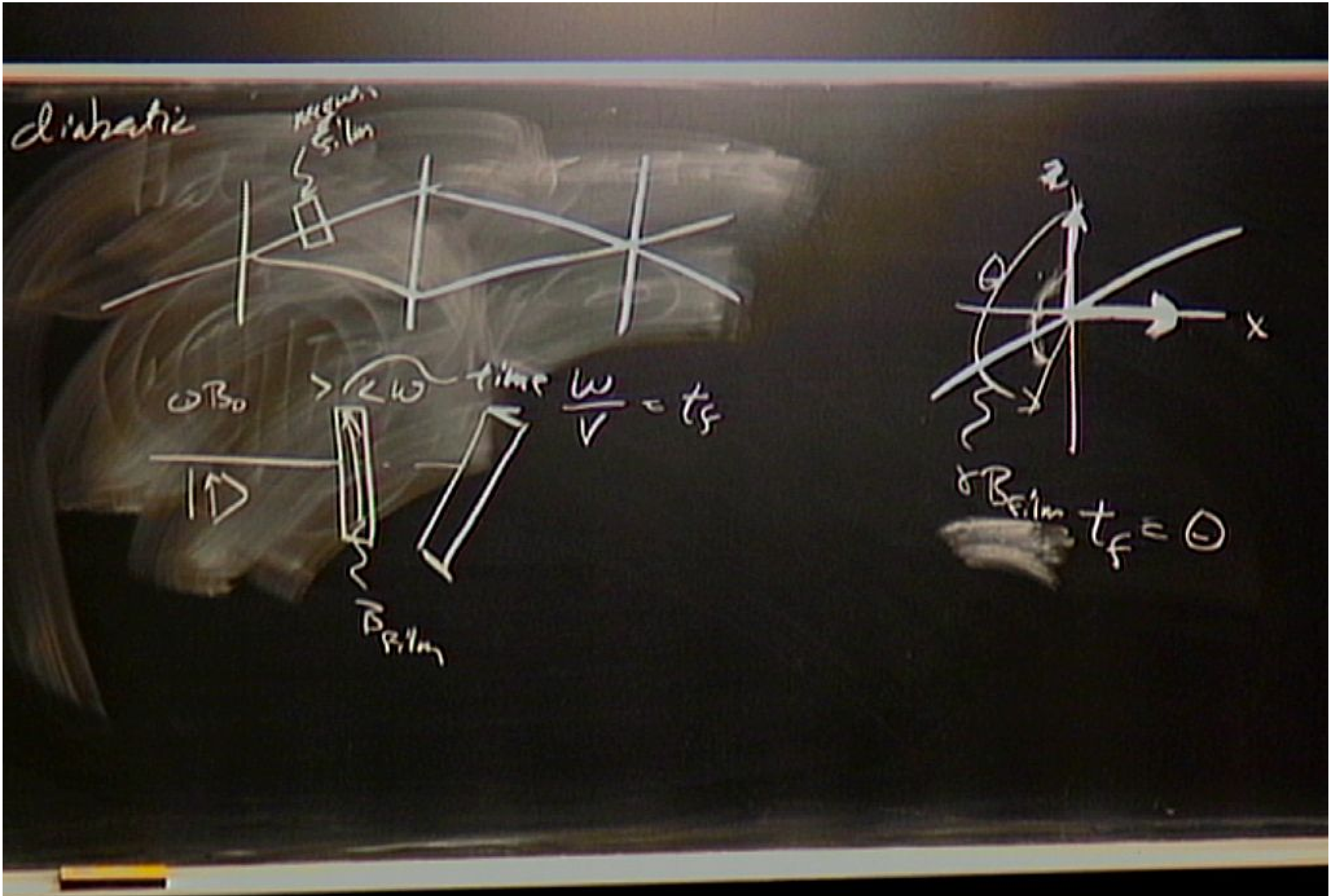

diabatic
negative film
B0
B film


diabatic
|↑⟩

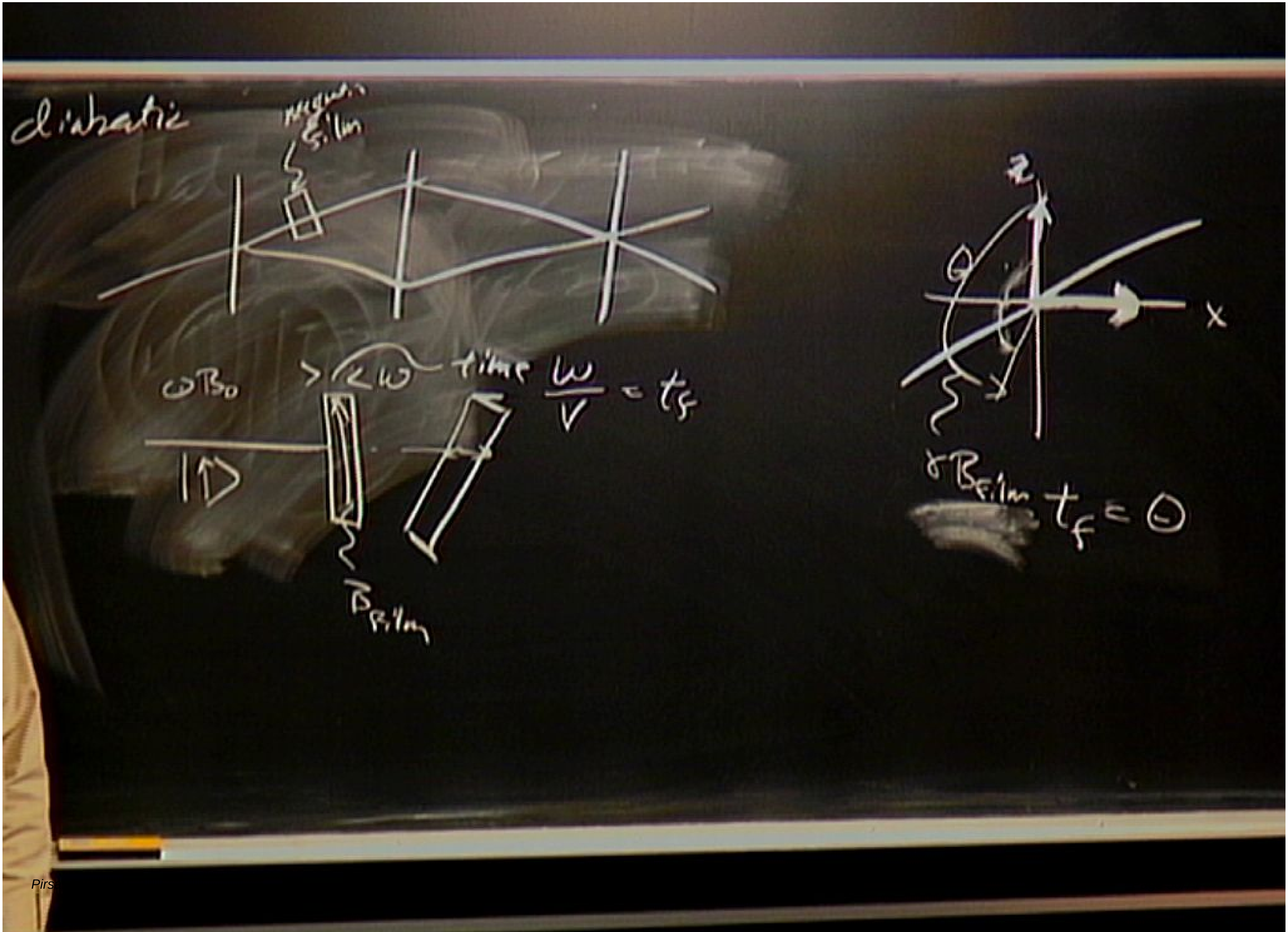

diabatic
1D
B film
z
x

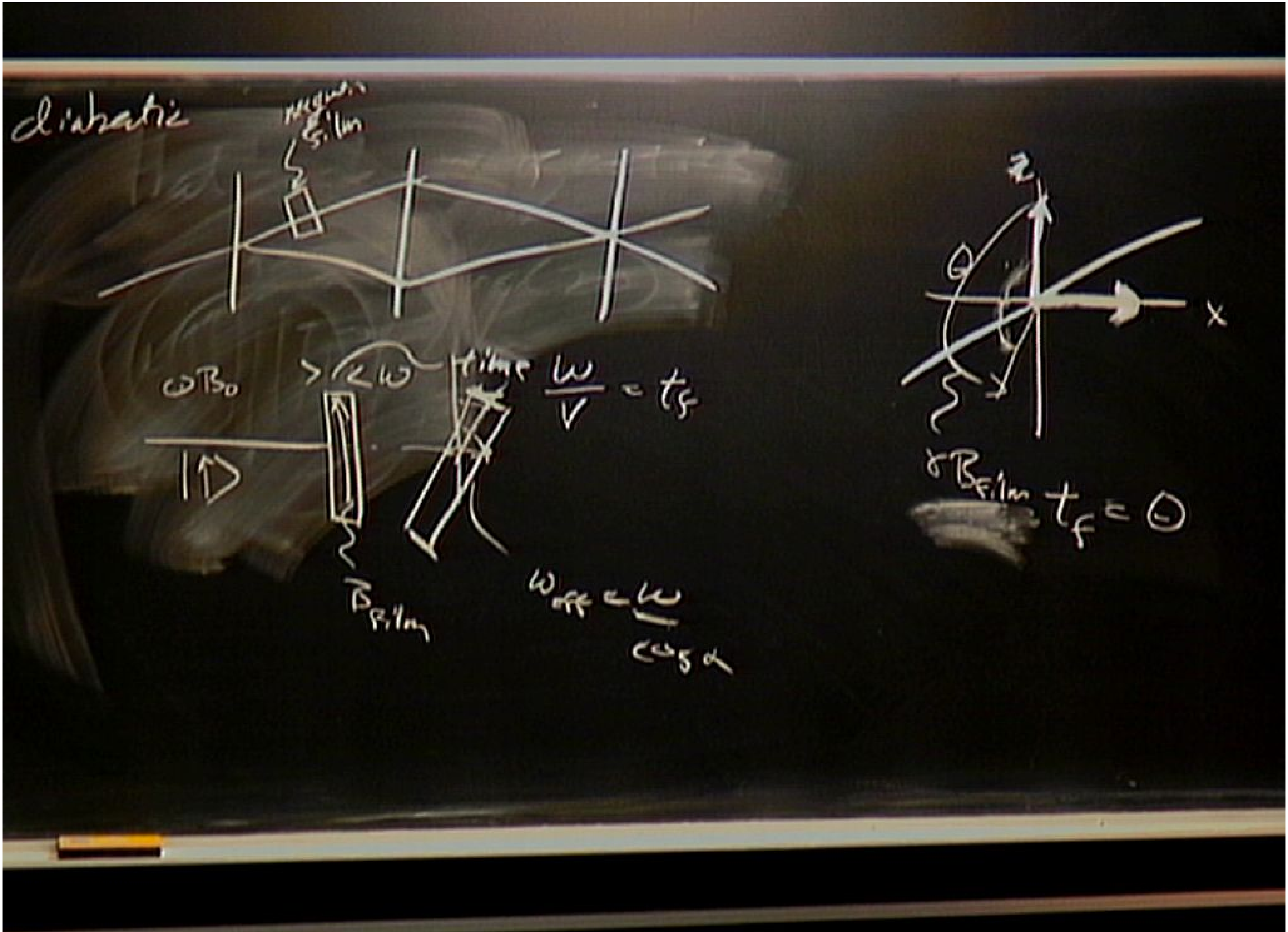

diabatic
film
ωB0
time
ω/v
1D
B film
z
x
δB film / ∂R


diabatic
time
$\frac{w}{V} = t_f$
1D
B_{film}
z
x
θ
$\delta B_{film} t_f = \theta$

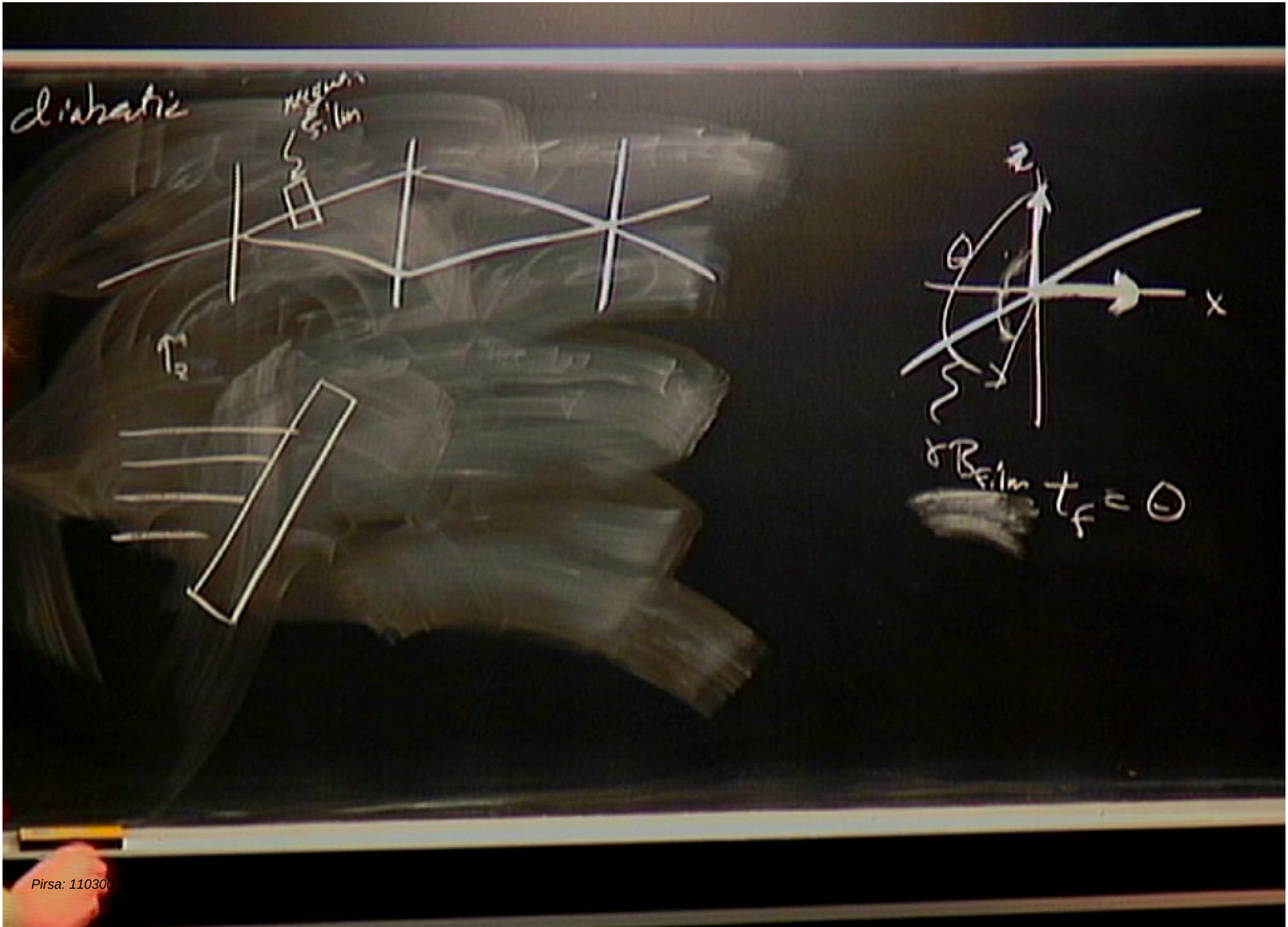


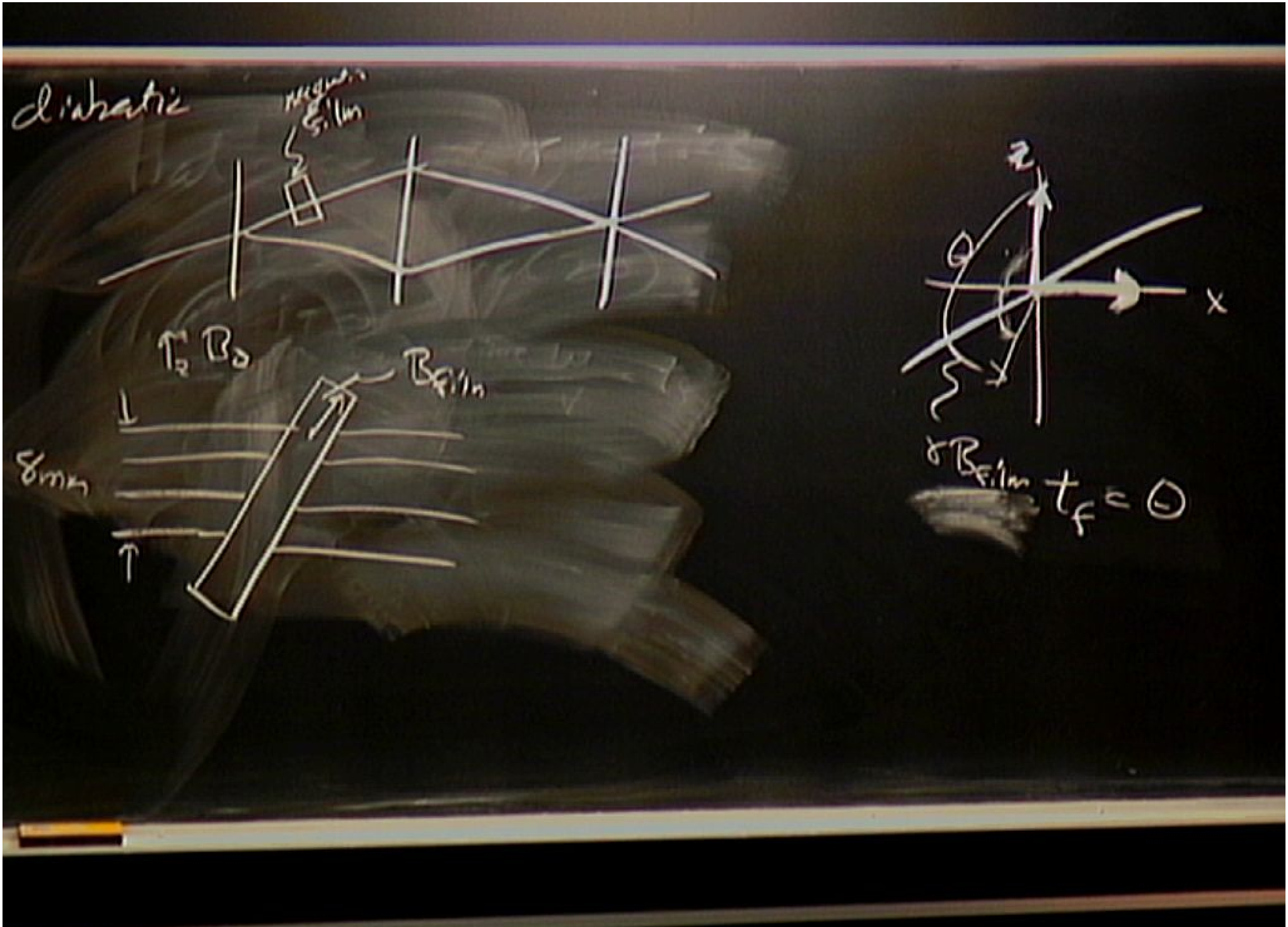
diabatic
ωB₀
time
W/V = t_f
1D
B_film
z
x
θ
δB_film
t_f = θ

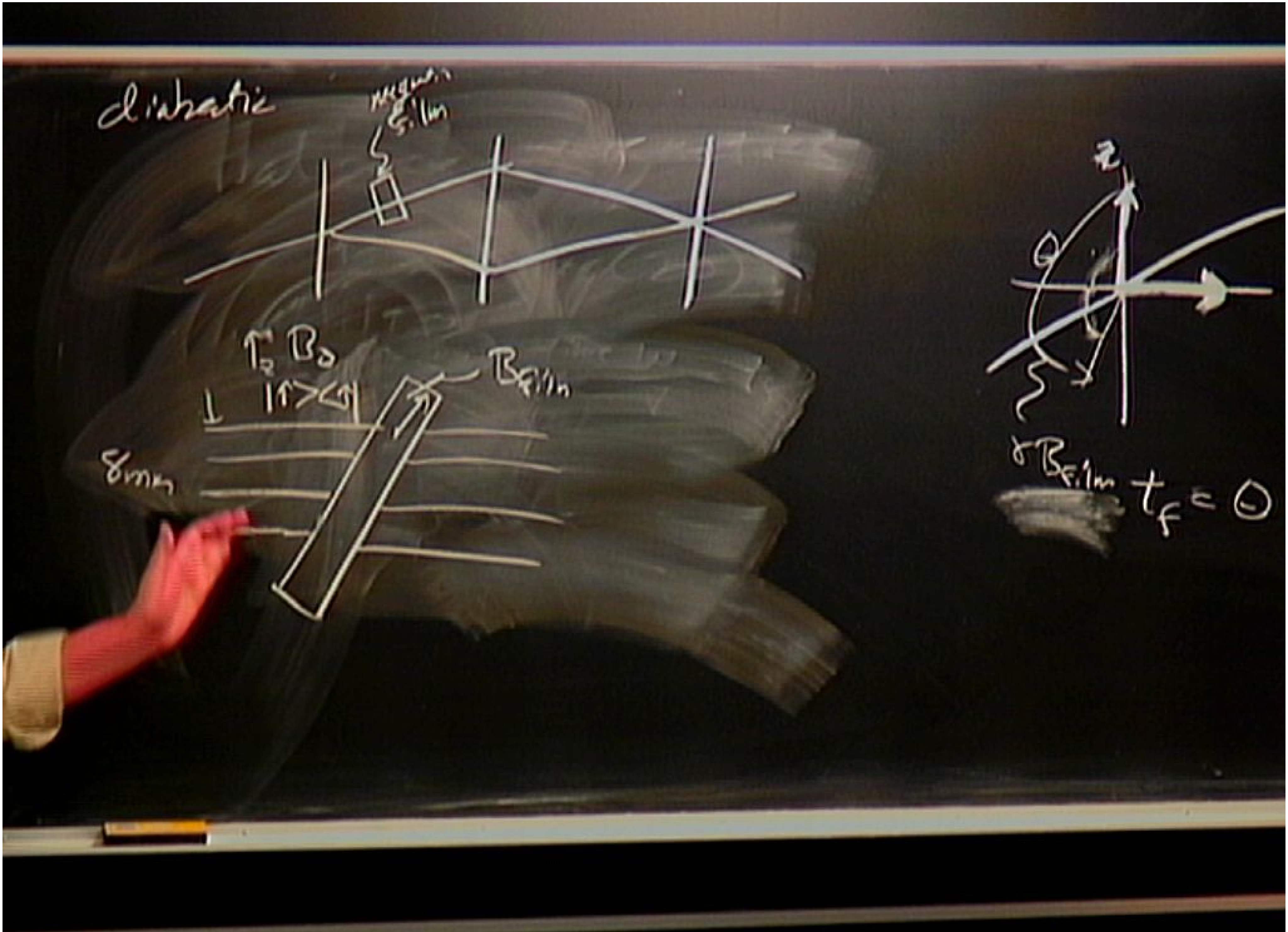

diabatic
time
z
x

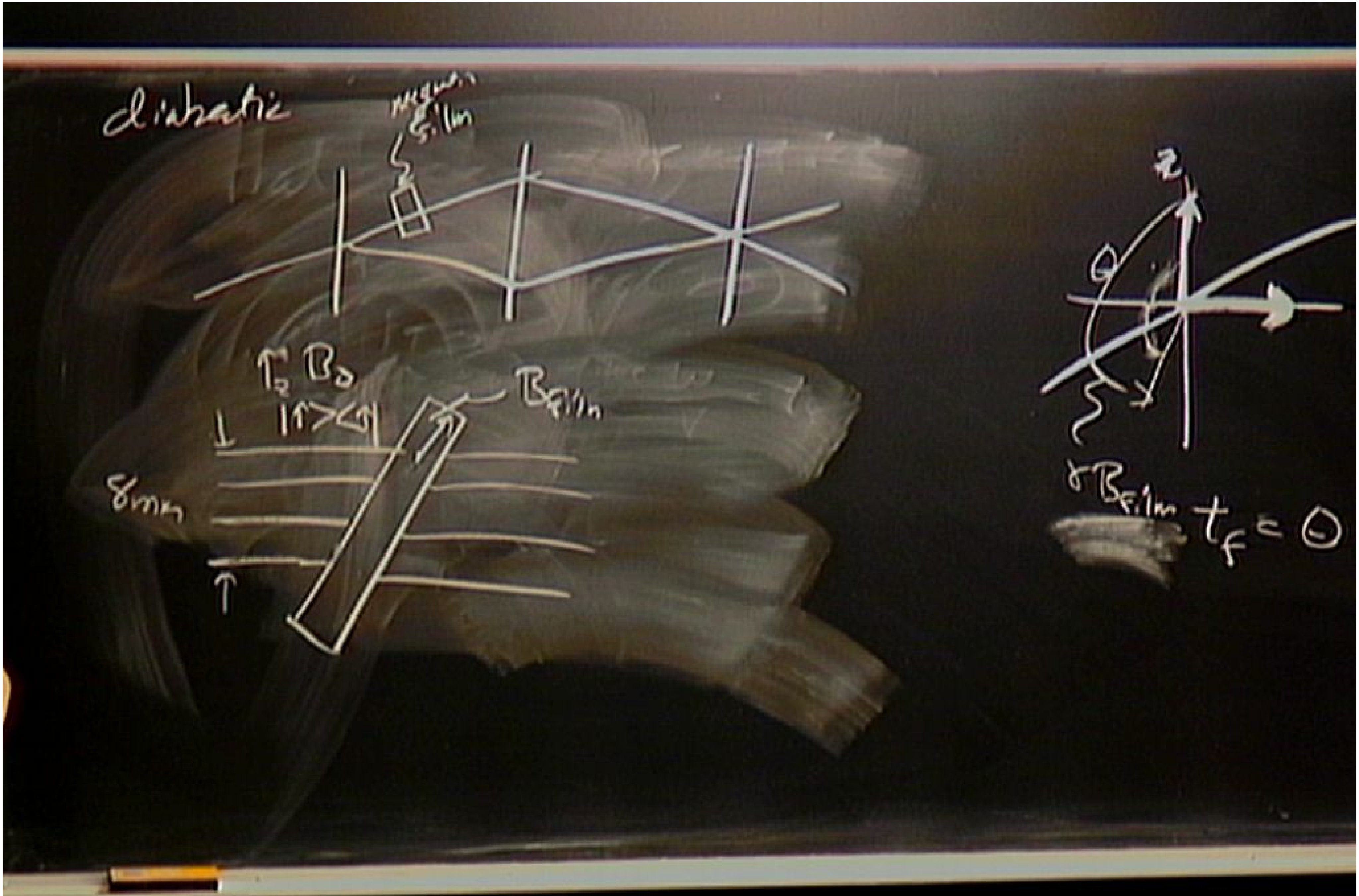


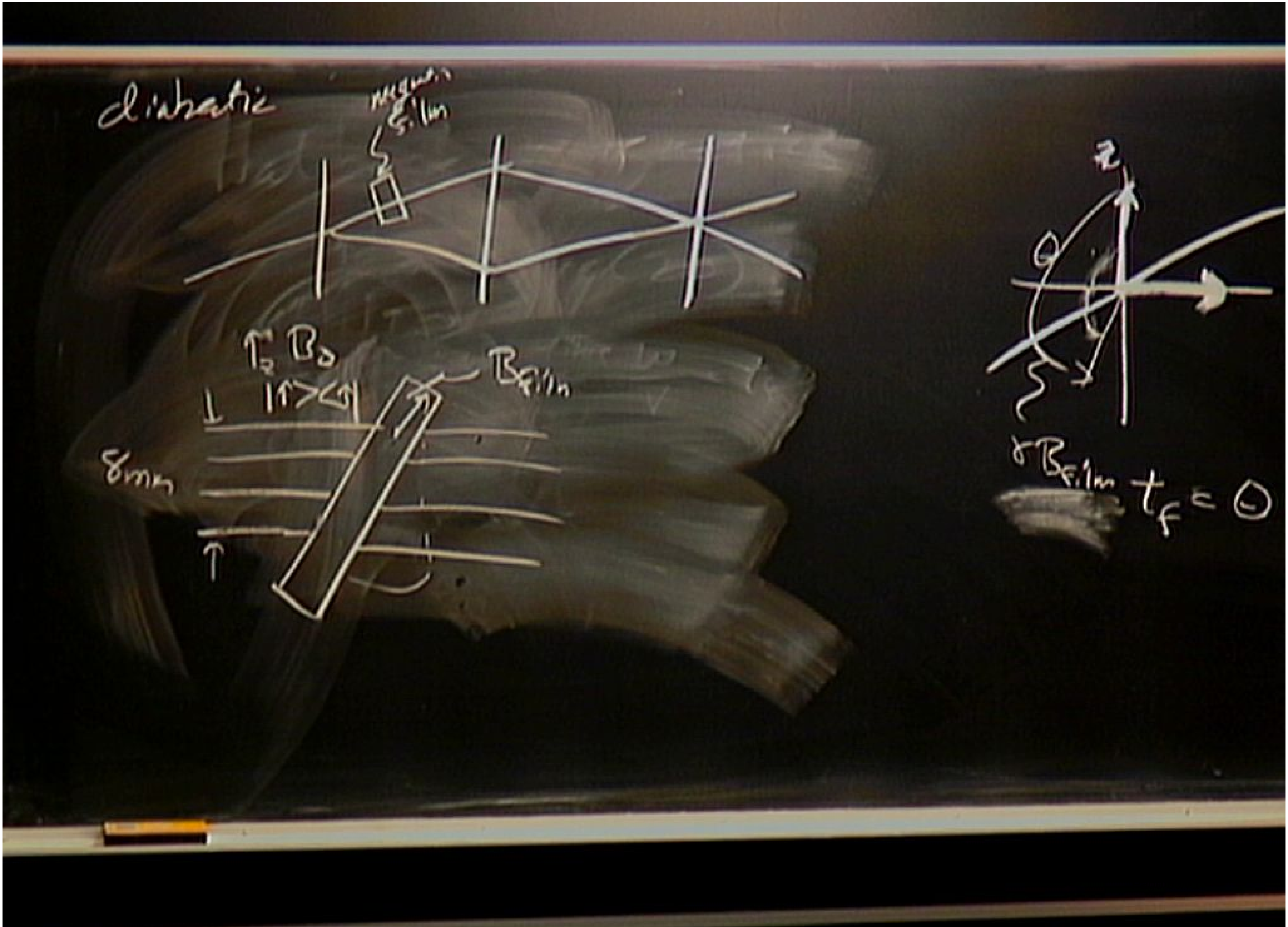
diabatic
magnetic film
time
w/v = t_f
1D
B_film
w_eff = w/cos α
z
x
δB_film t_f = θ

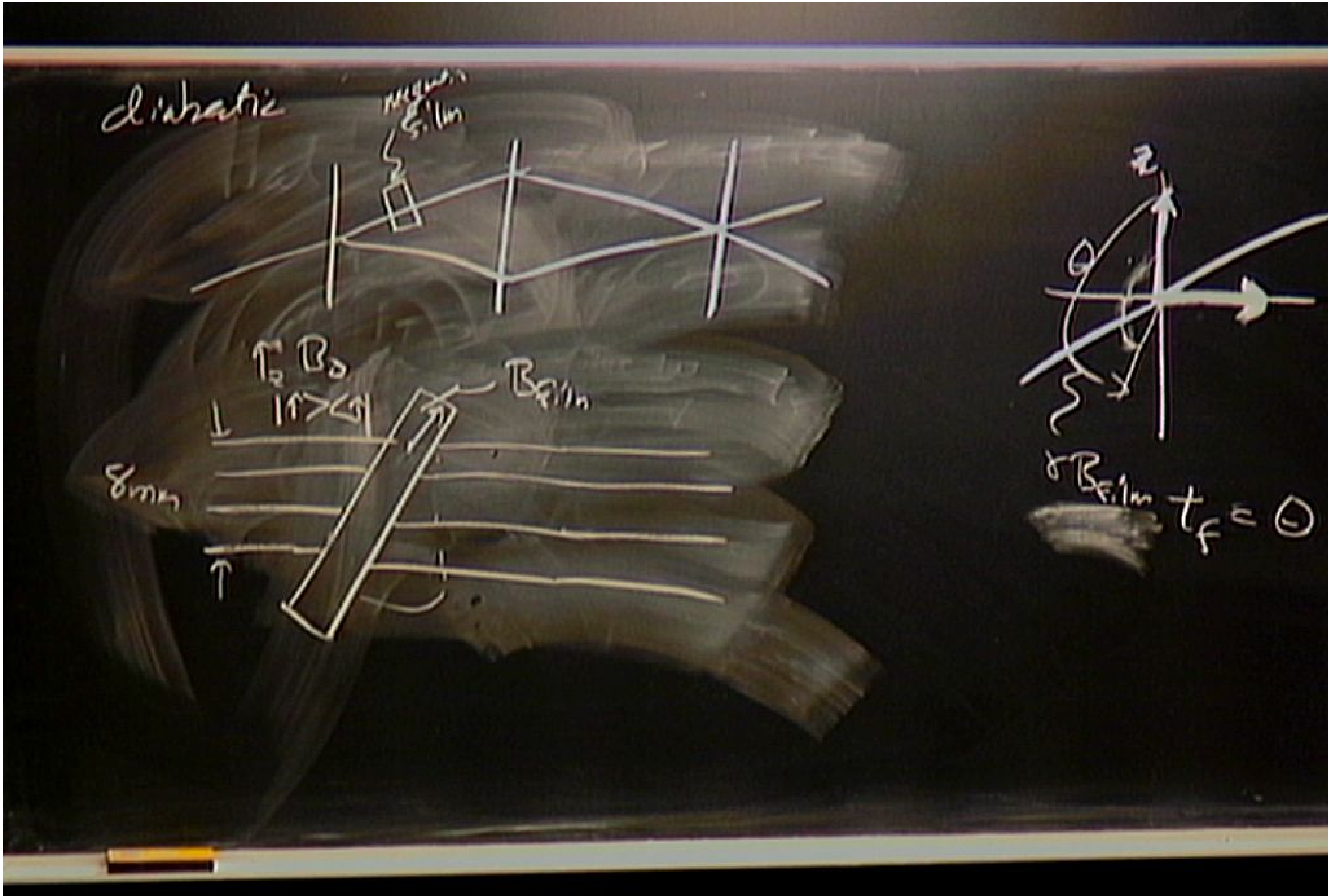

diabatic
z
x
θ
$t_F = 0$

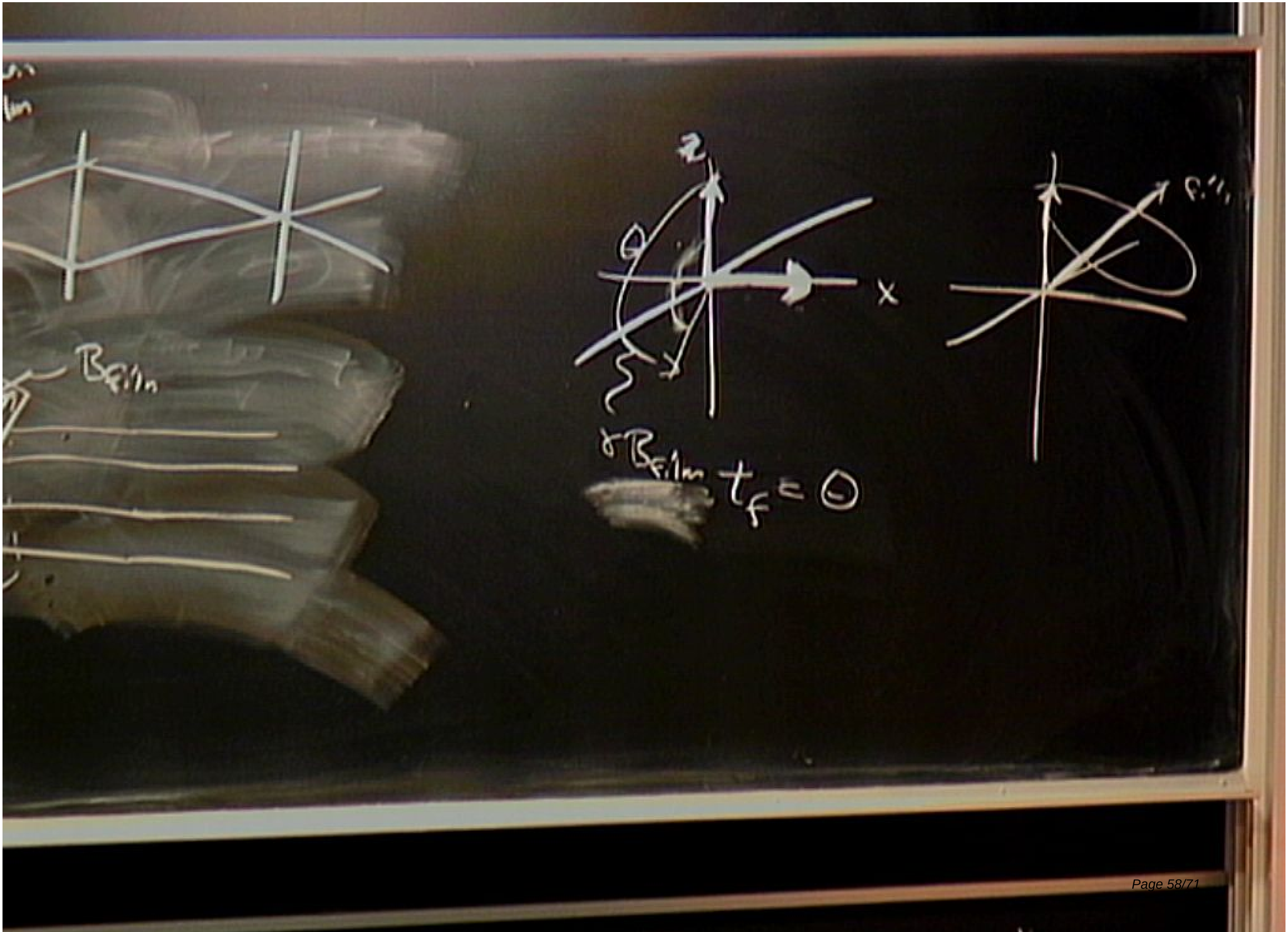

diabatic
B_film
8mm
z
x
θ
δB_film t_f = Θ

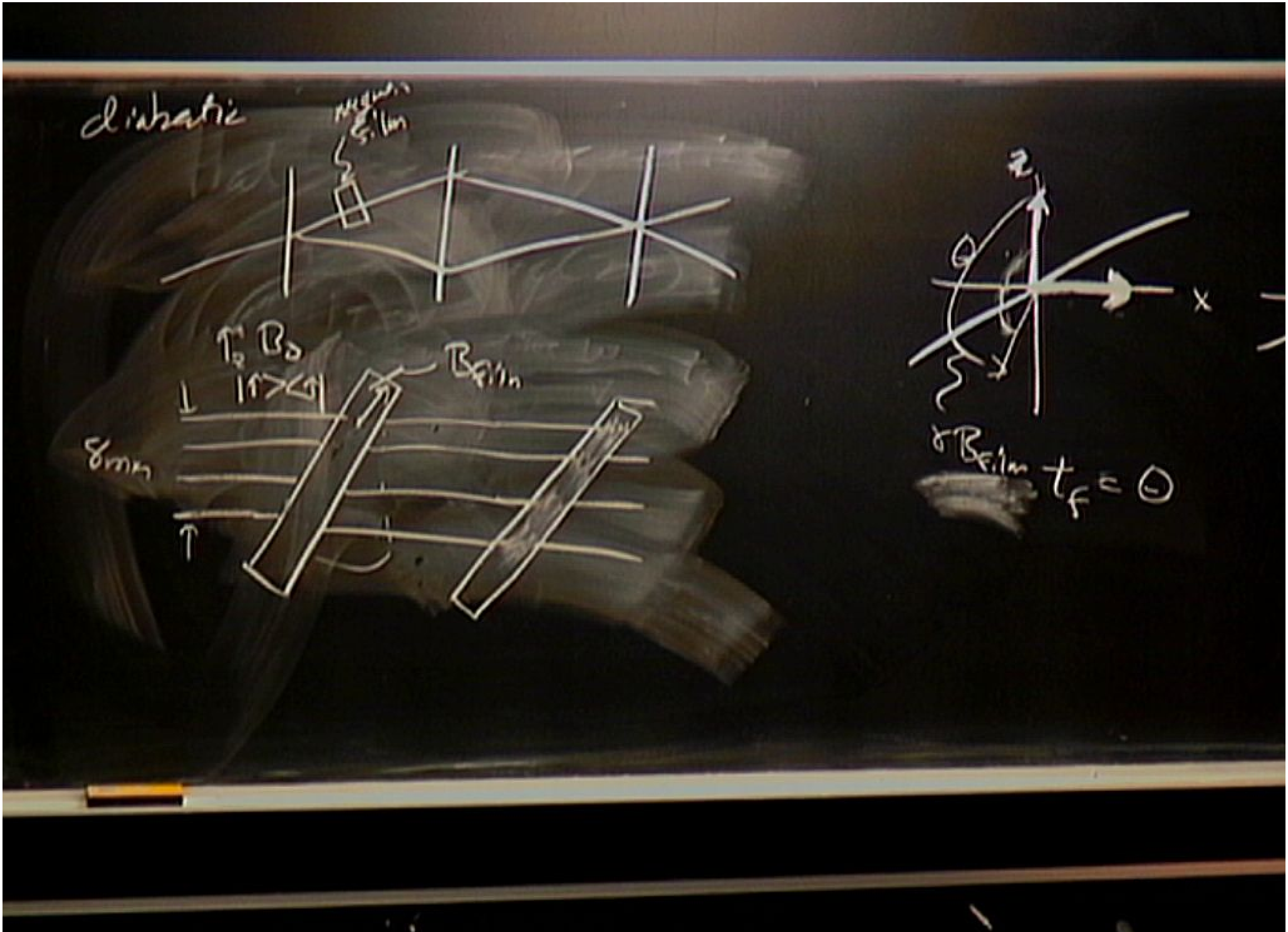

diabatic
8mm
z

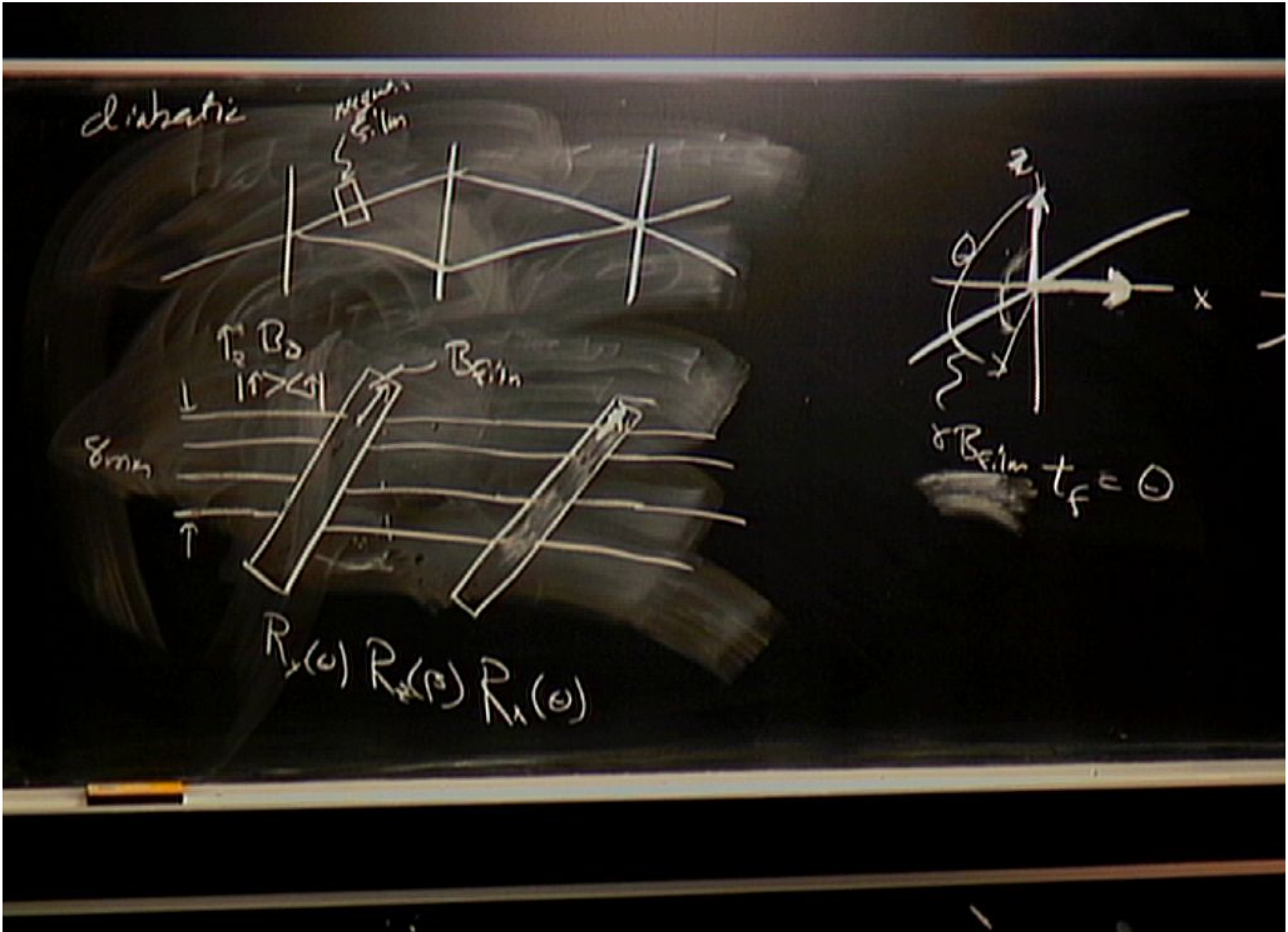

diabatic
magnet
Bfilm
T_2 B_0
$|\uparrow\rangle\langle\downarrow|$
B_{film}
8mm
z
θ
$\gamma B_{film} t_F = \Theta$


diabatic
8mm


diabatic
8mm
z
θ
t_f = Θ


z
x


diabatic
B0
Bfilm
8mm
z
x
θ
γBfilm tf = θ


diabatic
8mm
z
x

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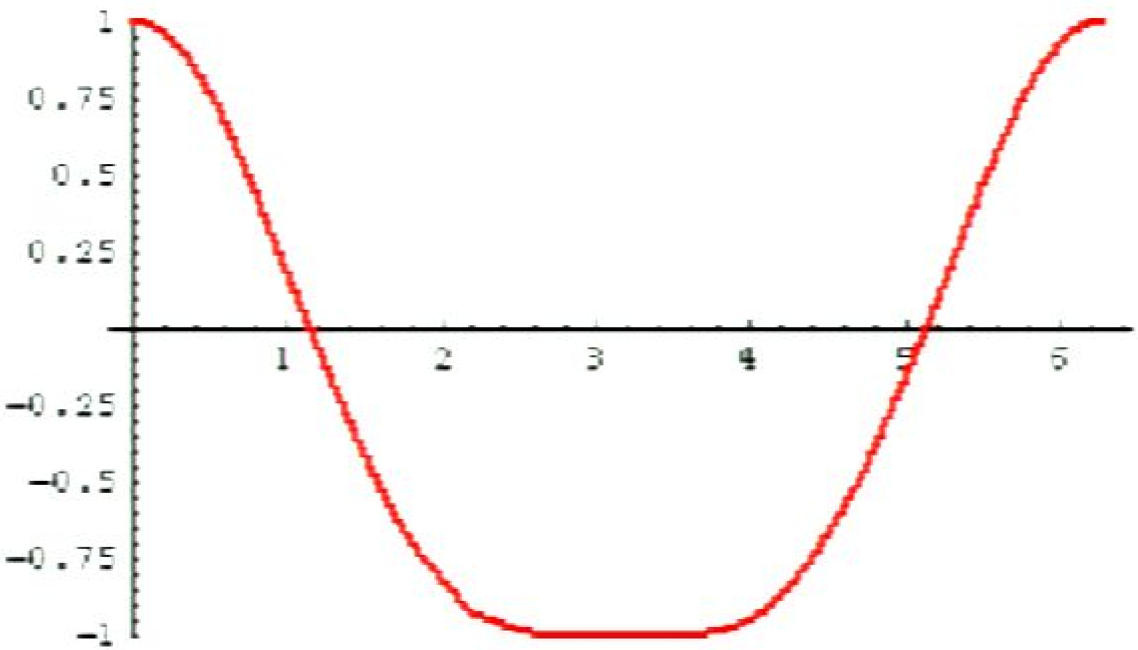
QE Lec 6 Composite Rot.nb

- Graphics -

```
p2 = Plot[MzCrot[a][[3]], {a, 0, 2 Pi},
  {PlotRange -> {-1, 1},
   PlotStyle → {Thickness[0.01], RGBColor[1, 0, 0]}}]
```



- Graphics -

```
Show[p1, p2]
```

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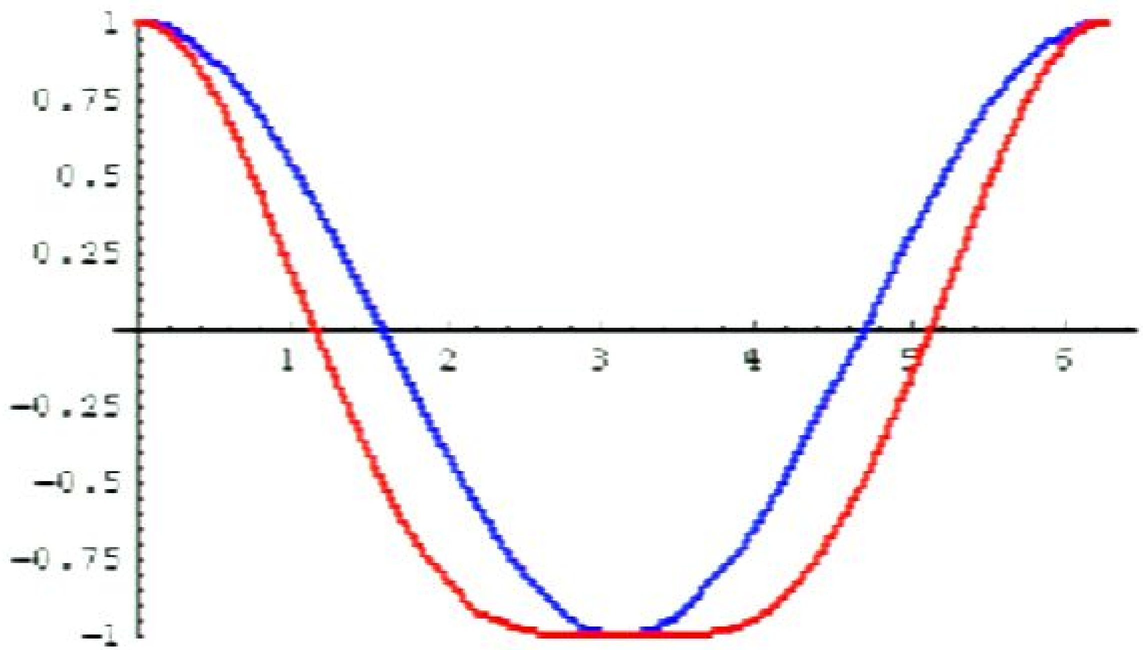
QE Lec 6 Composite Rot.nb

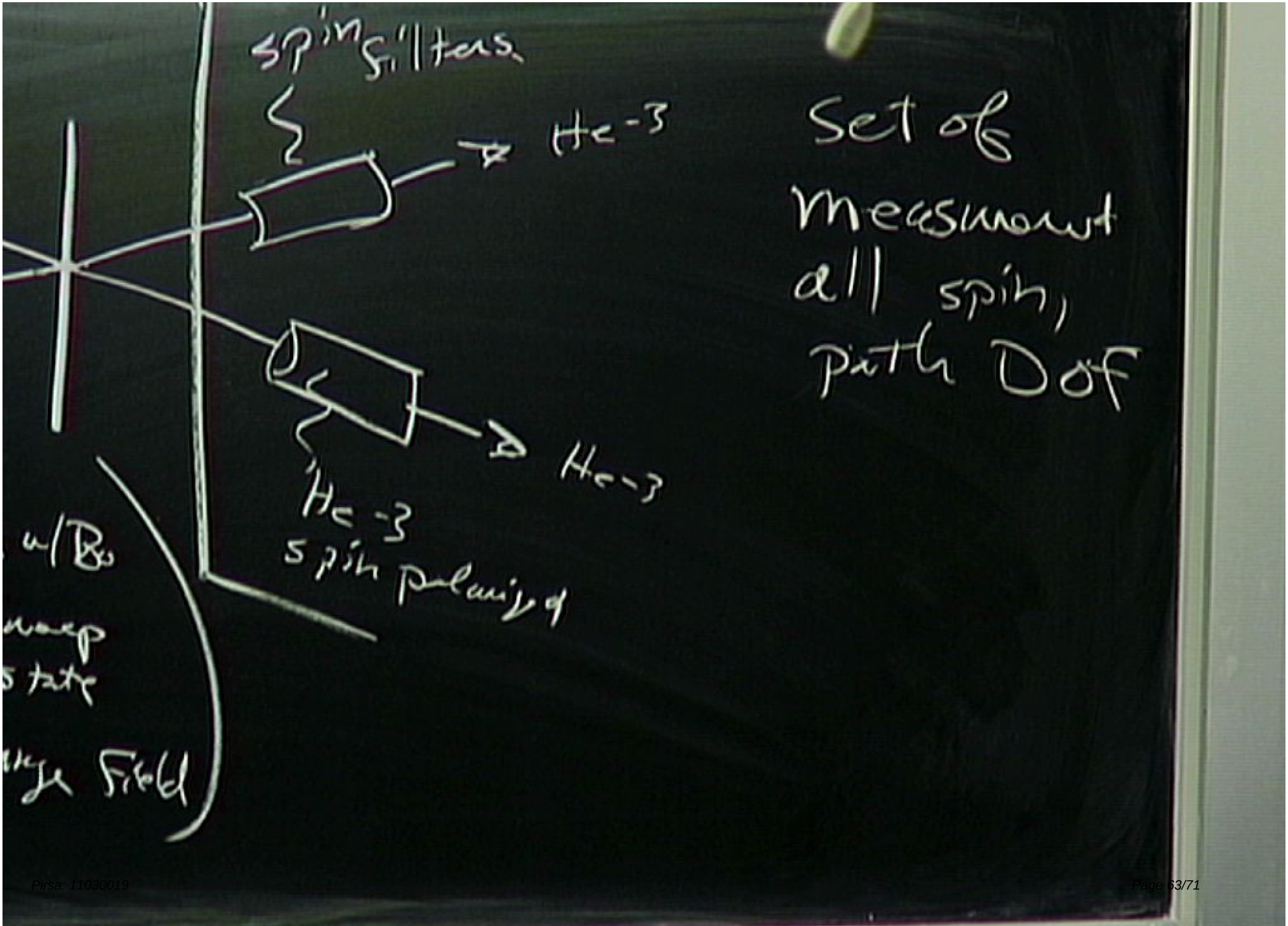
```
Show[p1, p2]
```

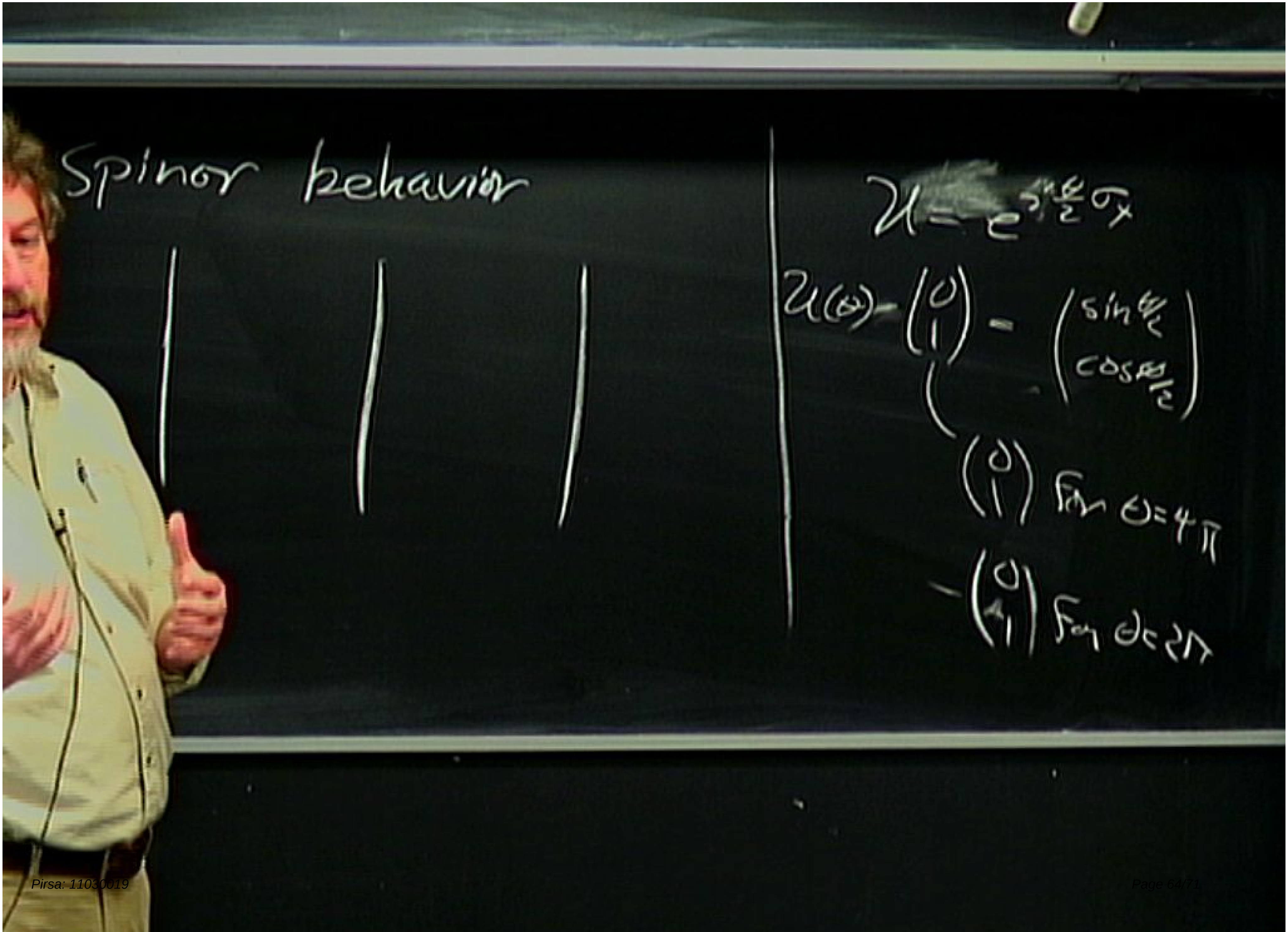


- Graphics -

```
sx = ParametricPlot3D[{Cos[a], Sin[a], b}, {a, 0, 2 π},
   {b, -.01, .01}, {Boxed → False, Axes → False,
    PlotPoints → {64, 2}, DisplayFunction -> Identity,
                  ViewPoint -> {1.3, -2.4, 0.5},

    PlotRange -> {{-1, 1}, {-1, 1}, {-1, 1}}}];
```


spin filters
He-3
He-3
He-3
spin polarizer
w/ B₀
sweep
state
Field
Set of
measurement
all spin,
path DoF


Spinor behavior
$U = e^{i\frac{\theta}{2}\sigma_x}$
$U(\theta)\begin{pmatrix}0\\1\end{pmatrix} = \begin{pmatrix}\sin\theta/2\\ \cos\theta/2\end{pmatrix}$
$\begin{pmatrix}0\\1\end{pmatrix}$ for $\theta = 4\pi$
$-\begin{pmatrix}0\\1\end{pmatrix}$ for $\theta = 2\pi$

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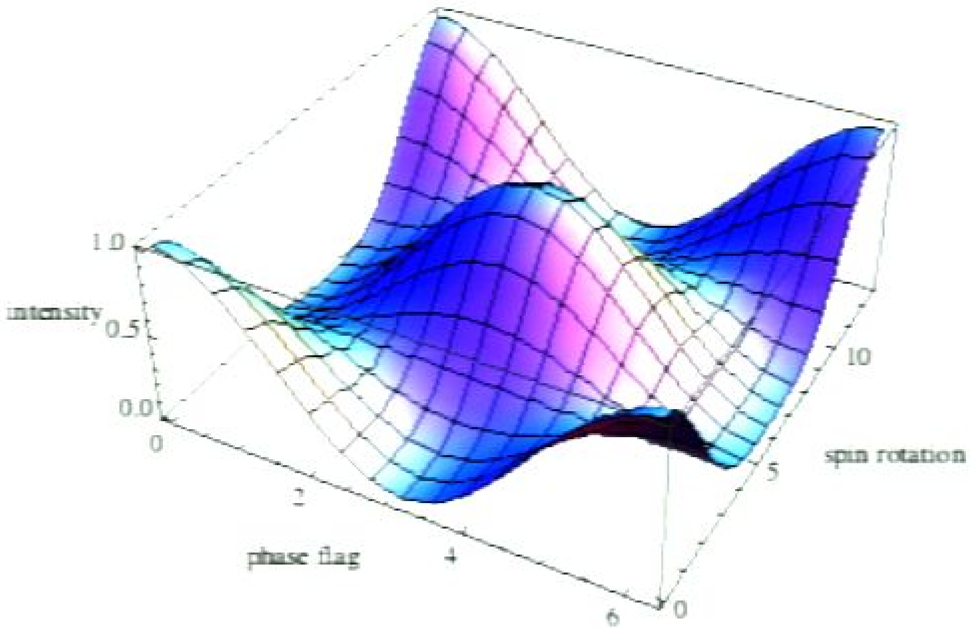
QE Lec 6.nb

$$\frac{1}{8}\left(3 - 2\,\text{Cos}\left[a - \frac{t}{2}\right] - 2\,\text{Cos}\left[a + \frac{t}{2}\right] - \text{Cos}[t]\right)$$

```
Plot3D[MOup[t, a], {a, 0, 2 π}, {t, 0, 4 π},
 {AxesLabel → { "phase flag", "spin rotation", "intensity"}}]
```

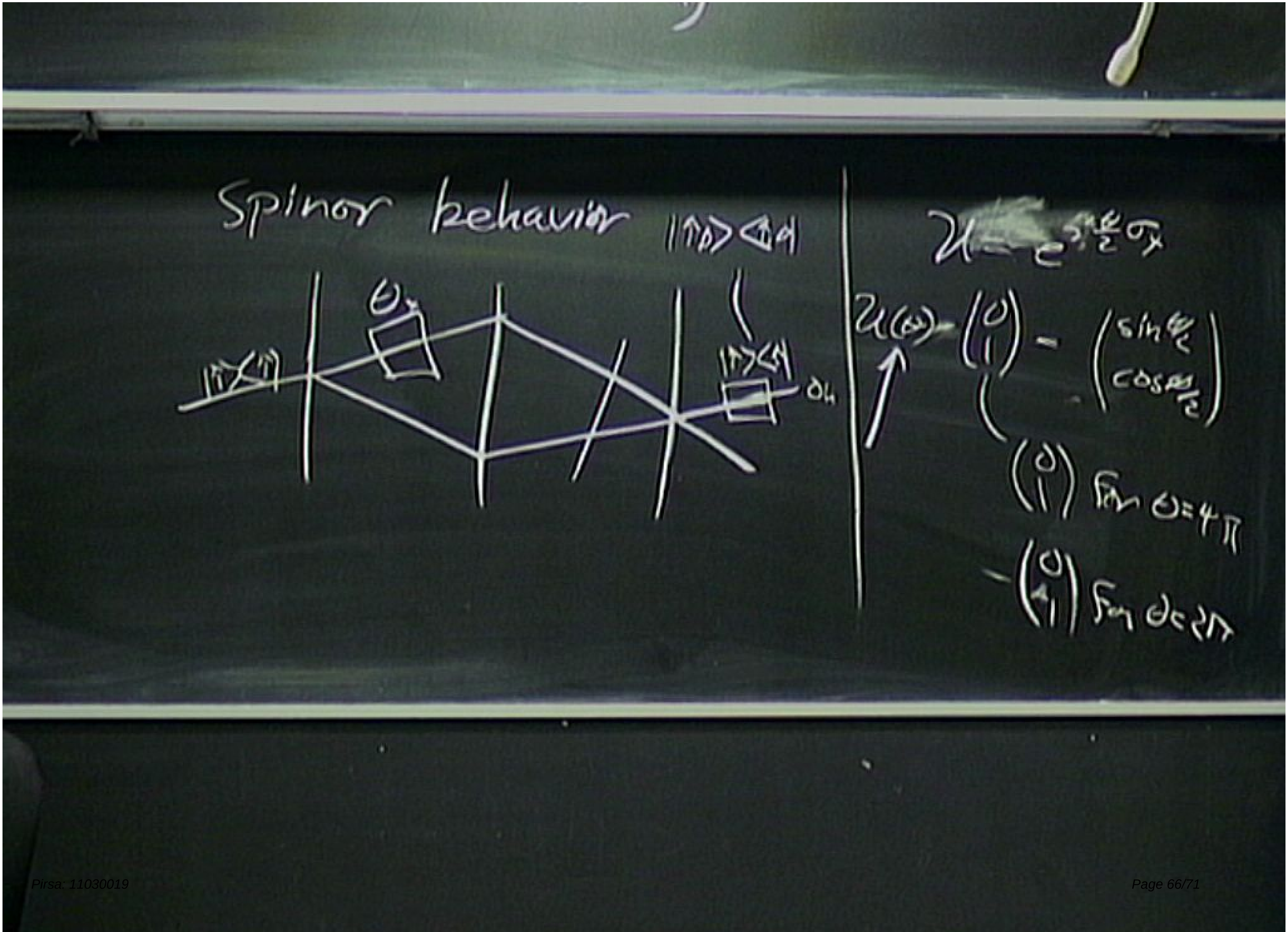


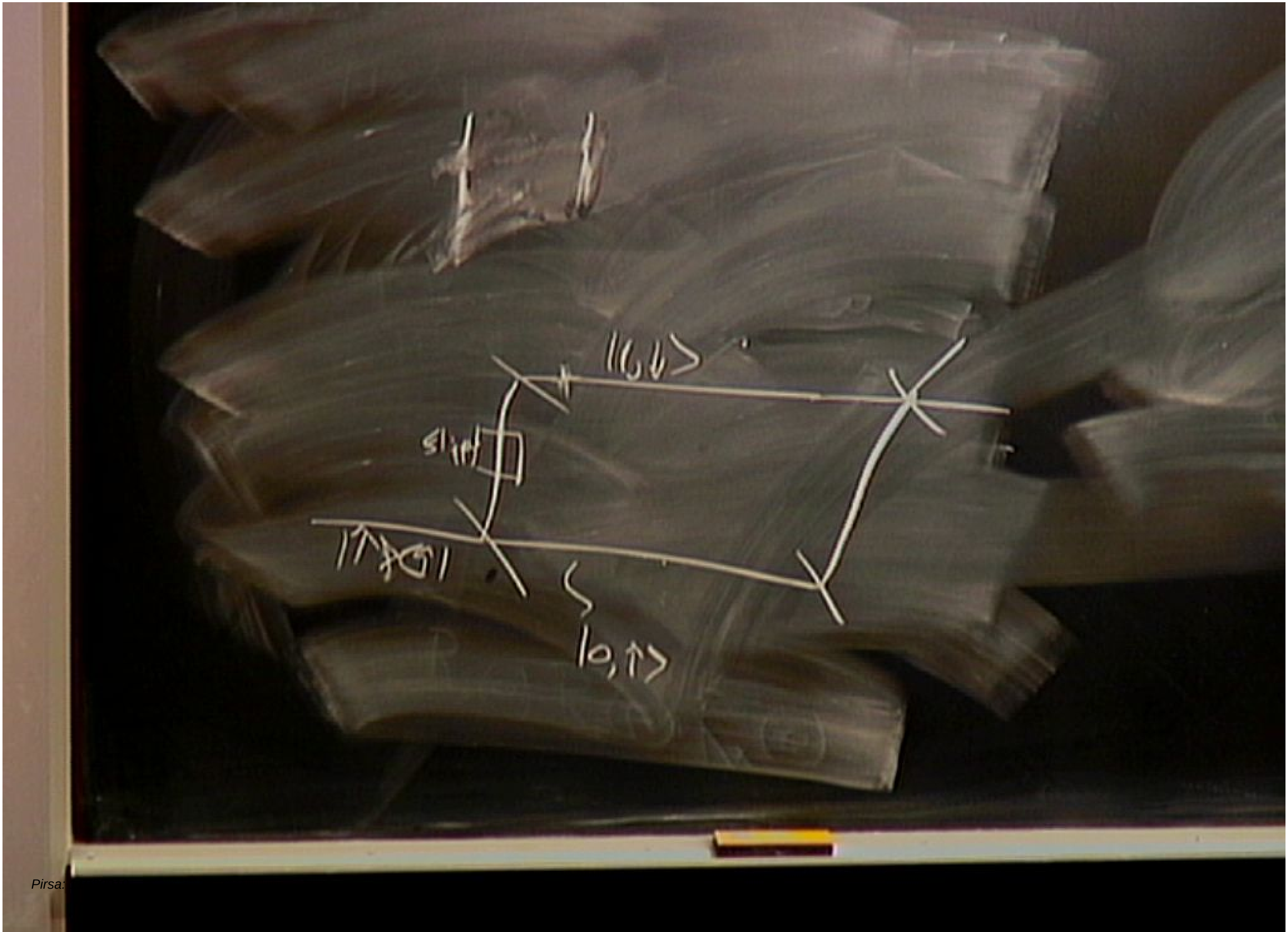
H-Beam with spin up filter

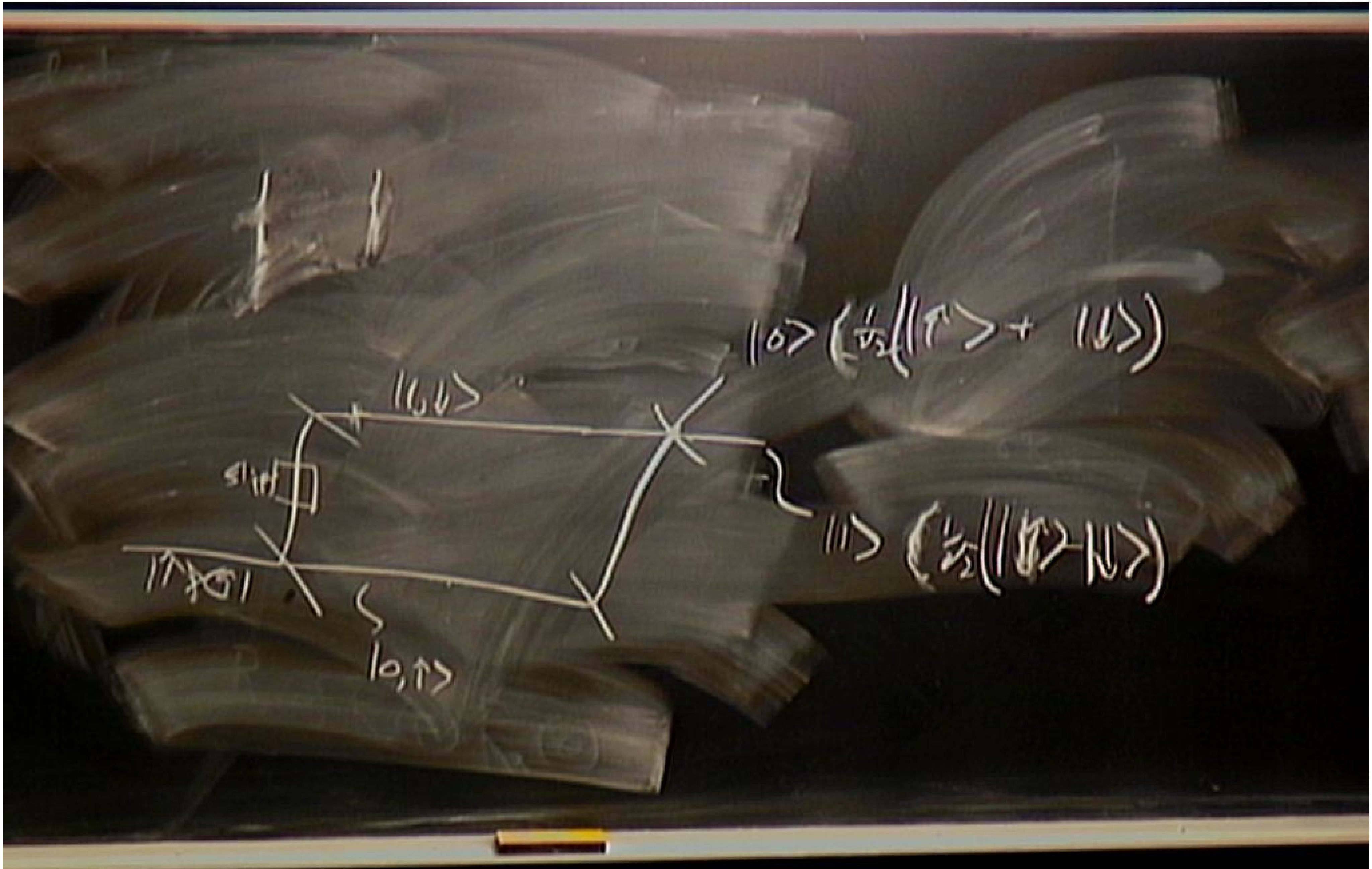
```
MHup[t_, a_] := Tr[Uzpdown . resls[t, a]]
MHup[t, a]
```

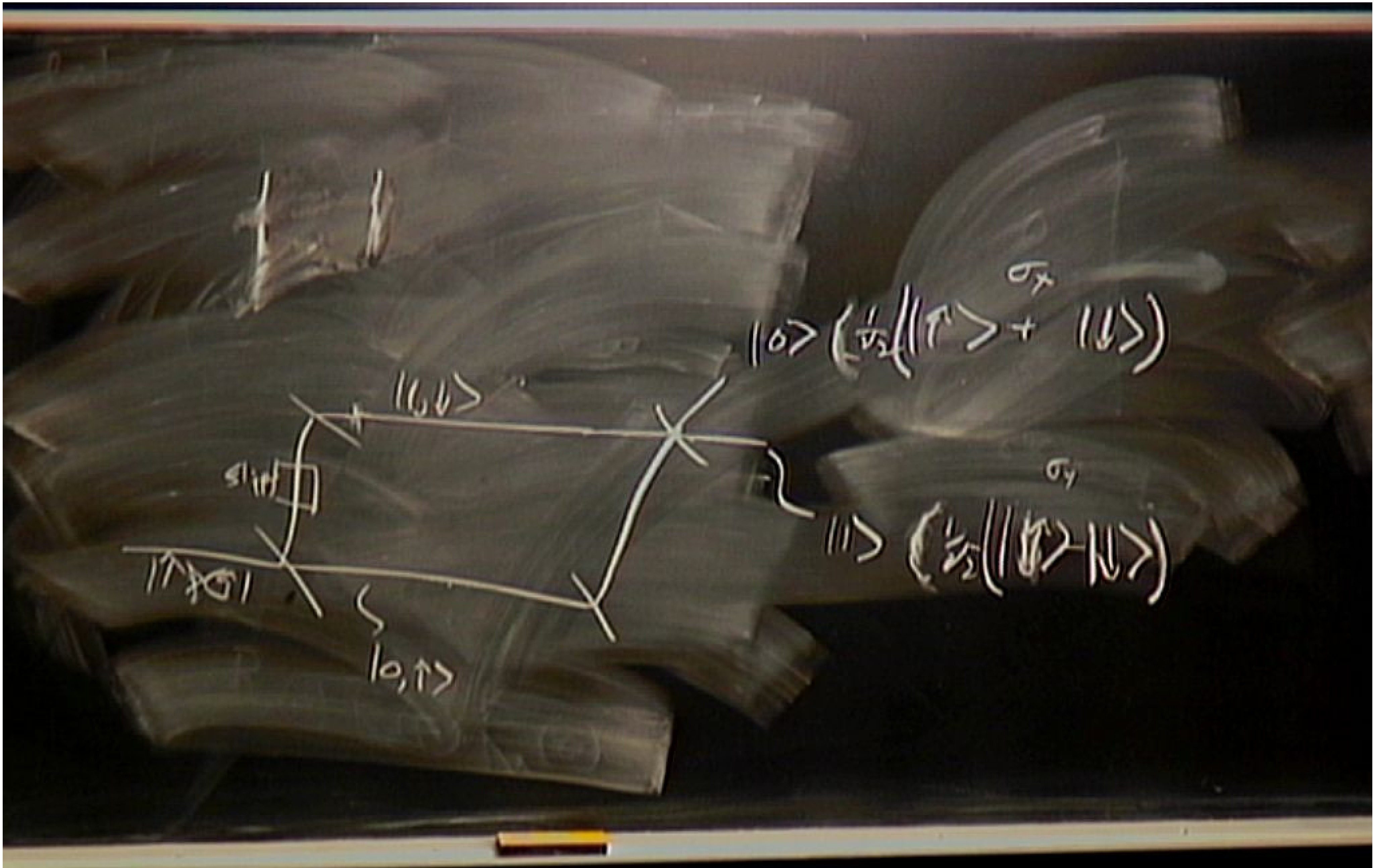
$$\frac{1}{8}\left(3 - 2\,\text{Cos}\left[a - \frac{t}{2}\right] - 2\,\text{Cos}\left[a + \frac{t}{2}\right] - \text{Cos}[t]\right)$$

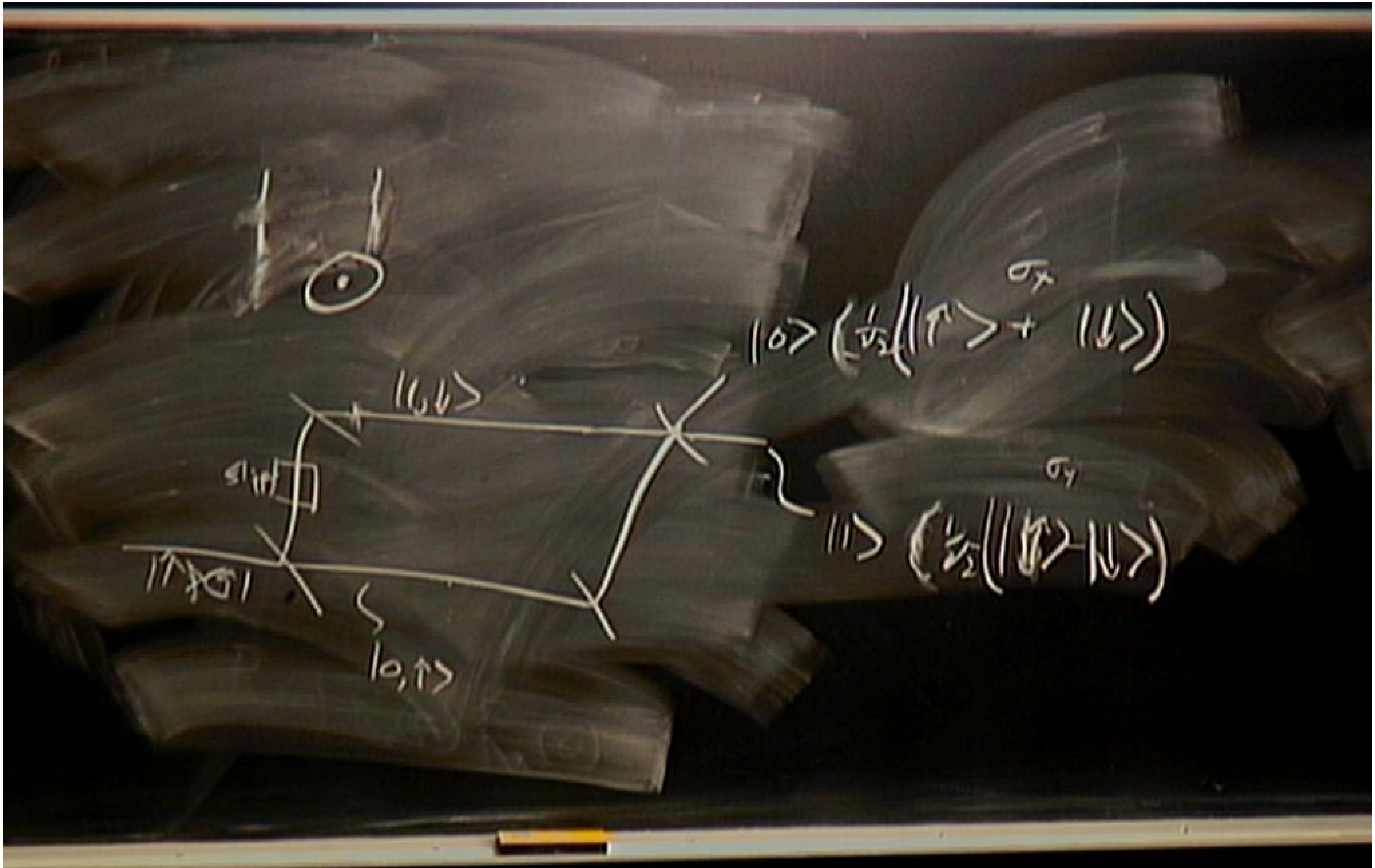
```
Plot3D[MHup[t, a], {a, 0, 2 π}, {t, 0, 4 π},
 {AxesLabel → { "phase flag", "spin rotation", "intensity"}}]
```


Spinor behavior
for θ=4π
for θ=2π


|0,↑>


|0> (1/√2(|↑> + |↓>)
|1,↓>
|1> (1/√2(|↑> − |↓>)
|0,↑>


|0,↓⟩
|1,↑⟩
|0,↑⟩
|0⟩ (1/√2 (|↑⟩ + |↓⟩)
|1⟩ (1/√2 (|↑⟩ − |↓⟩)
σx
σy


σx
|0> (1/√2(|↑> + |↓>)
|1,↓>
σy
|1> (1/√2(|↑> − |↓>)
|0,↑>