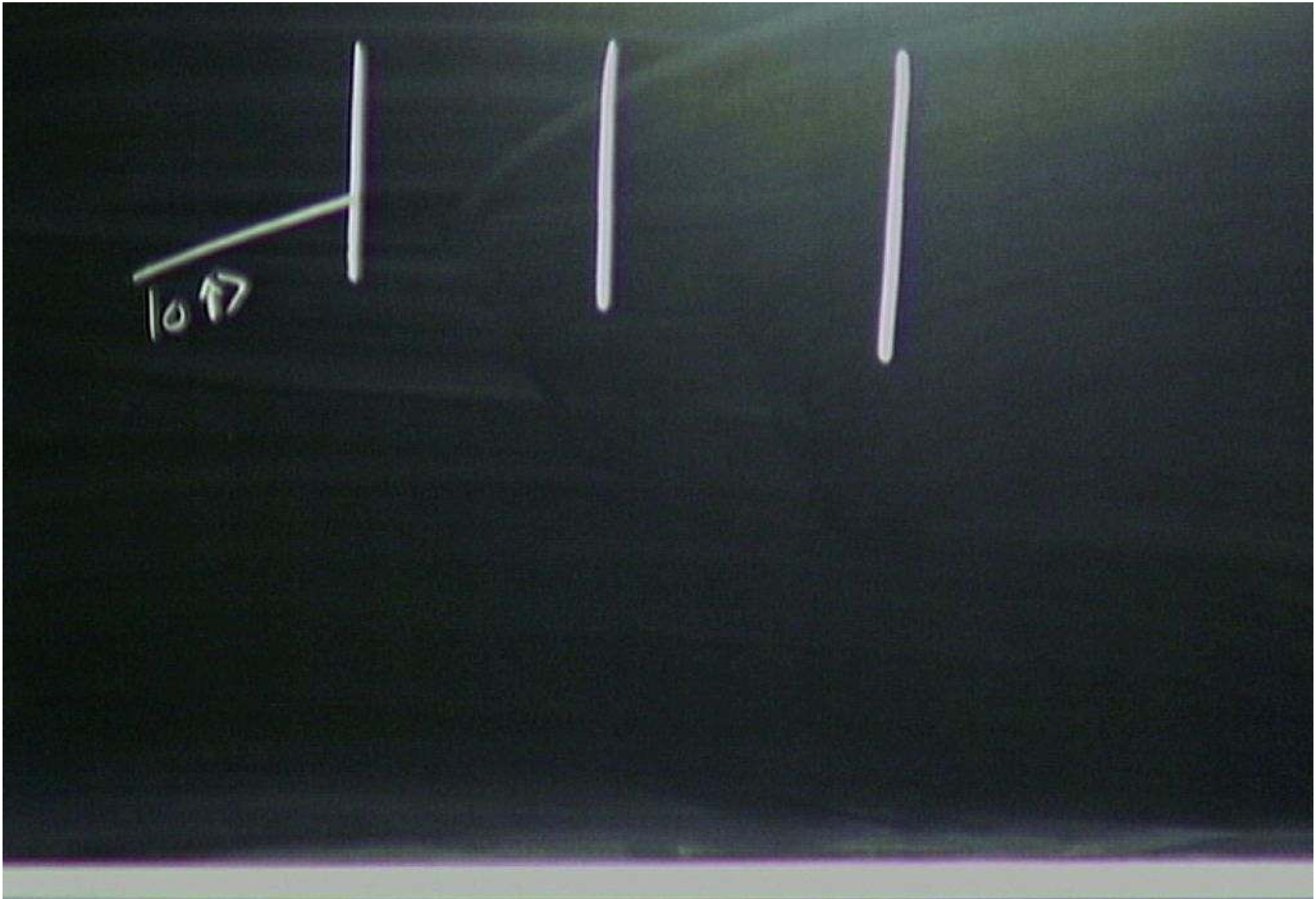
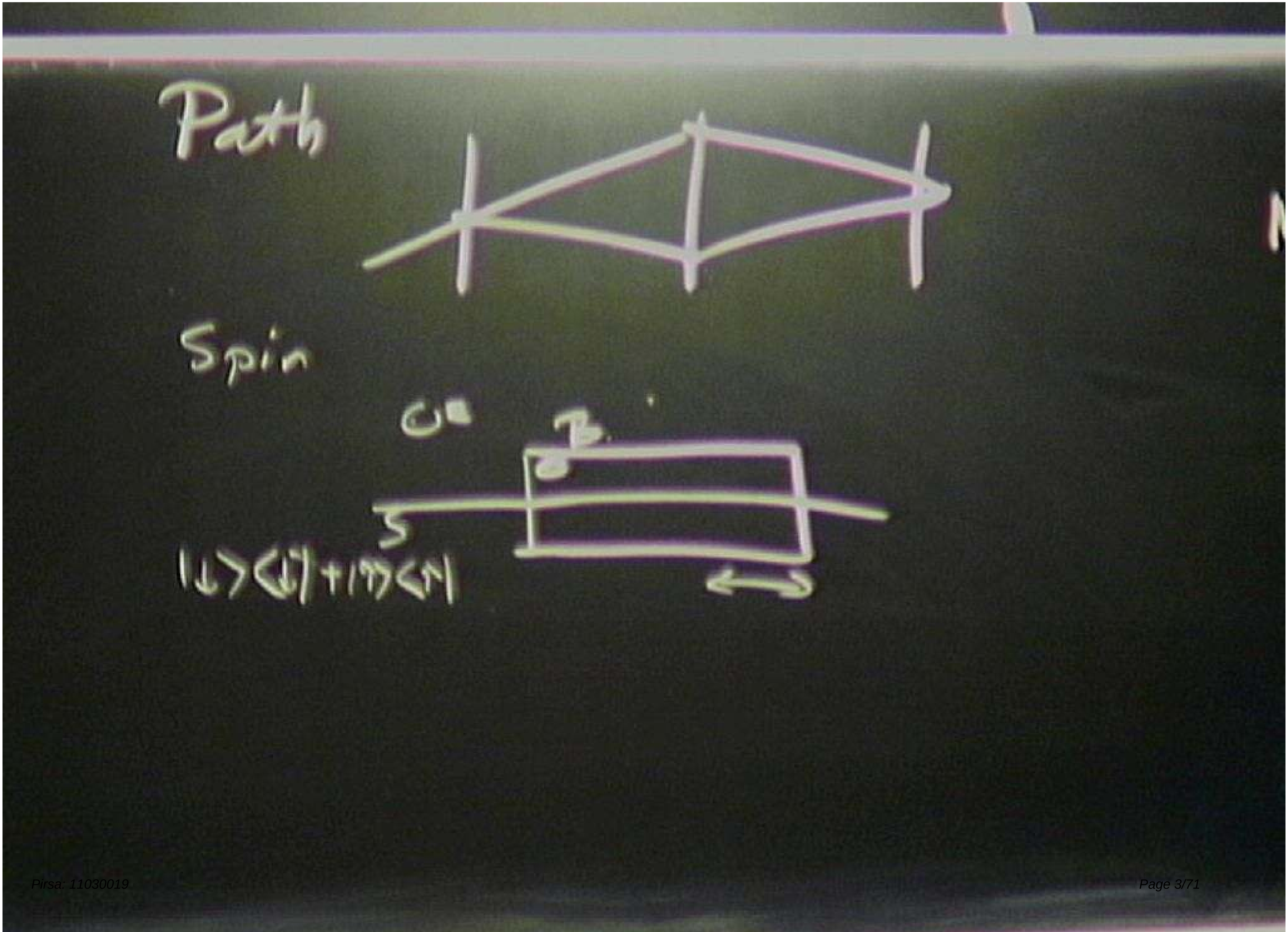
Title: Explorations in Quantum Information - Lecture 6

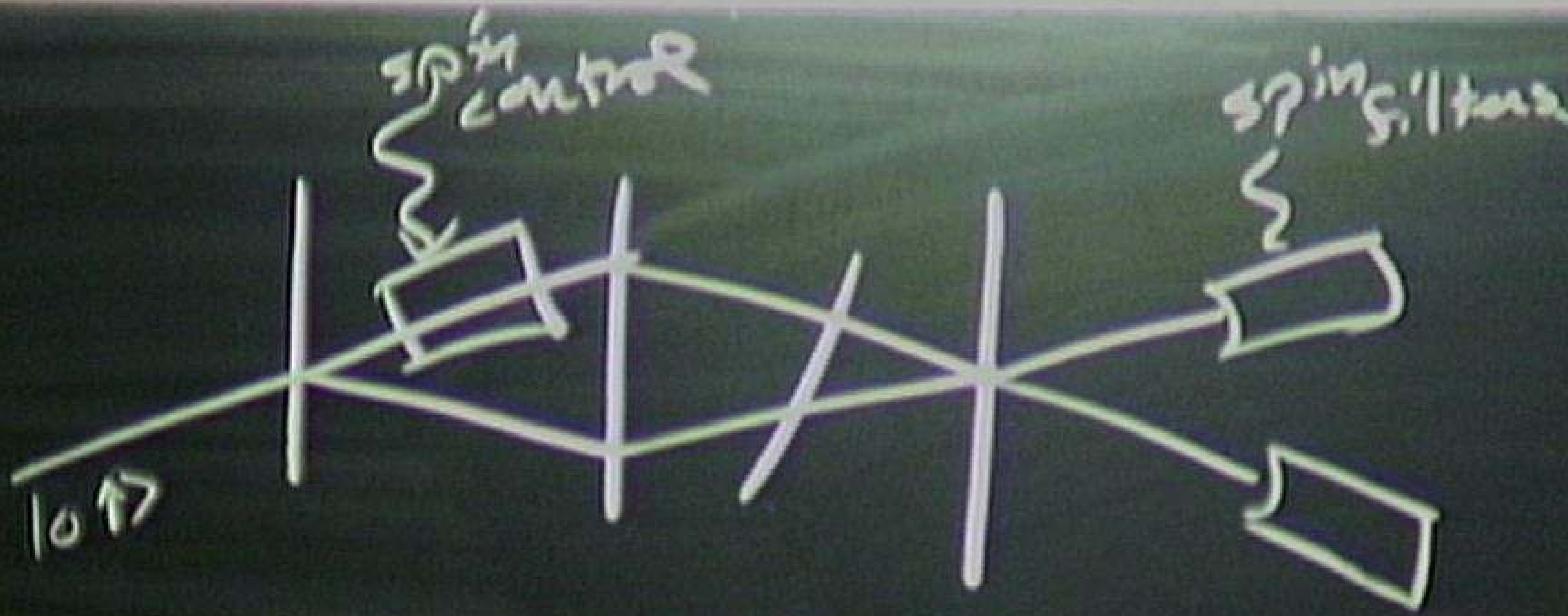
Date: Mar 22, 2011 09:00 AM

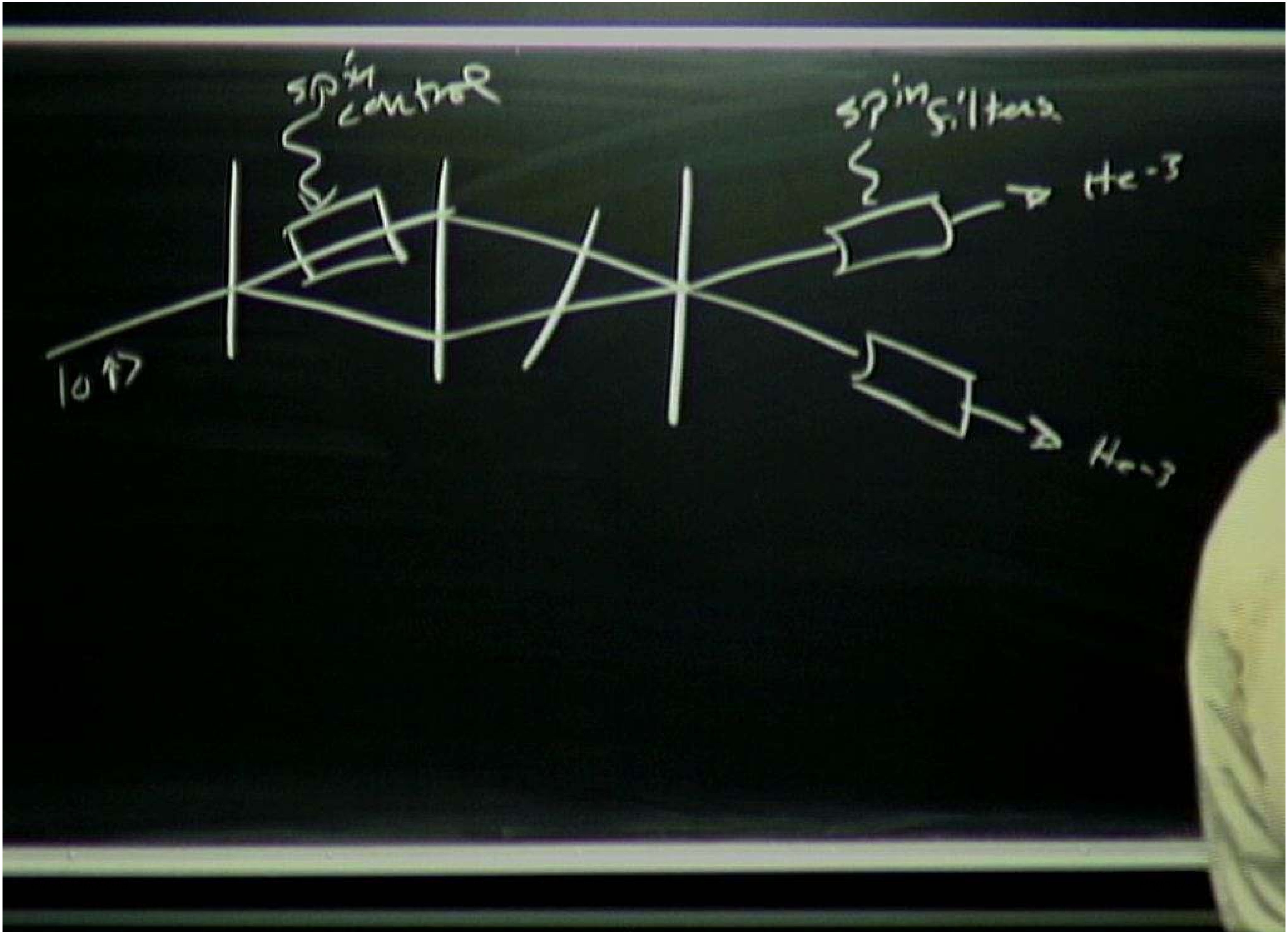
URL: http://pirsa.org/11030019

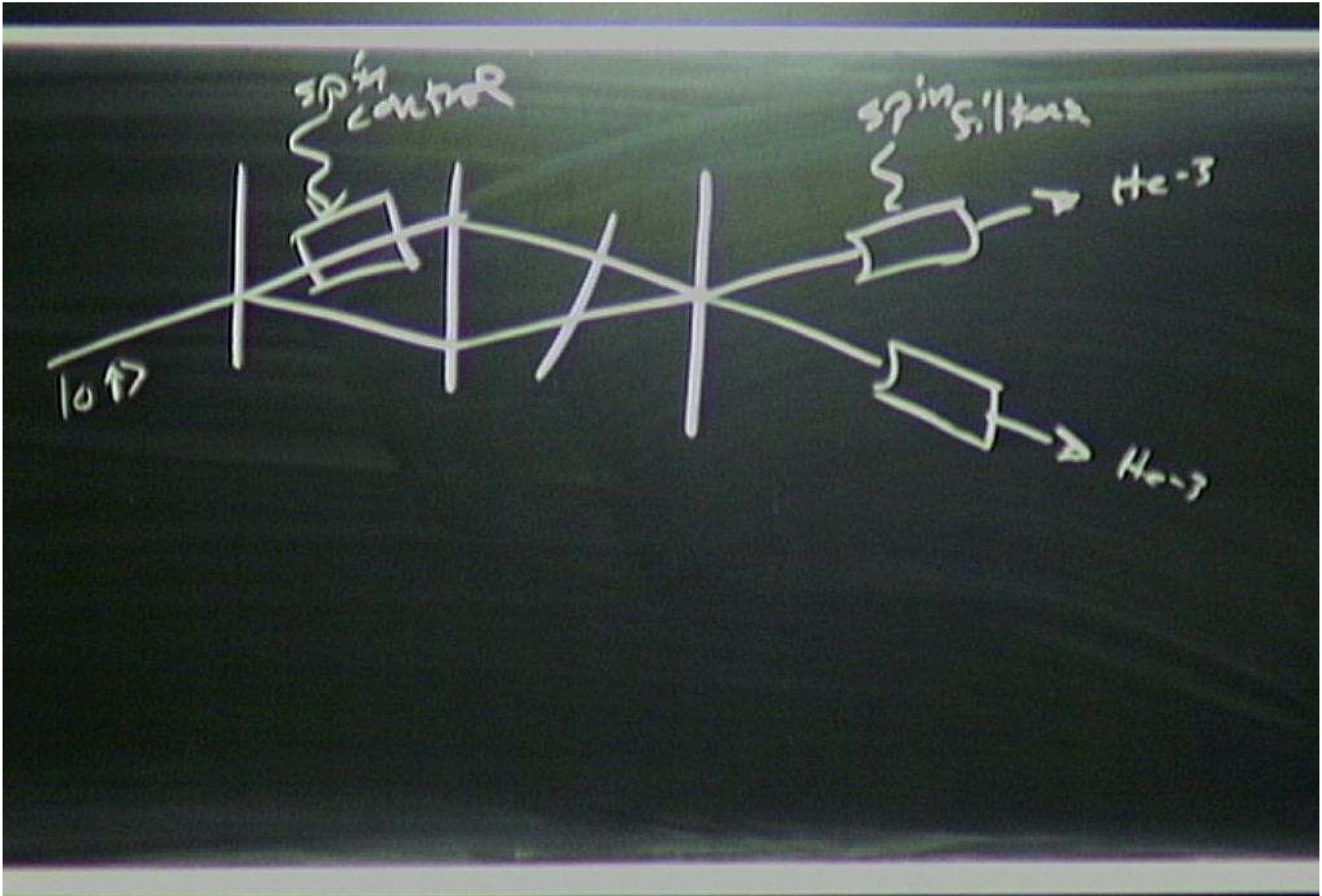
Abstract:

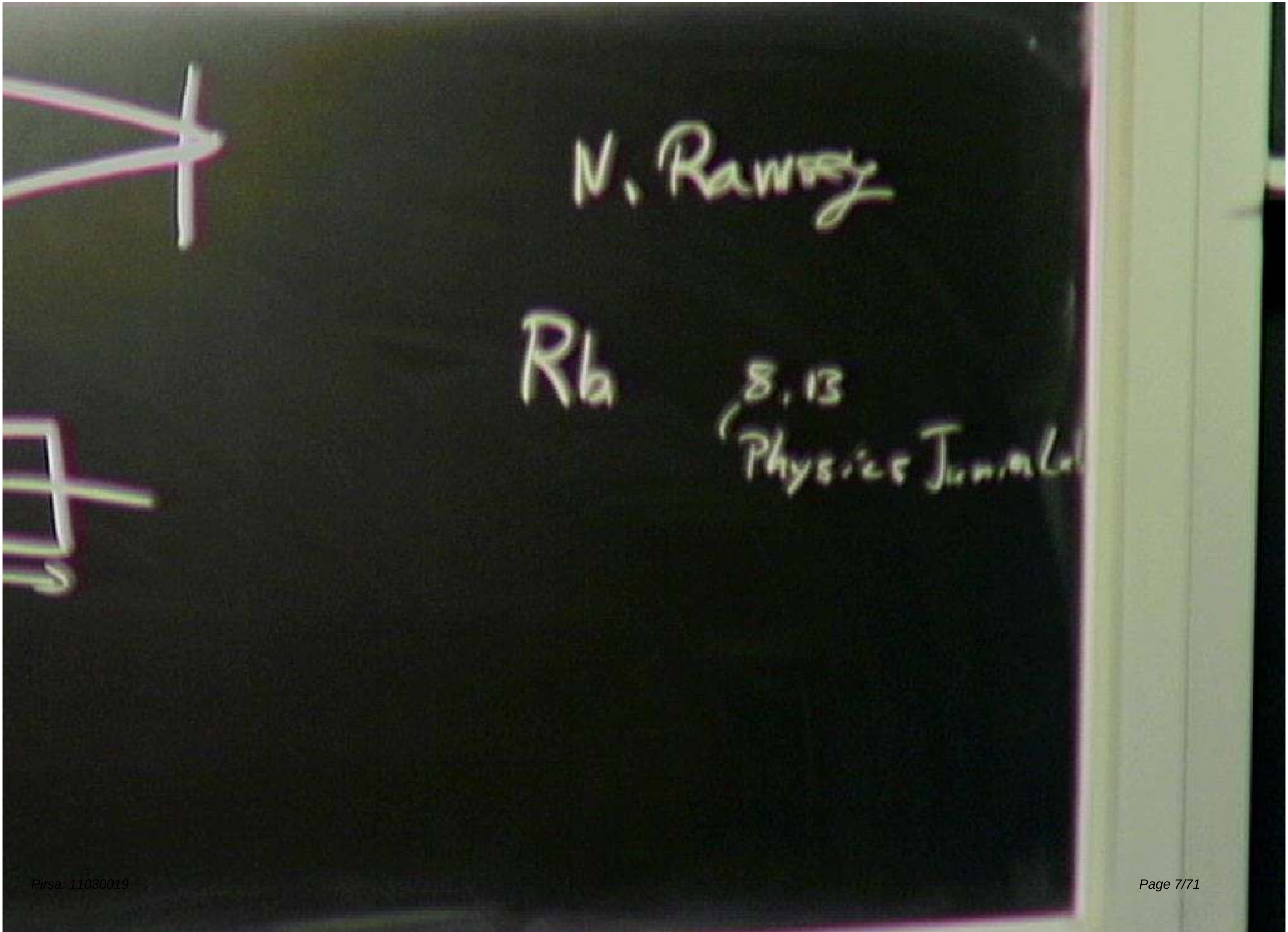

|0↑⟩

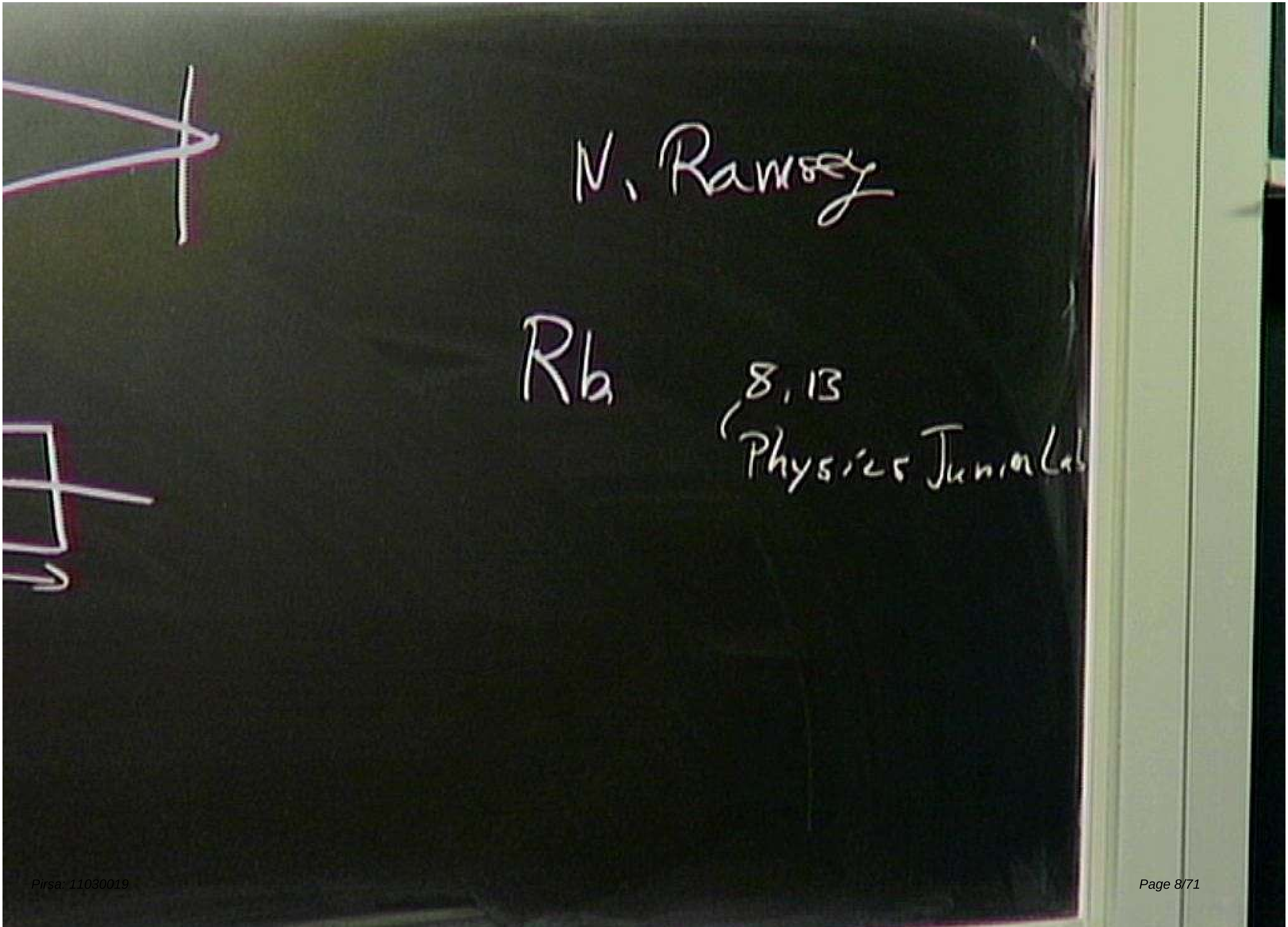

Path
Spin
S
|↓⟩⟨↓|+|↑⟩⟨↑|

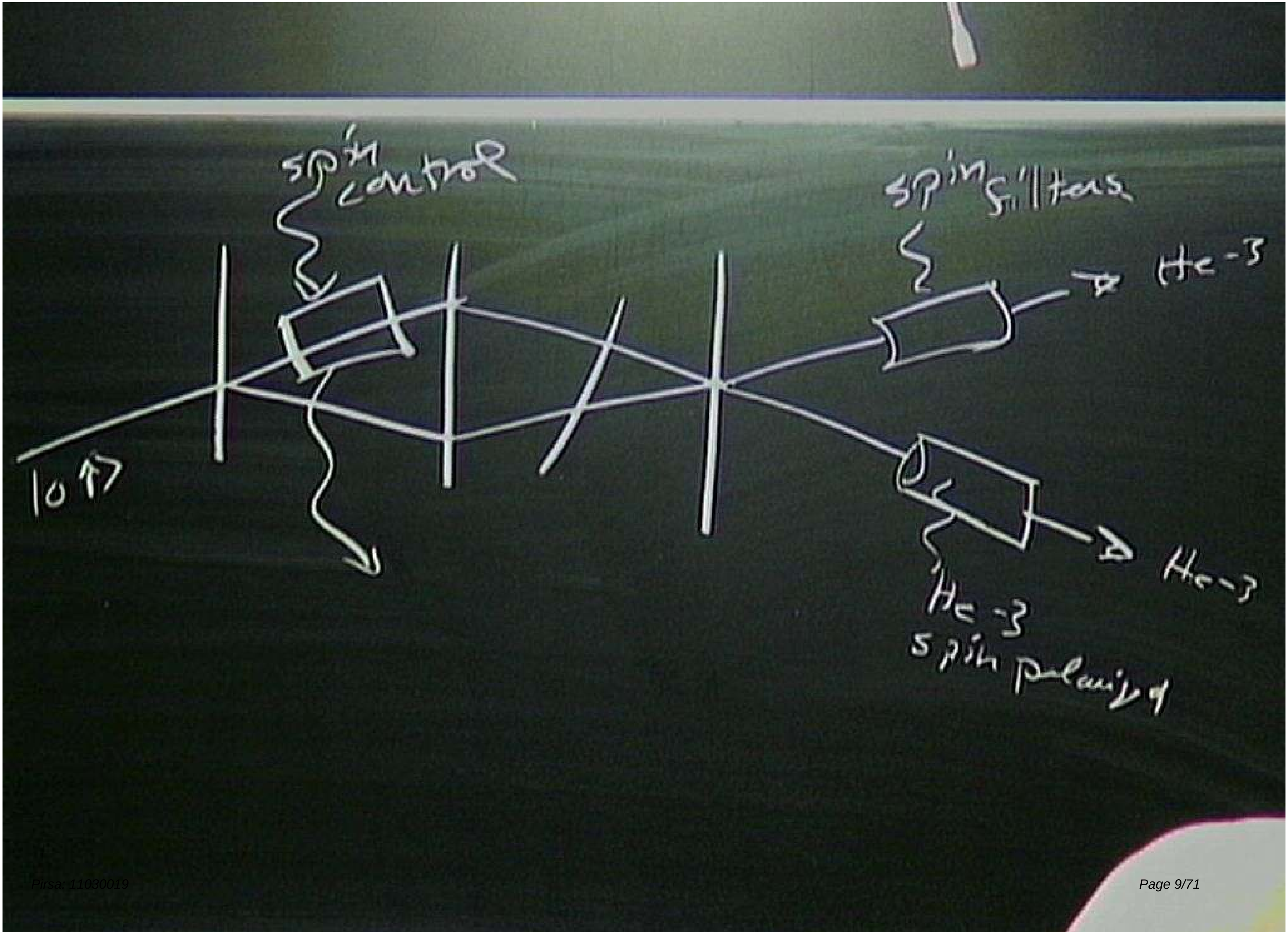

spin
spin
$|0\uparrow\rangle$


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

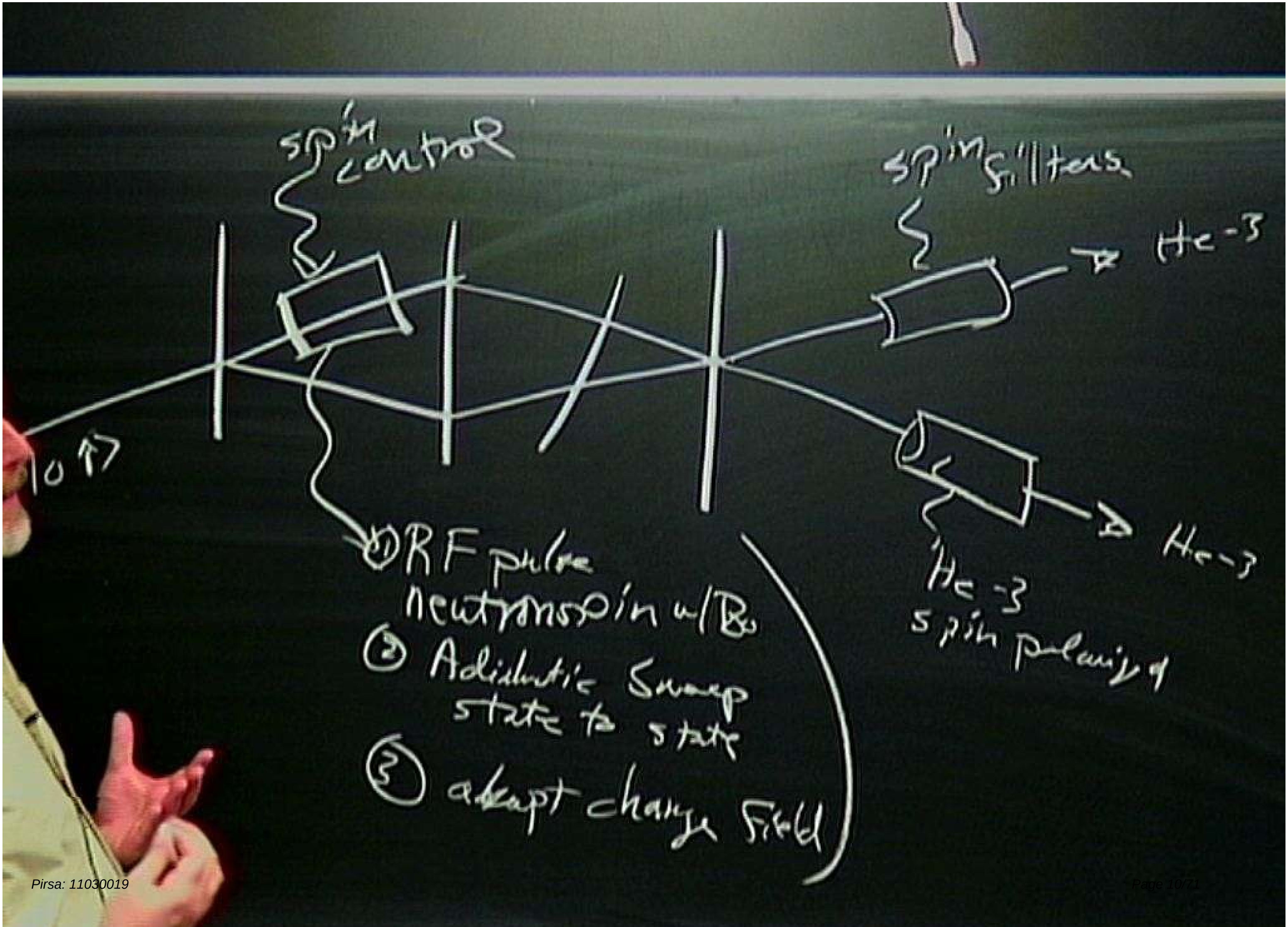

spin control
spin filter
He-3
He-3
|0 ↑⟩

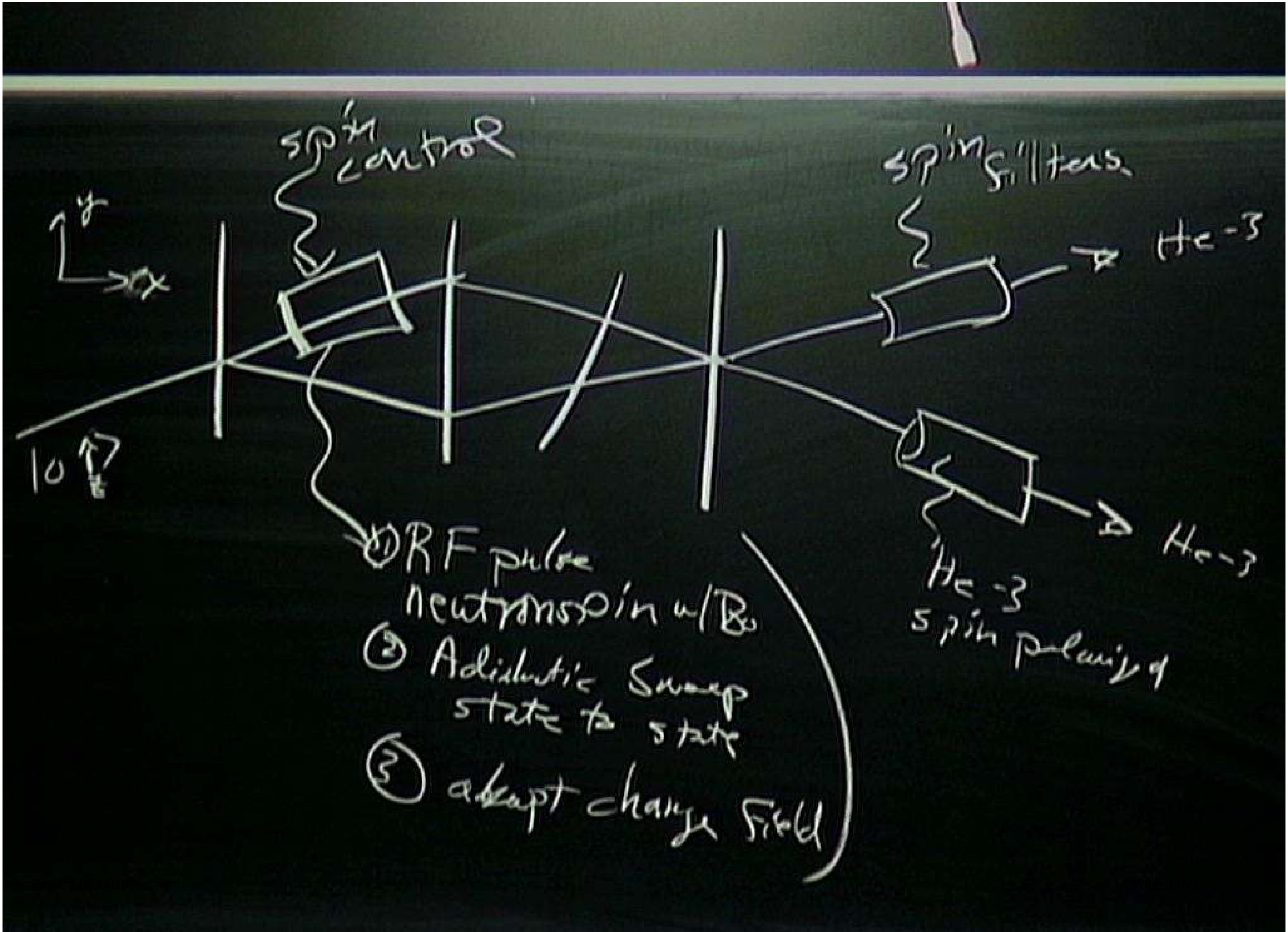

Rb
8, 13
Physics


N. Ramsey
Rb
8, 13
Physics Junior Lab

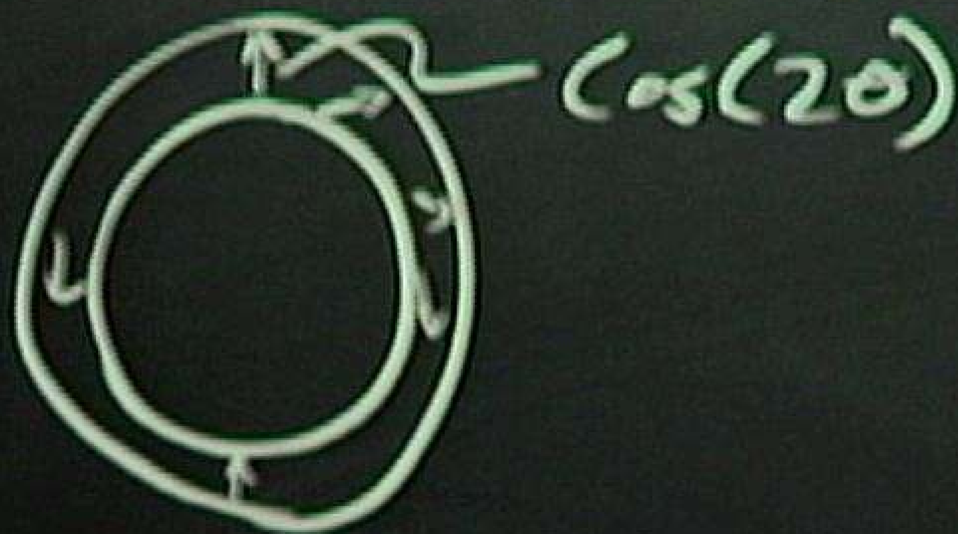


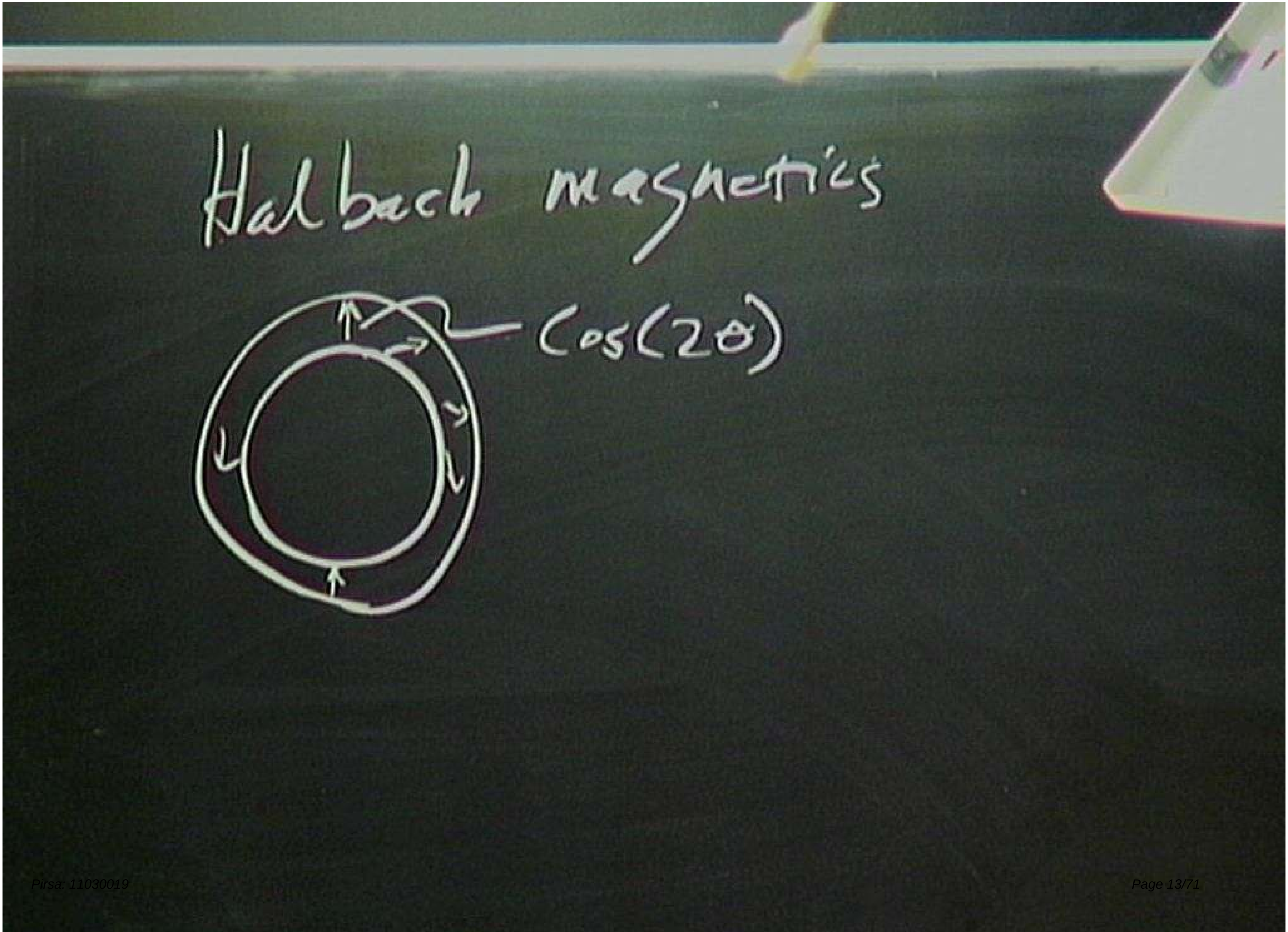
spin control
spin filters
He-3
He-3
He-3
spin polarized


spin control
spin filters
He-3
He-3
He-3
spin polarized
① RF pulse
neutron spin w/ B0
② Adiabatic Sweep
state to state
③ adapt change field

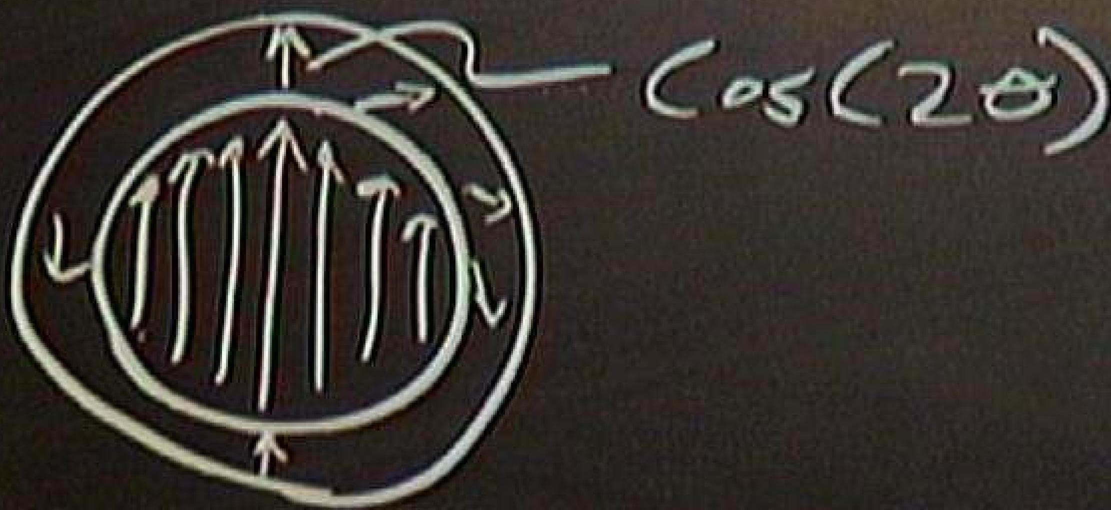

spin control
spin filters
y
x
He-3
He-3
He-3
spin polarized
① RF pulse
neutron spin w/ B_0
② Adiabatic Sweep
state to state
③ abrupt change field

Halbach magnetics

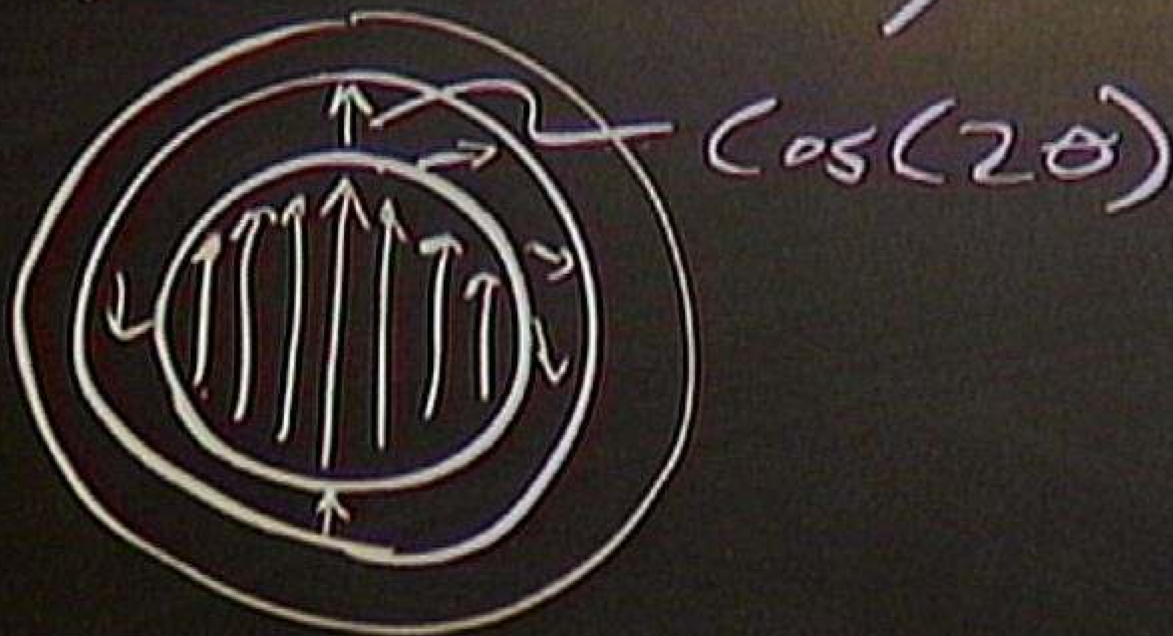


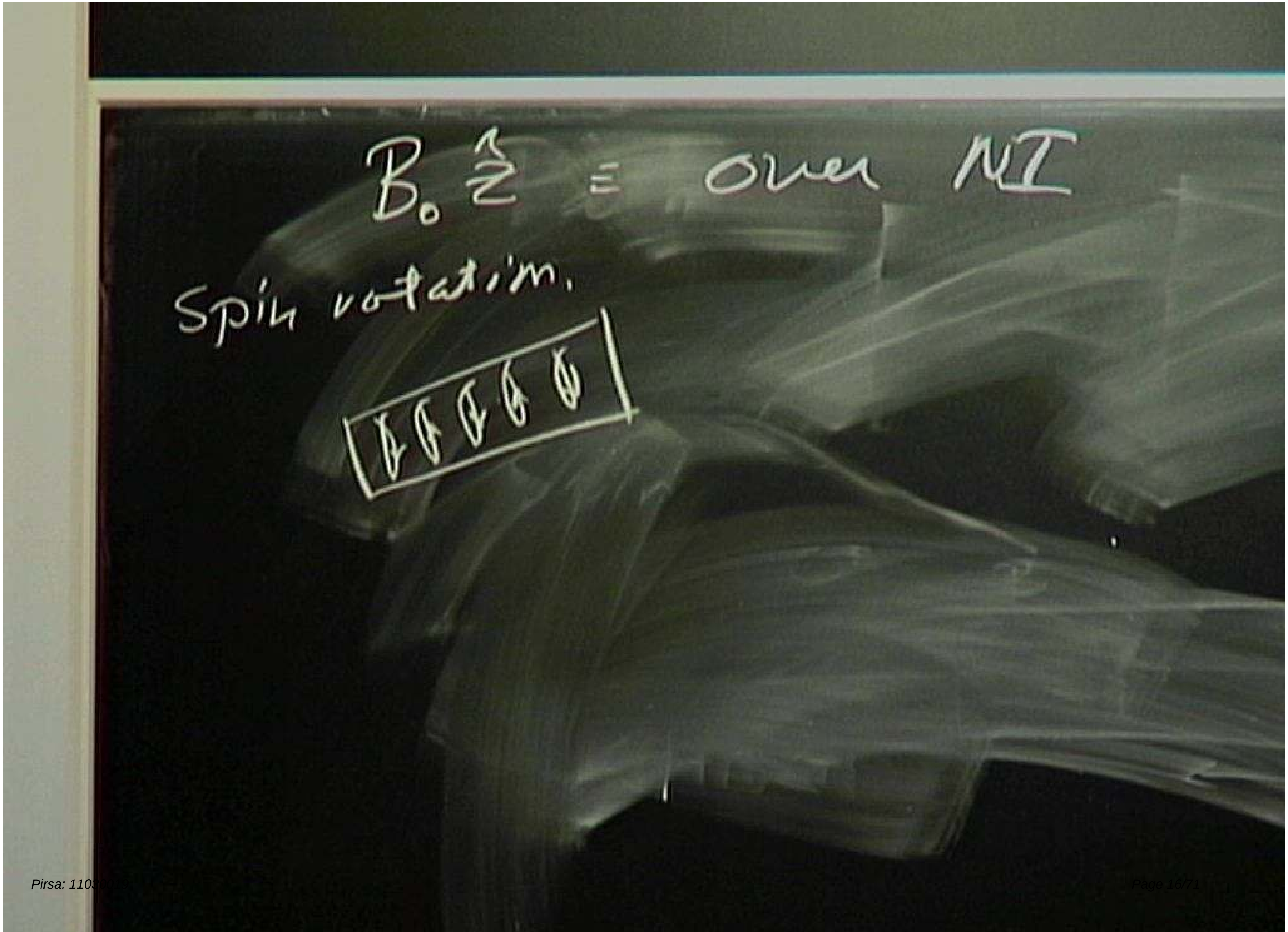

Halbach magnetics
cos(2θ)

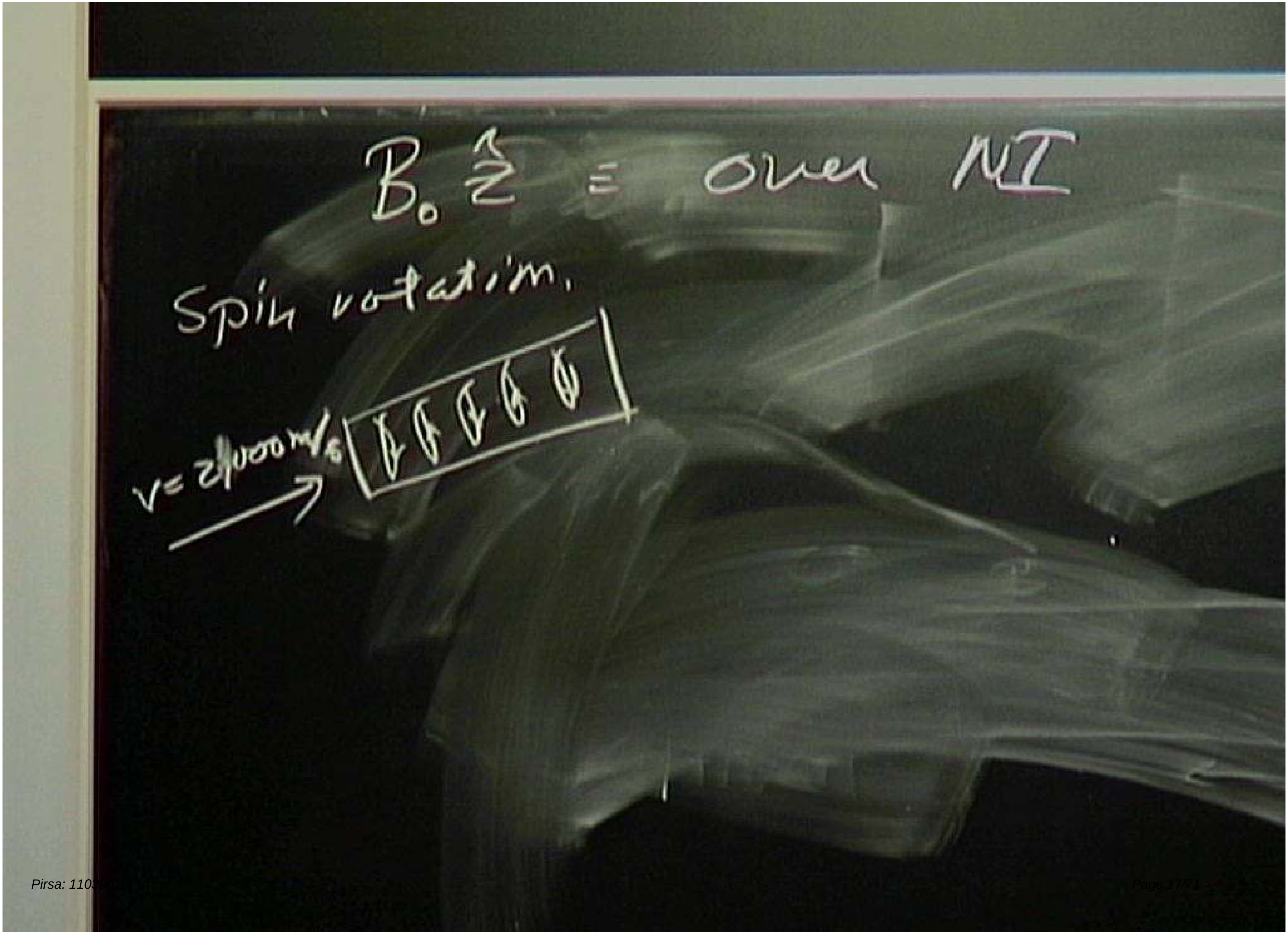
Halbach magnetics



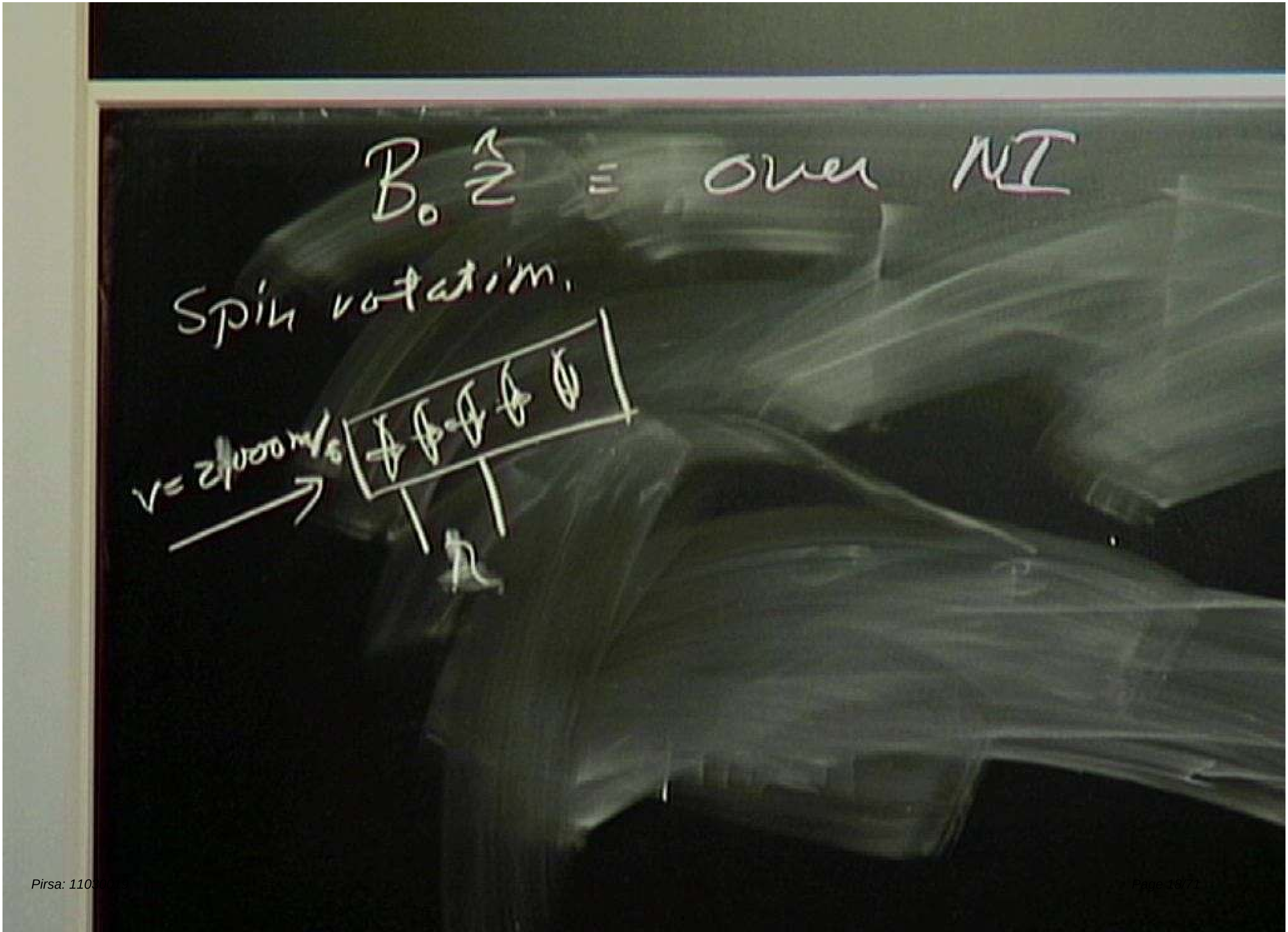
Halbach magnetics




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



$B_0 \hat{z}$ = over NI
Spin rotation.
v = 2400 m/s


$B_0 \hat{z} \equiv$ over NI
Spin rotation.
v = 2400 m/s
ħ

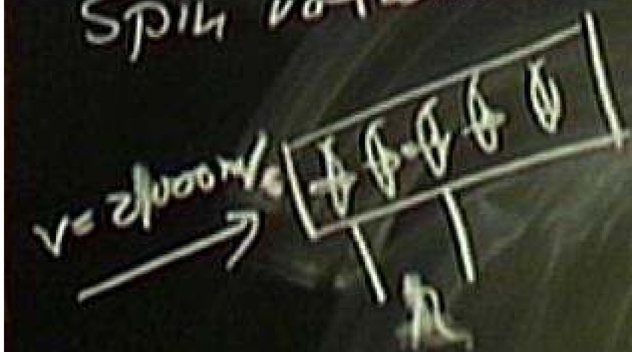
$B_0 \hat{z}$ = over NI

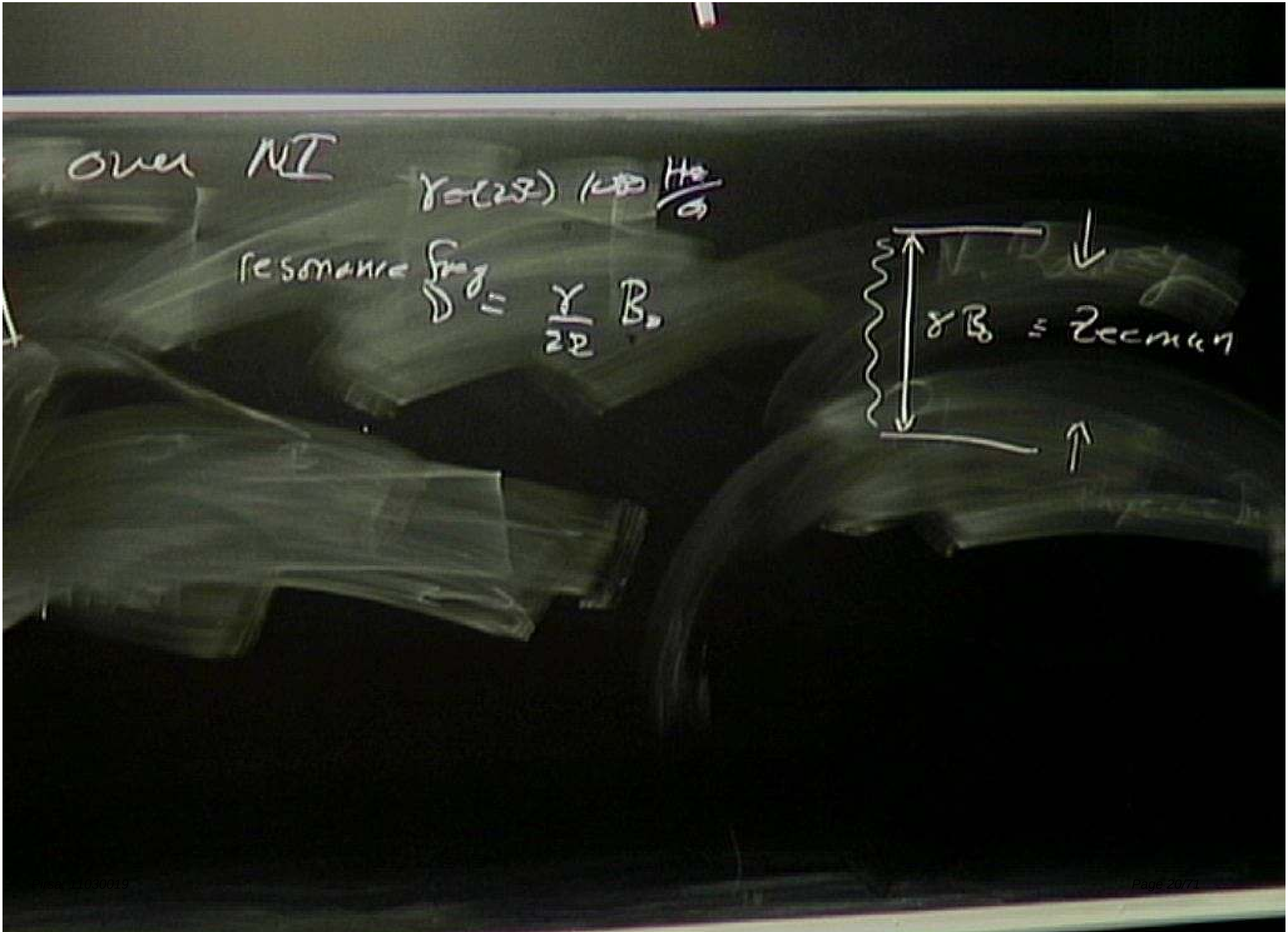
$\gamma = (2\pi)$ [illegible] $\frac{\text{Hz}}{\text{G}}$

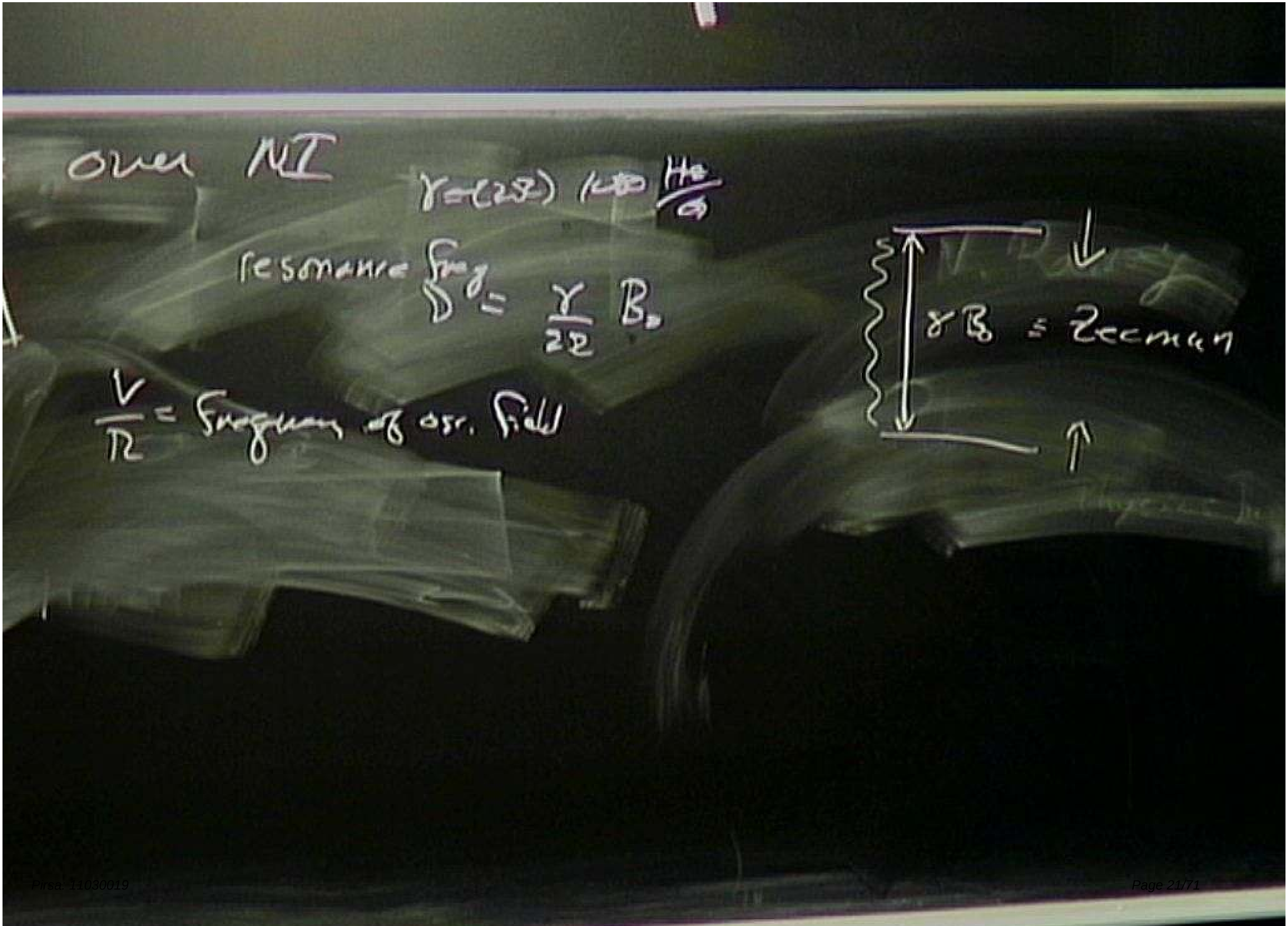
Spin rotation.

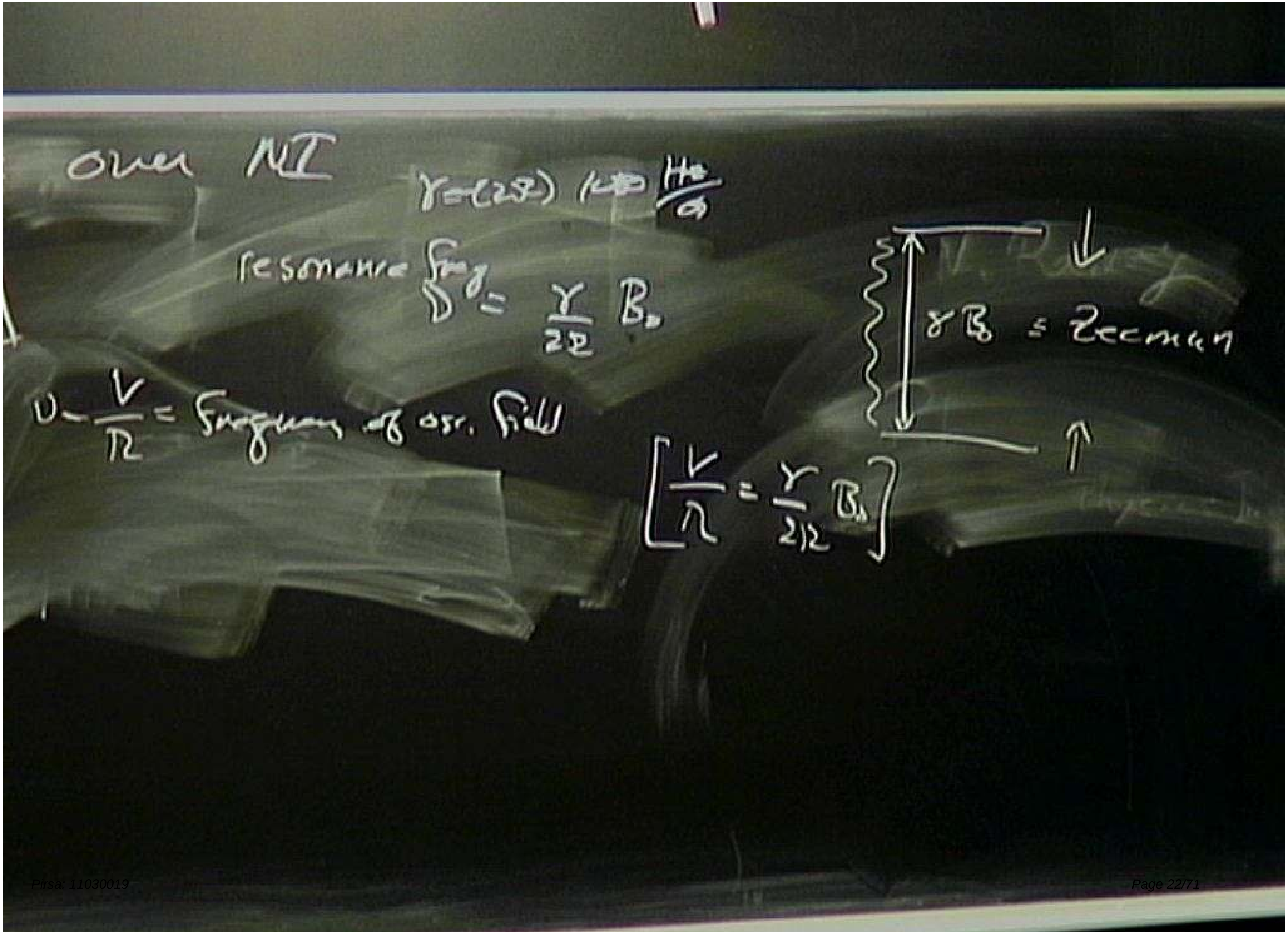
resonance freq.

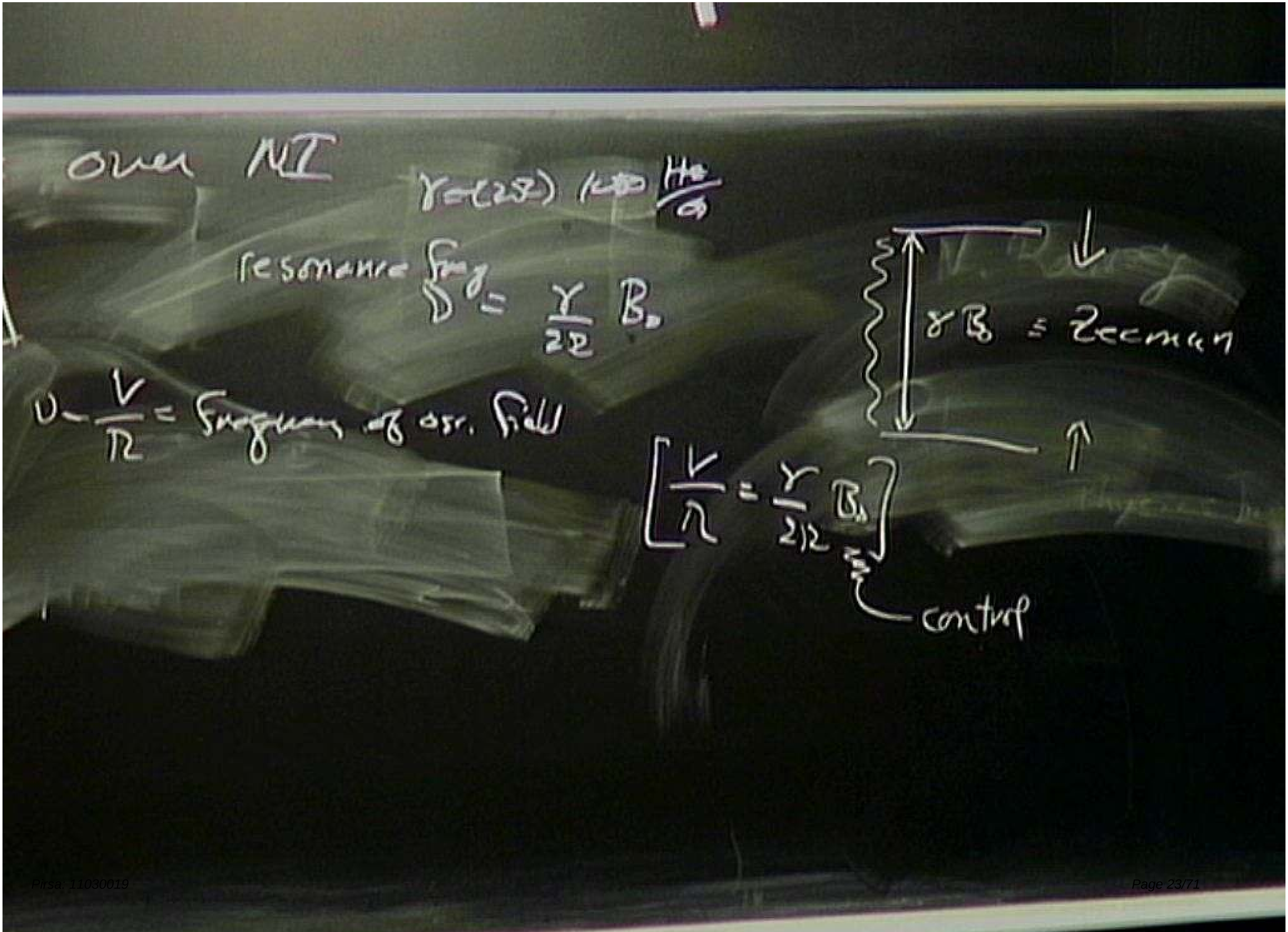
$f_0 = \frac{\gamma}{2\pi} B_0$

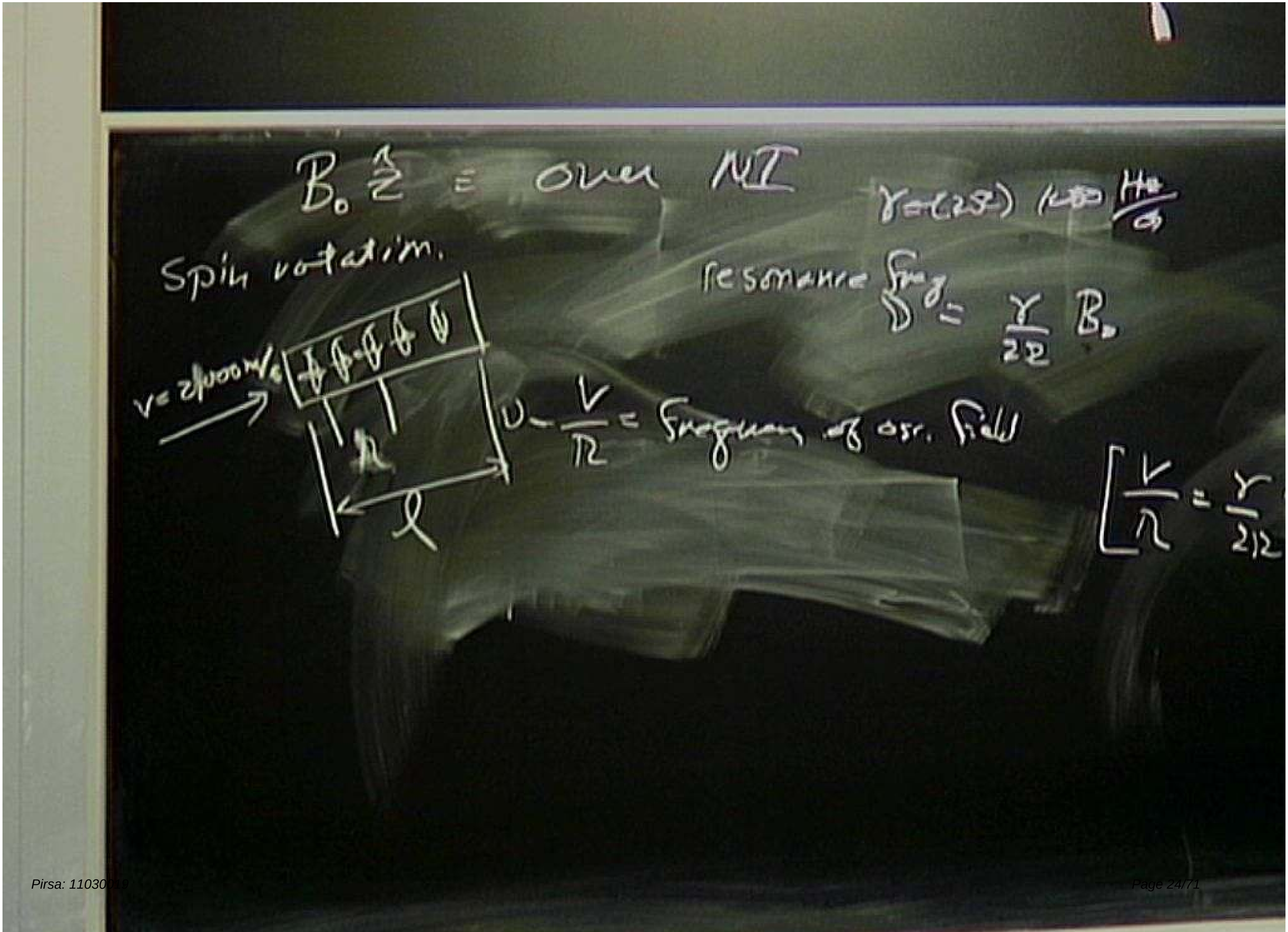


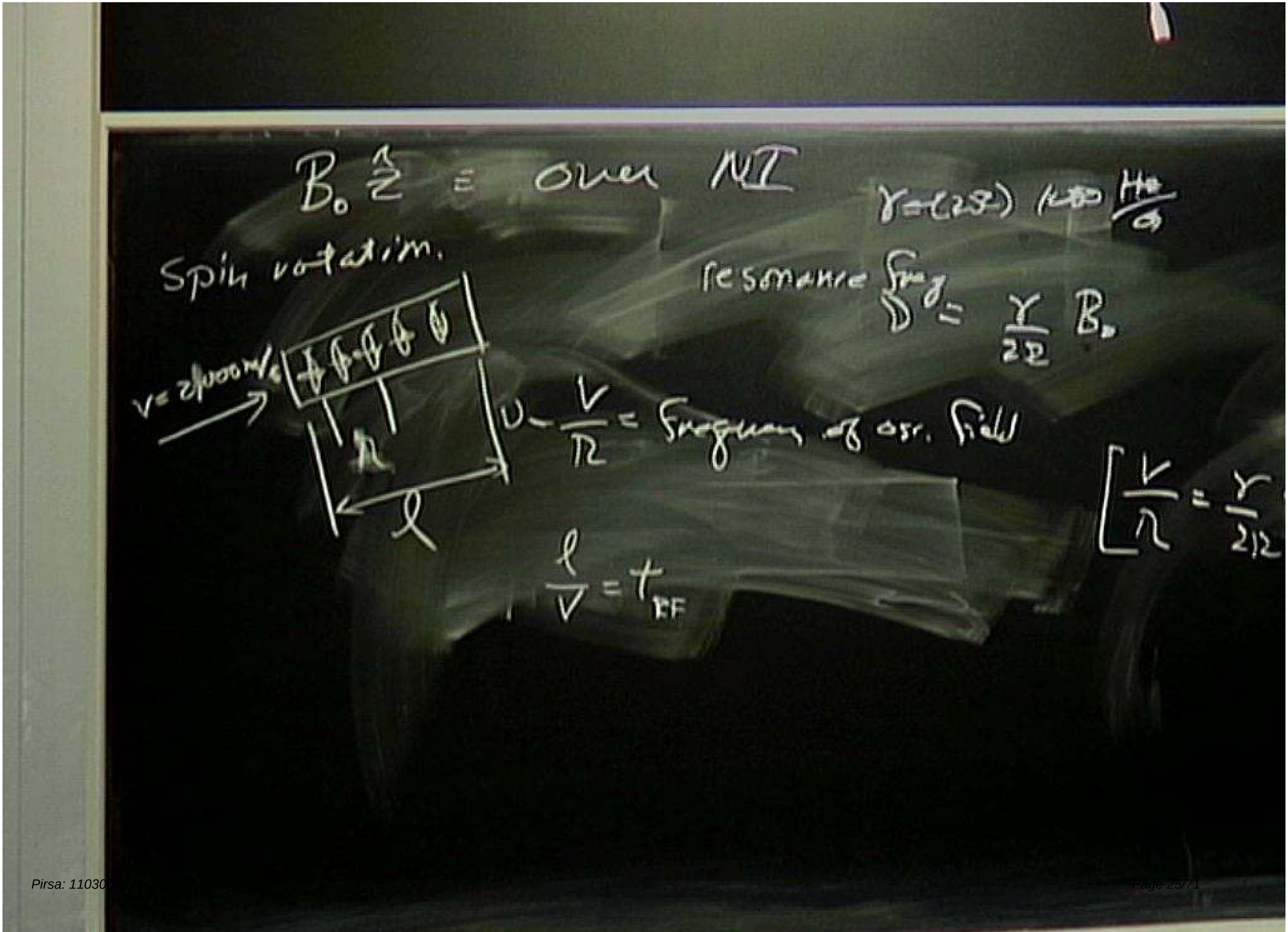

over
resonance freq
= Zeeman

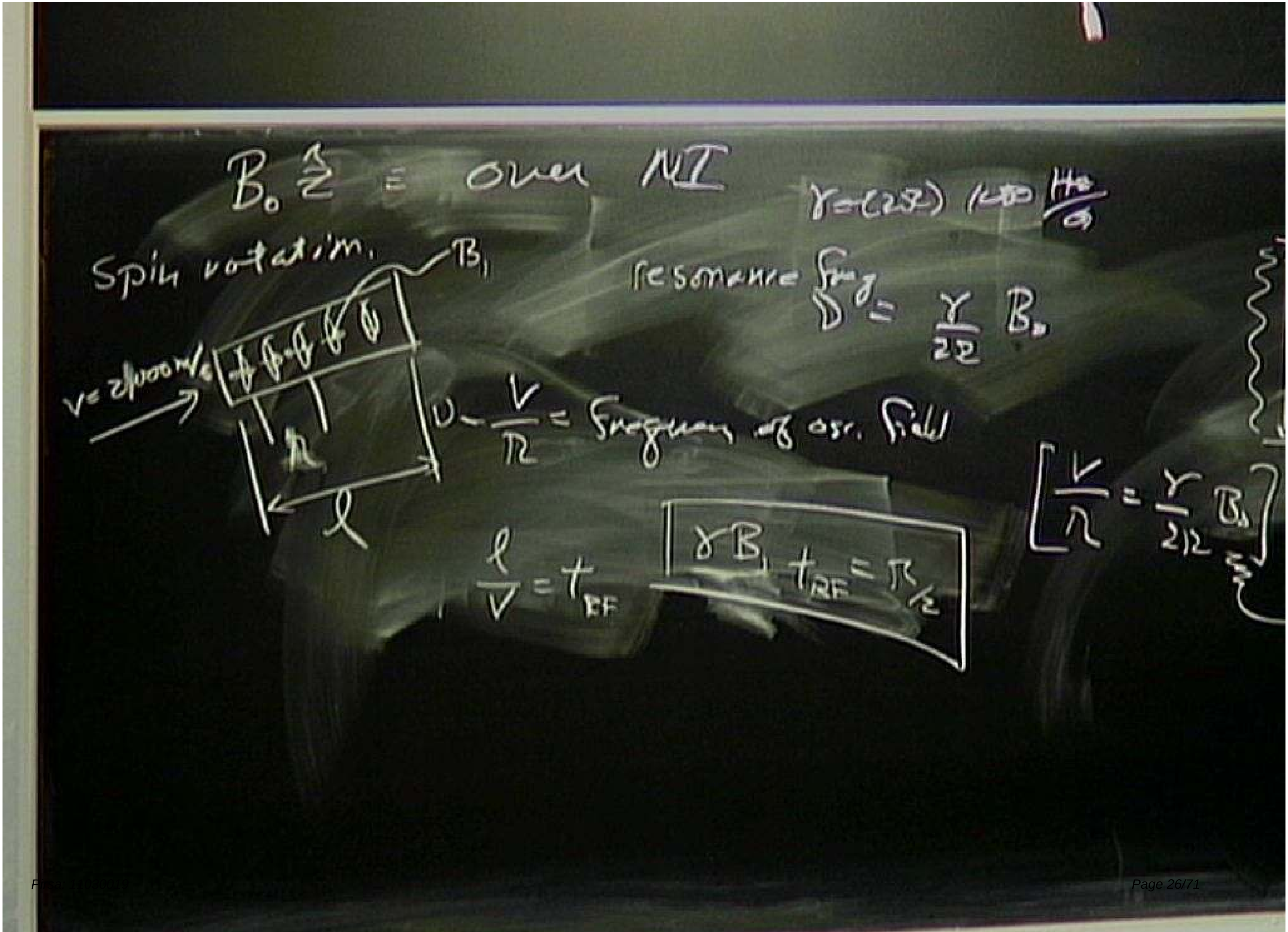

over NI
resonance freq
= Zeeman

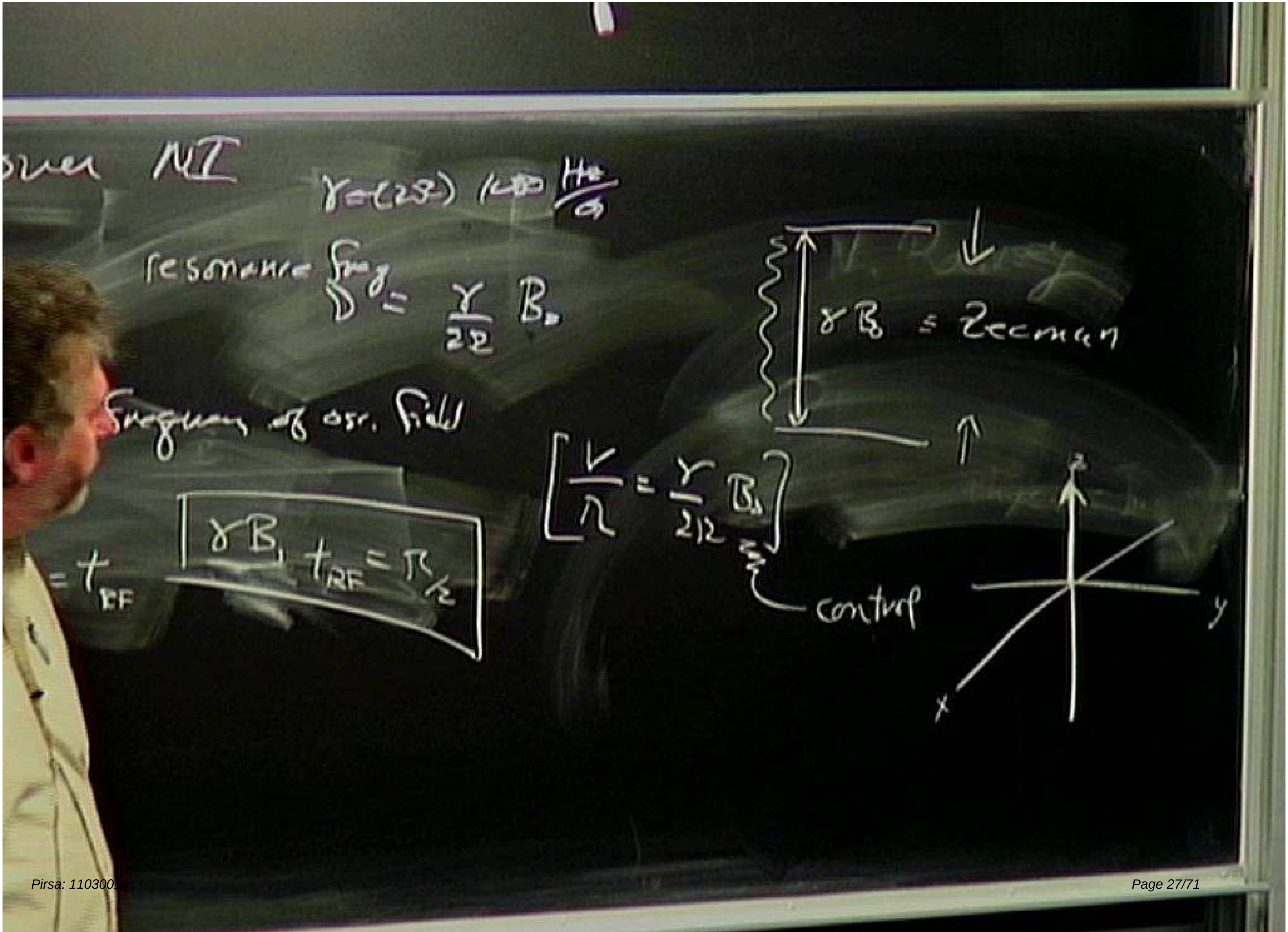

resonance freq
$\nu_0 = \frac{\gamma}{2\pi} B_0$
$\nu = \frac{V}{R}$ = frequency of osc. field
γB_0 = Zeeman
$\left[\frac{V}{R} = \frac{\gamma}{2\pi} B_0\right]$

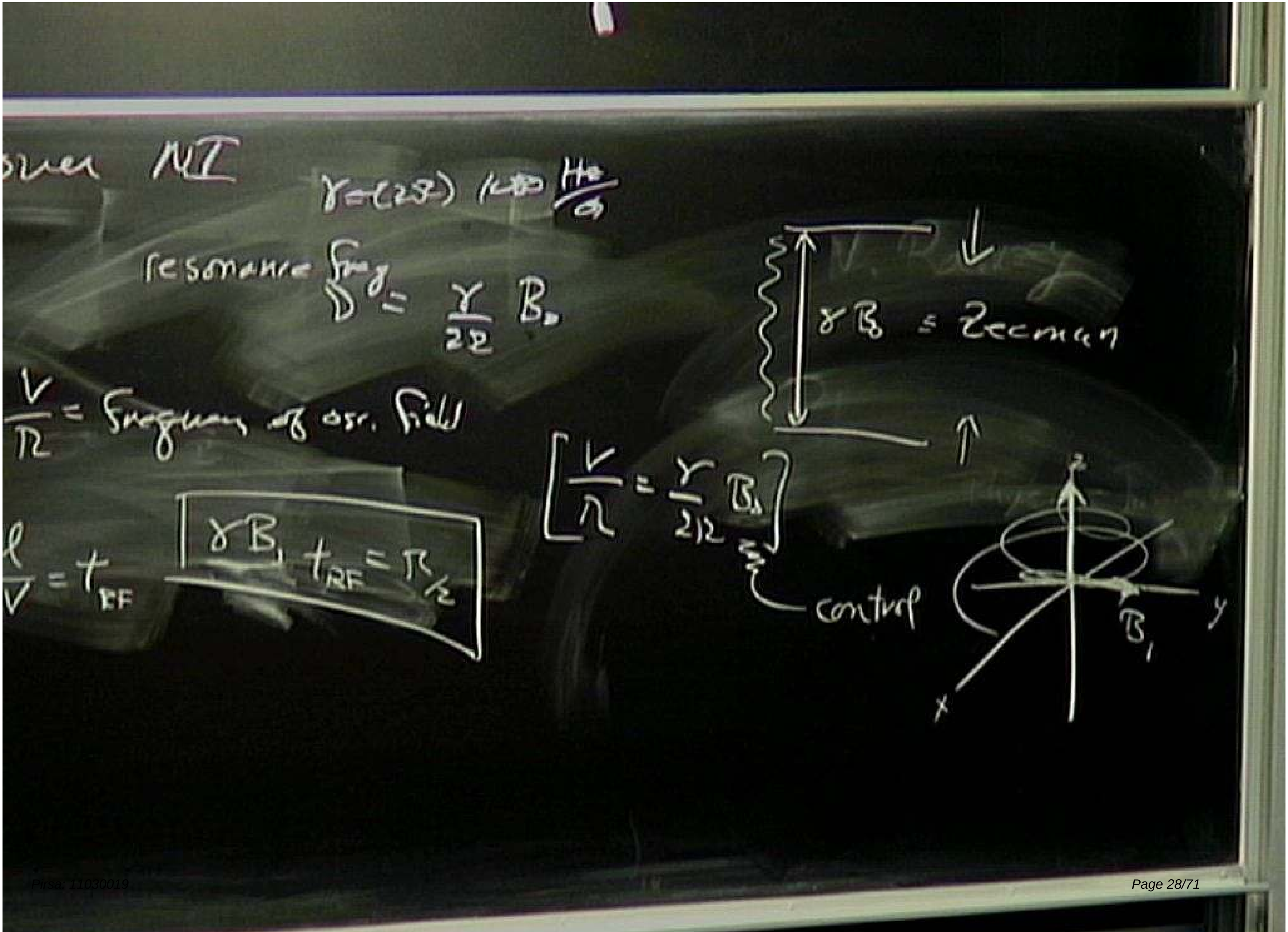

over
resonance freq
Zeeman
frequency of osc. field
control

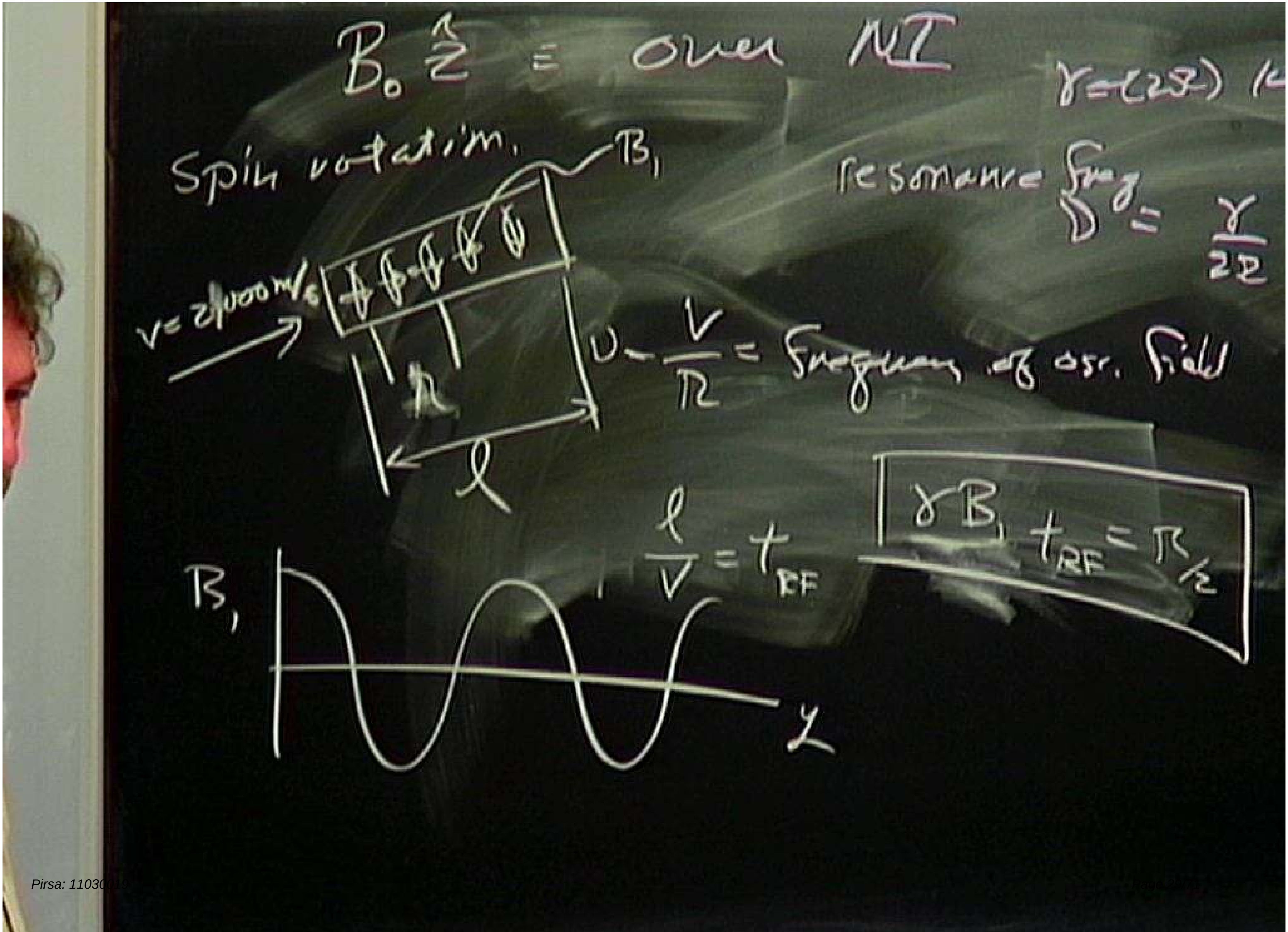

B0 ẑ = over NI
Spin rotation.
resonance freq
ν0 = γ/2π B0
ν = v/λ = frequency of osc. field
v/λ = γ/2π
λ
l

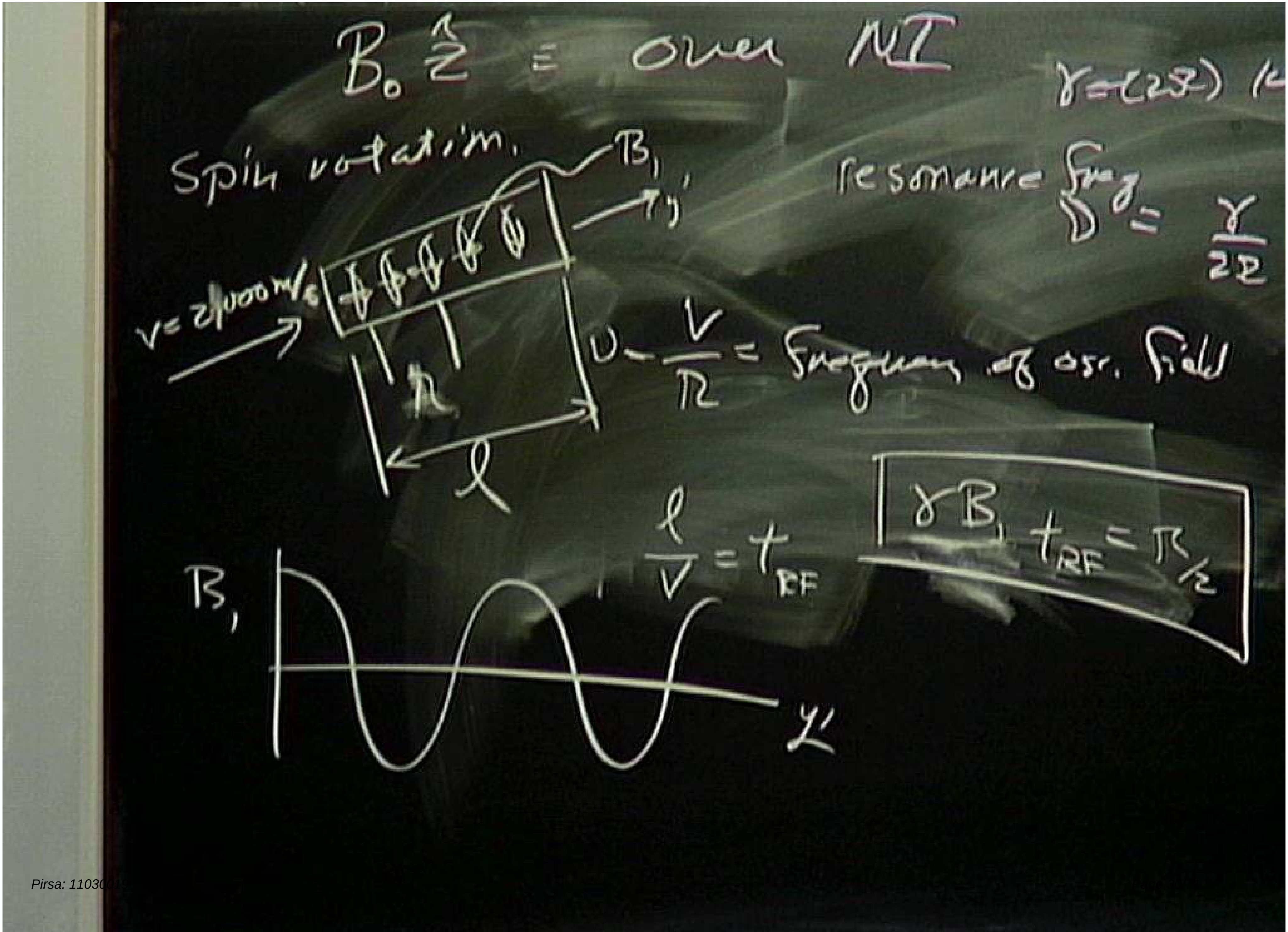

Spin rotation.
resonance freq
frequency of osc. field

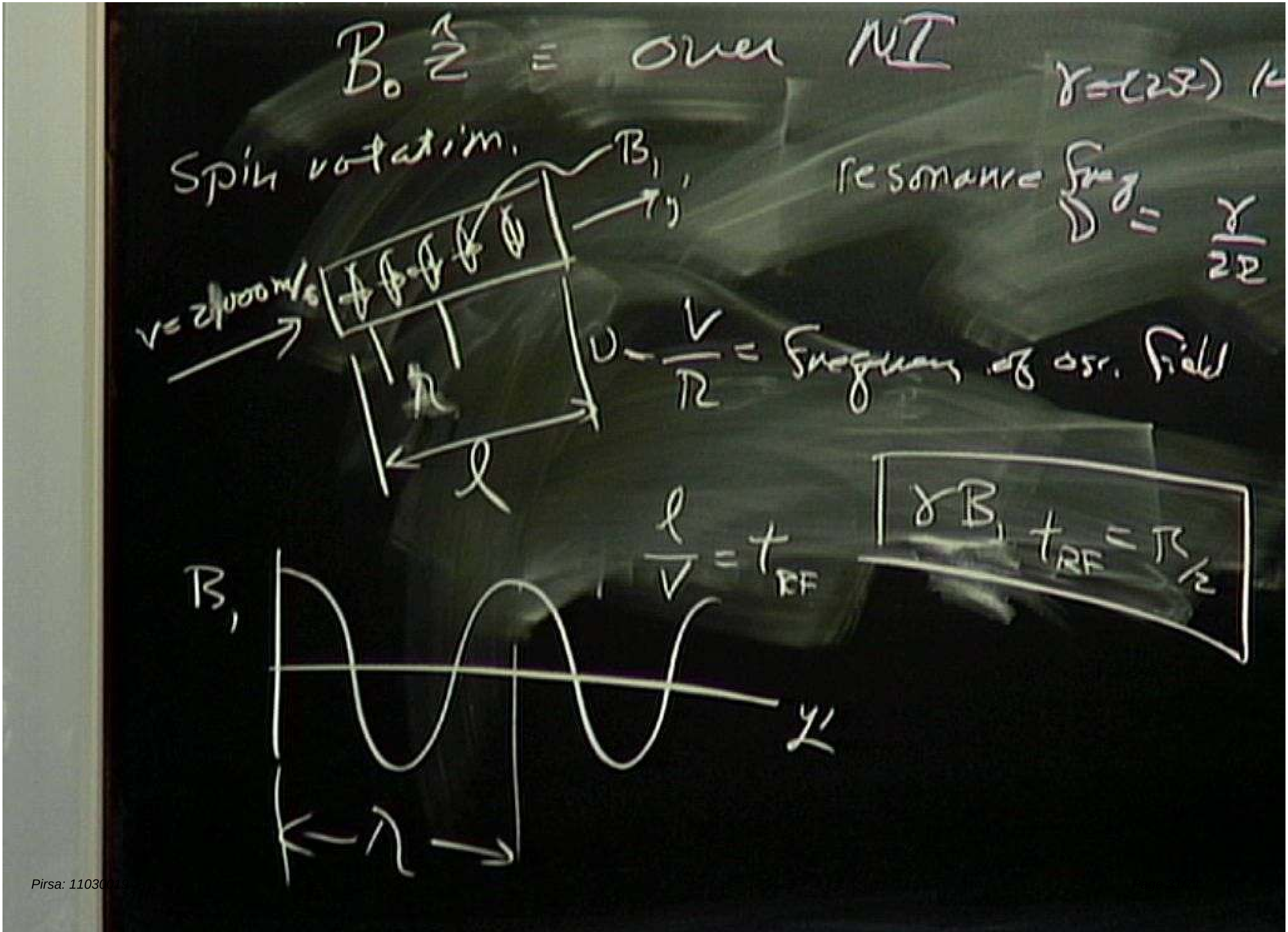

B0 ẑ = over MI
Spin rotation.
B1
resonance freq
ν = γ/2π B0
ν = V/R = frequency of osc. field
l
l/V = t_RF
γB1 t_RF = π/2
[V/R = γ/2π B0]

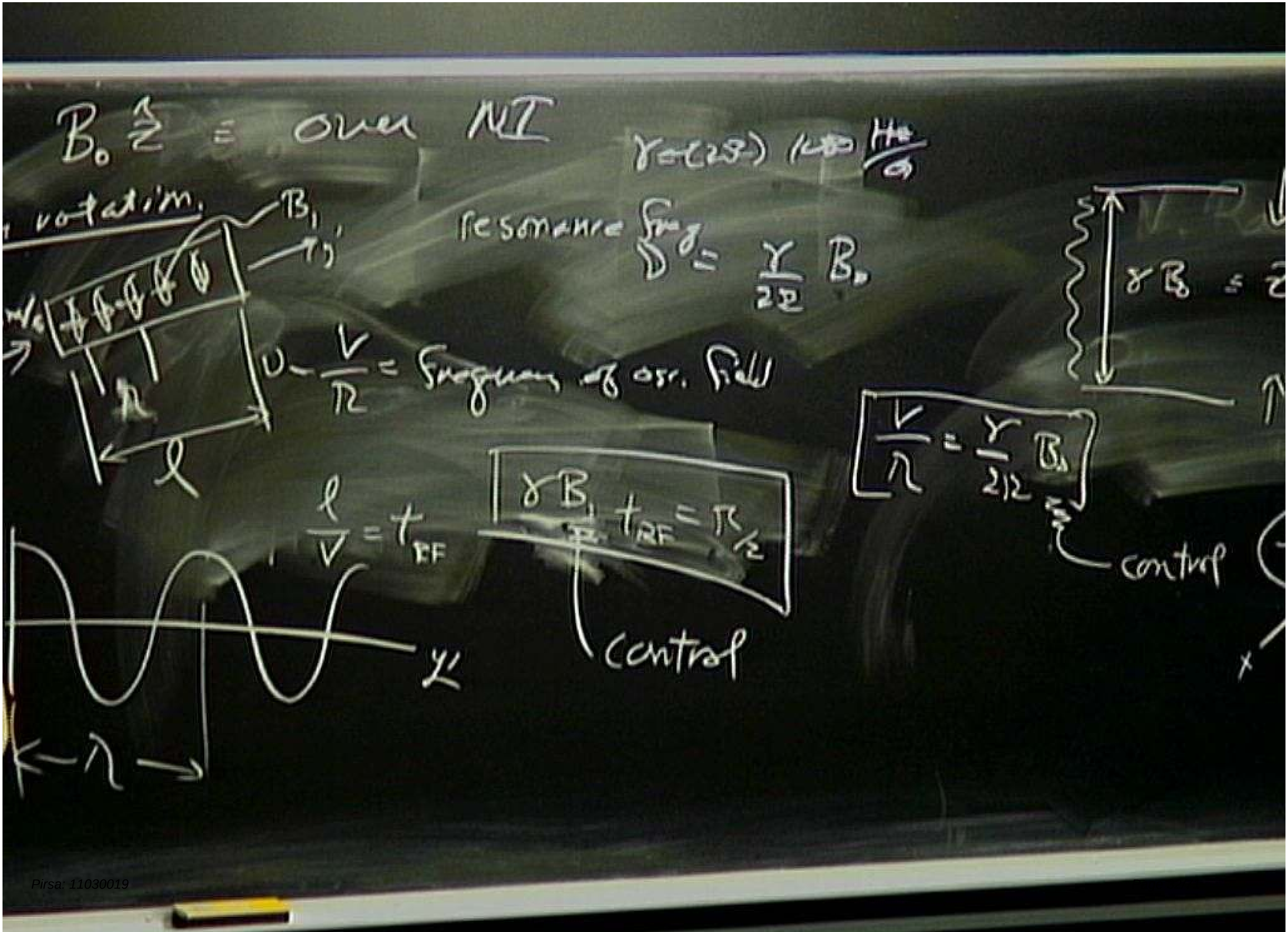

NI
resonance freq
γB = Zeeman
frequency of osc. field
control
x
y
z


NMR
resonance freq
Zeeman
= frequency of osc. field
control
B1
x
y
z

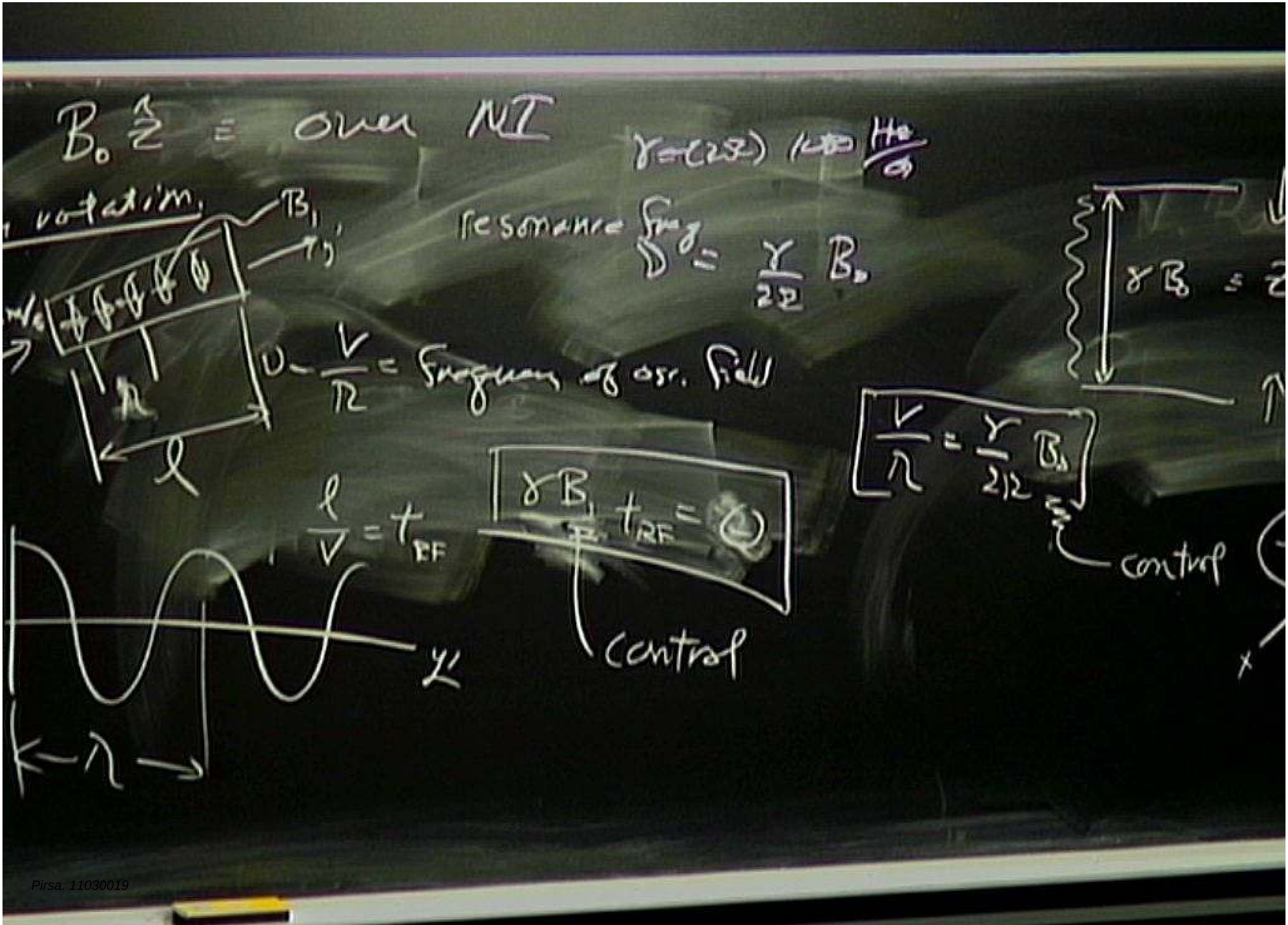

B0 ẑ = over NI
Spin rotation.
B1
resonance freq
ν0 = γ/2π
ν ~ V/R = frequency of osc. field
l
l/V = tRF
γB1 tRF = π/2
B1
z


B₀ ẑ = over NI
γ = (2π) (
Spin rotation.
B₁
resonance freq
ν₀ = γ/2π
v = 2/1000 m/s
ν ~ V/R = frequency of osc. field
R
ℓ
ℓ/V = t_RF
γB₁ t_RF = π/2
B₁
x

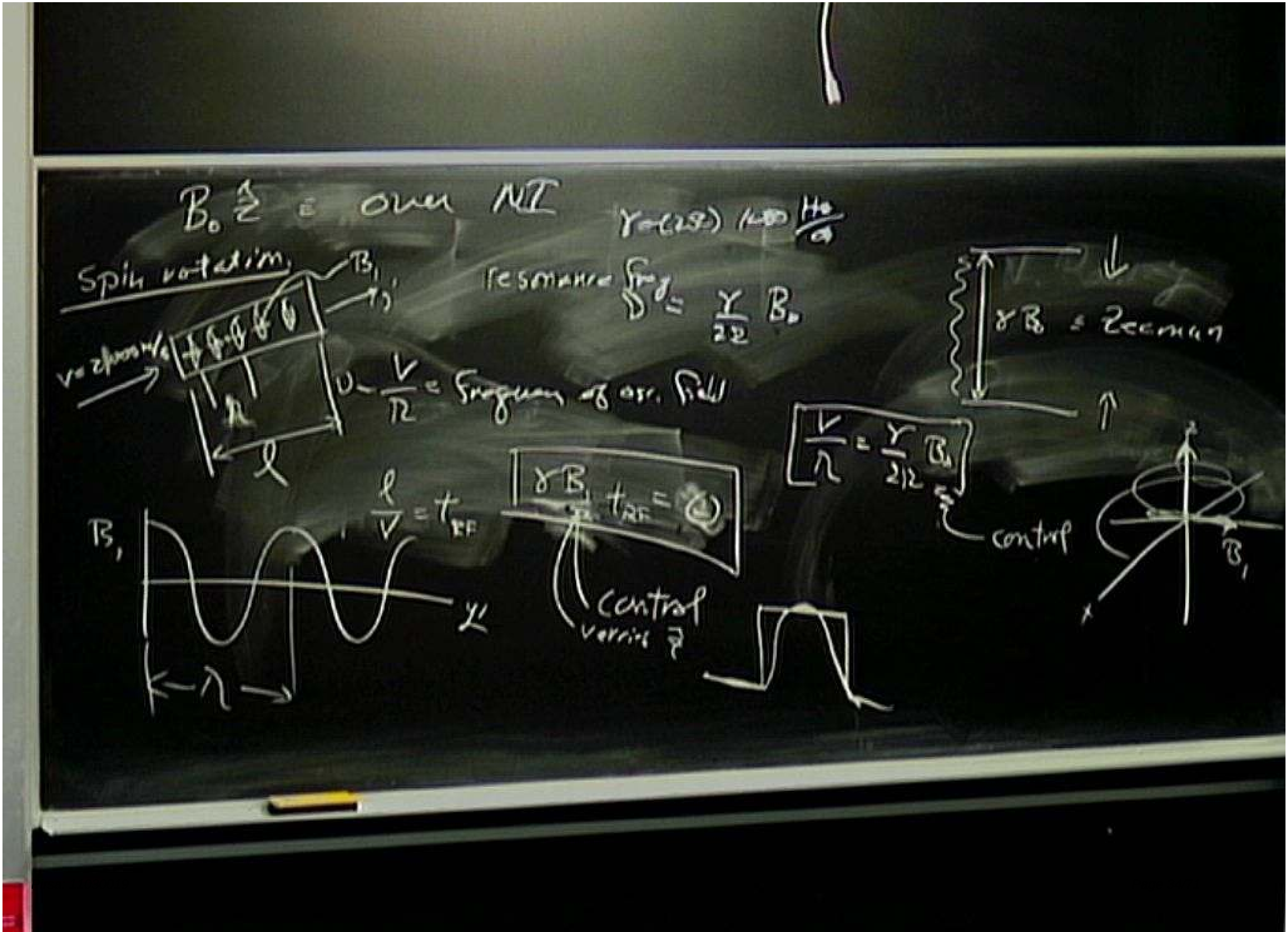

Spin rotation.
resonance freq
frequency of osc. field
γB1 tRF = π/2
l/v = tRF

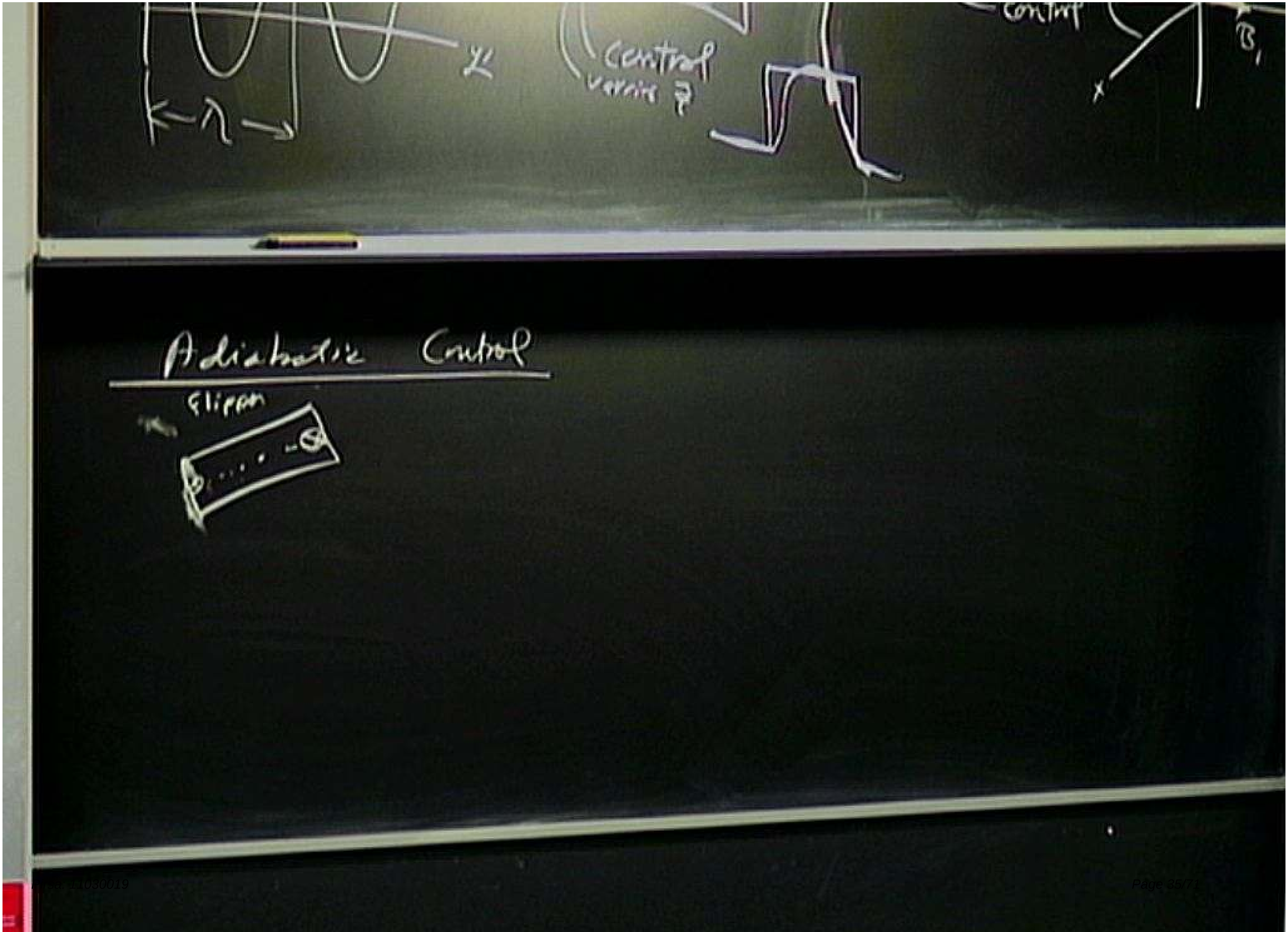


$B_0 \hat{z}$ = over NI
rotation
B_1
B_1'
resonance freq
$\nu = \frac{\gamma}{2\pi} B_0$
$\nu \sim \frac{v}{\lambda}$ = frequency of osc. field
λ
ℓ
$\frac{\ell}{v} = t_{RF}$
control
$\frac{v}{\lambda} = \frac{\gamma}{2\pi} B_0$
γB_0
control

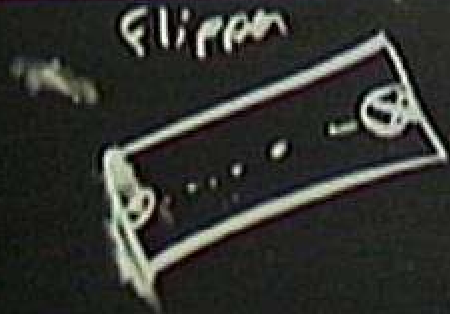


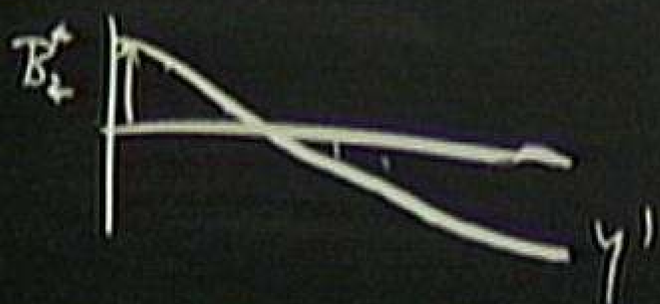
B₀ ẑ = over NI
rotation
B₁
resonance freq
ν = γ/2π B₀
ν ~ v/λ = frequency of osc. field
l
l/v = t_RF
γB₁ t_RF = π
control
v/λ = γ/2π B₀
γB₀
control
z
λ

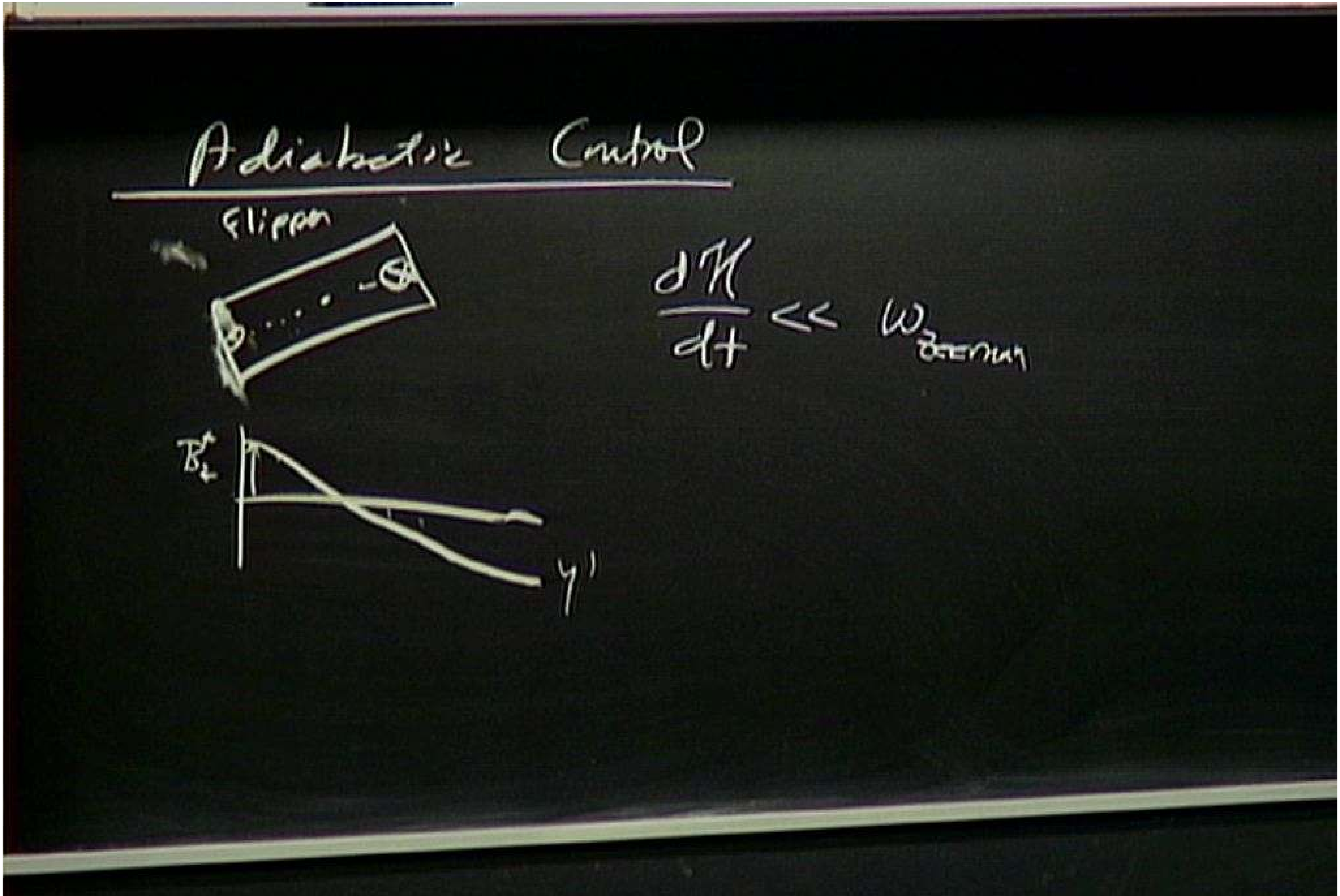

B₀ ẑ = over NI
Spin rotation
resonance freq
= frequency of osc. field
γB₀ = Zeeman
control
control


Control
Adiabatic Control

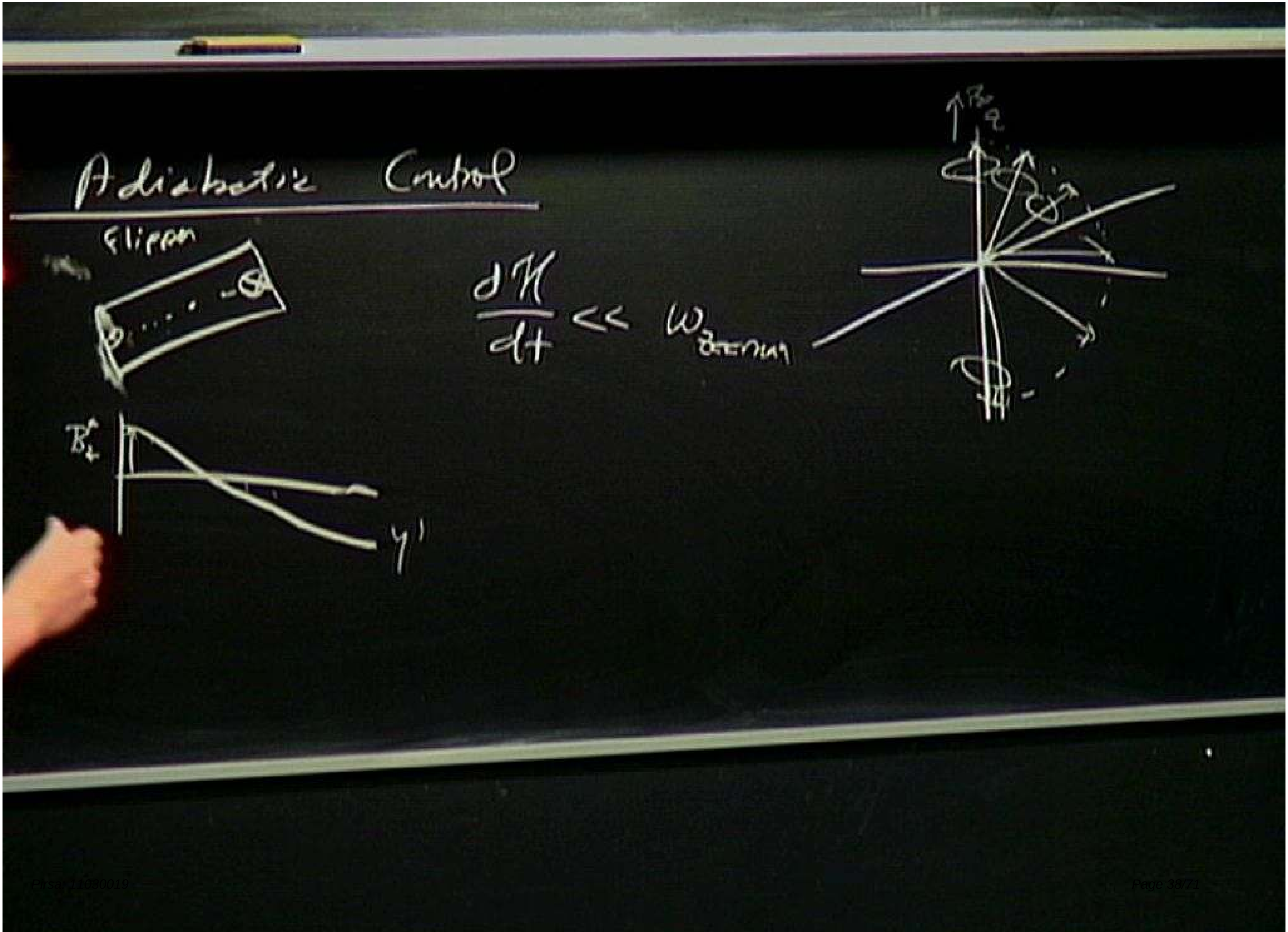
Adiabatic Control

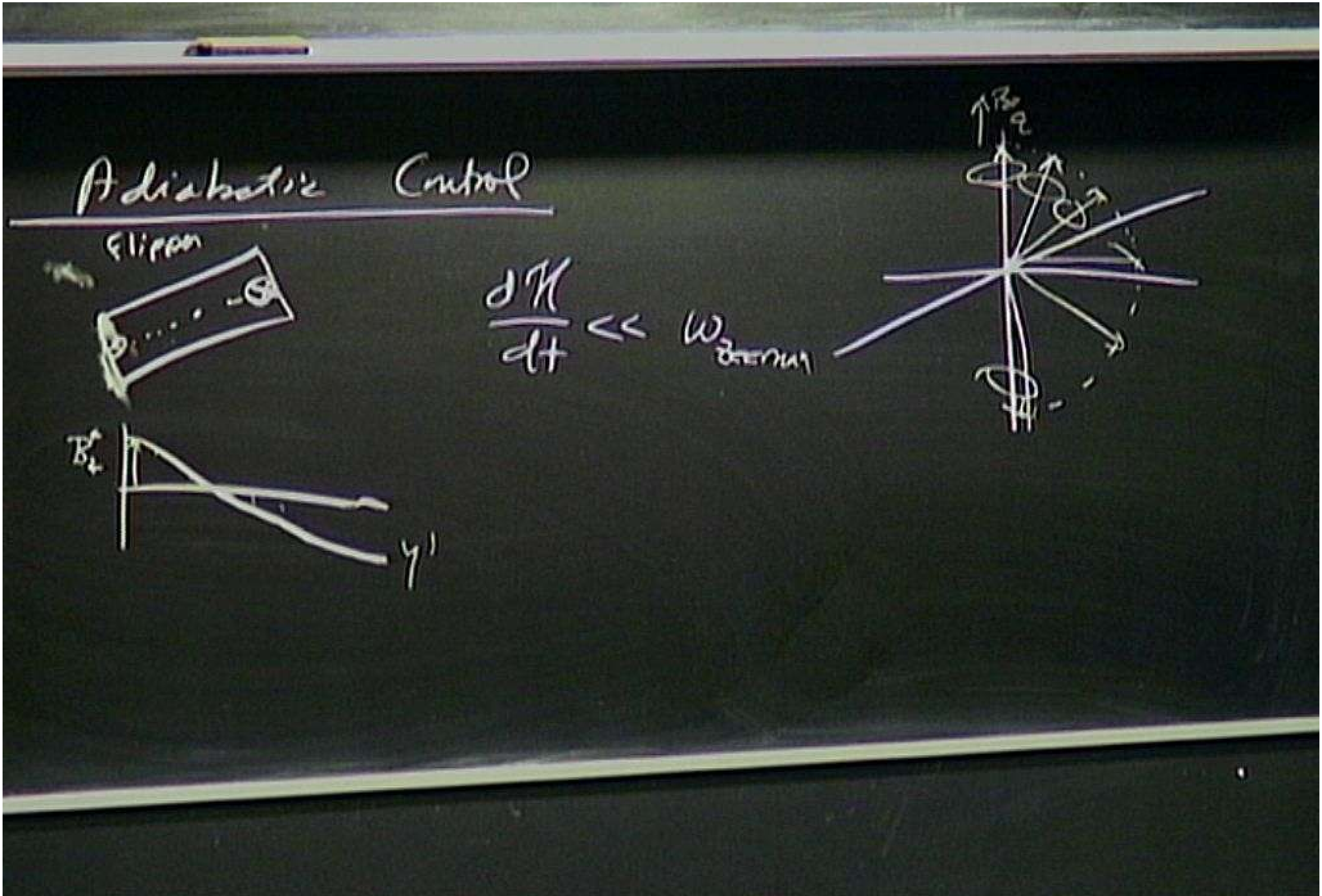






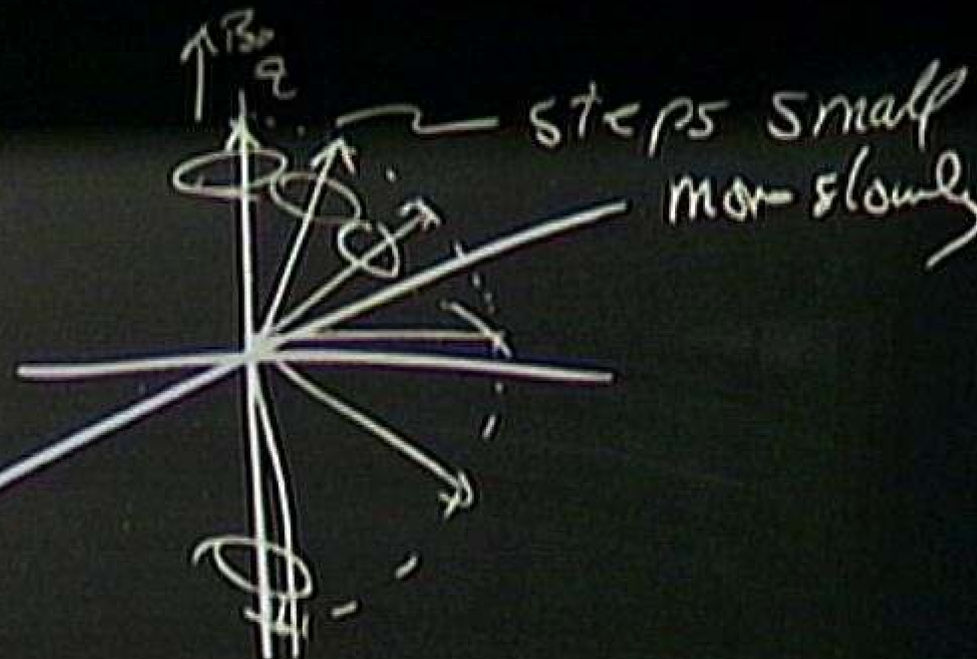
Adiabatic Control
Flipper
$\frac{dH}{dt} \ll \omega$
y'

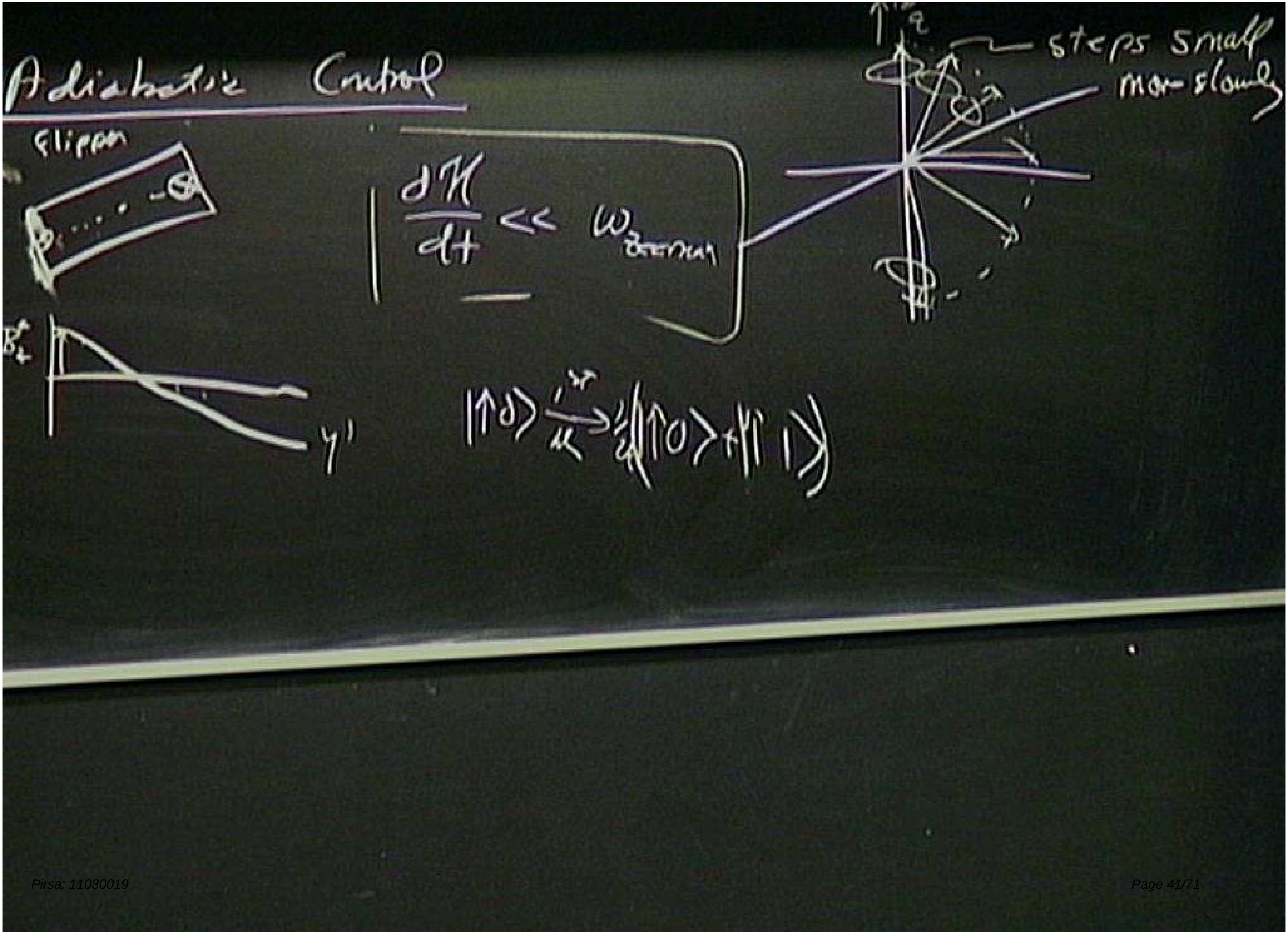

Adiabatic Control
Flipper
y'


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

ntrol

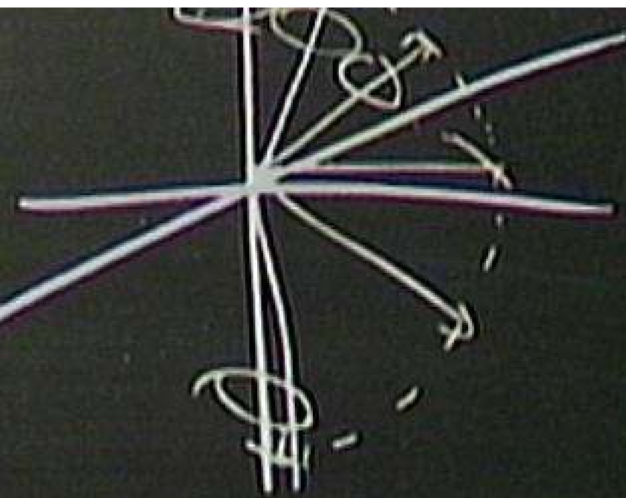
$$\left| \frac{d\mathcal{H}}{dt} \right| \ll \omega_{\text{Larmor}}$$



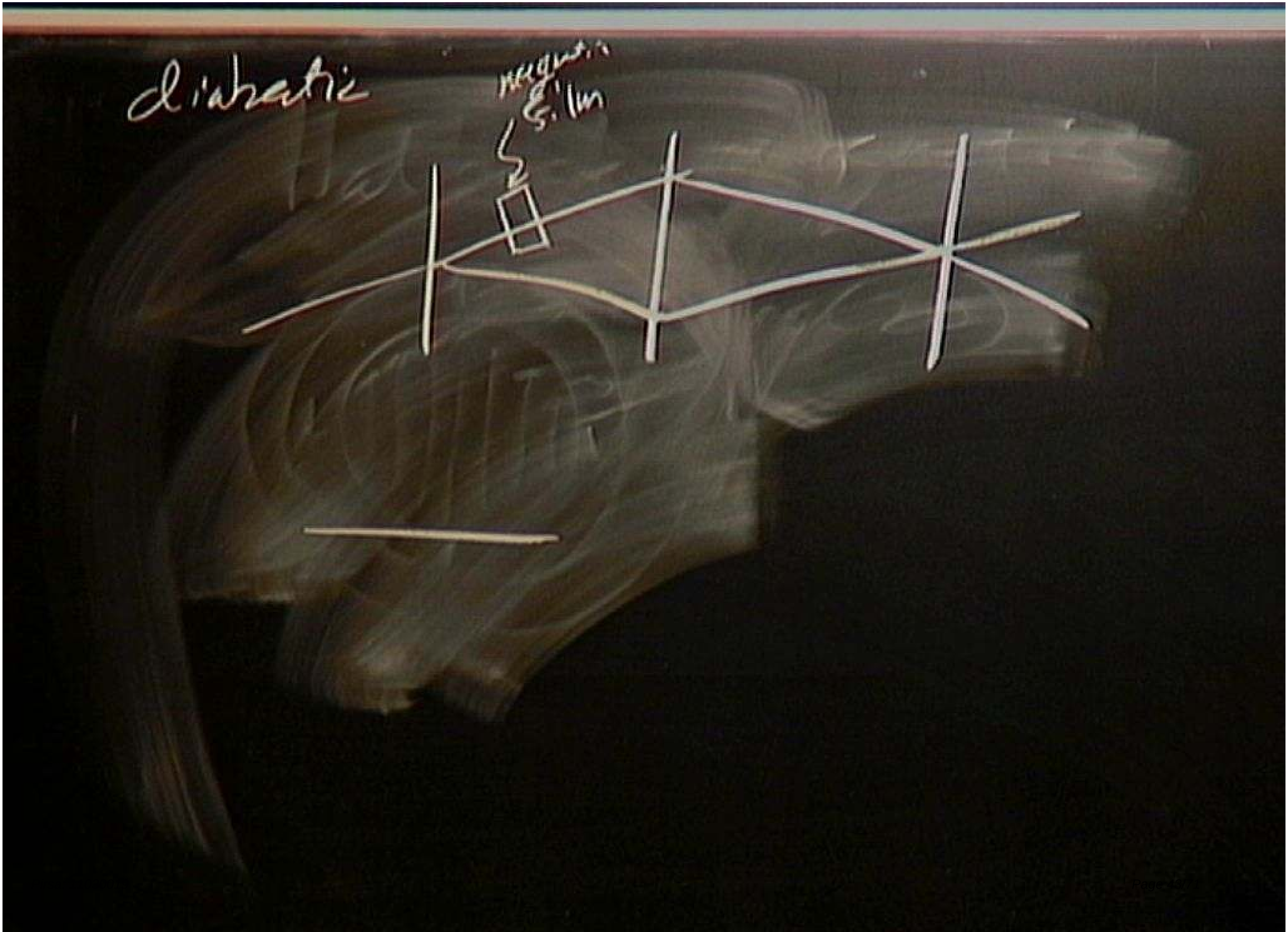

Adiabatic Control
Flipper
steps small
more slowly

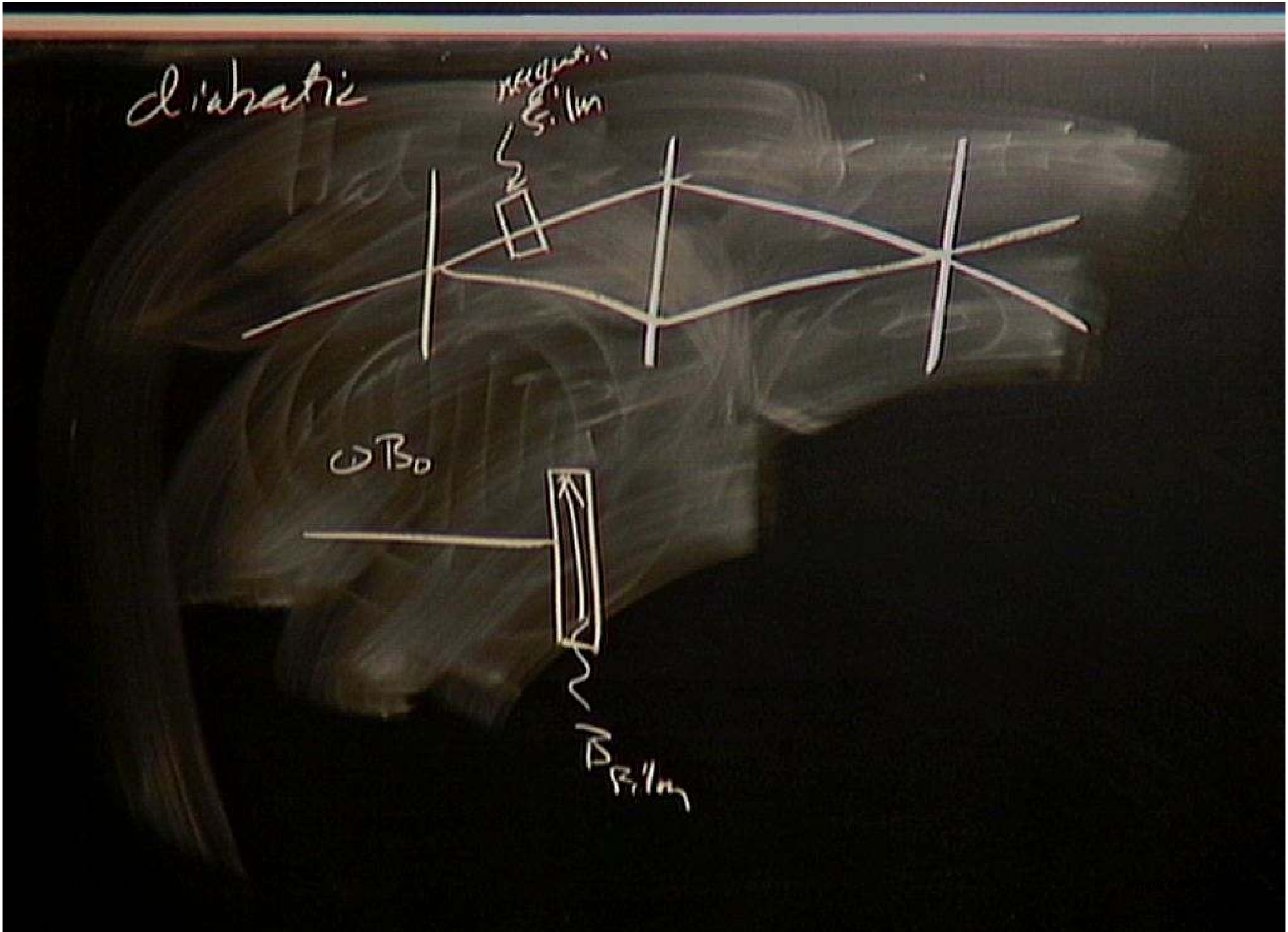
control

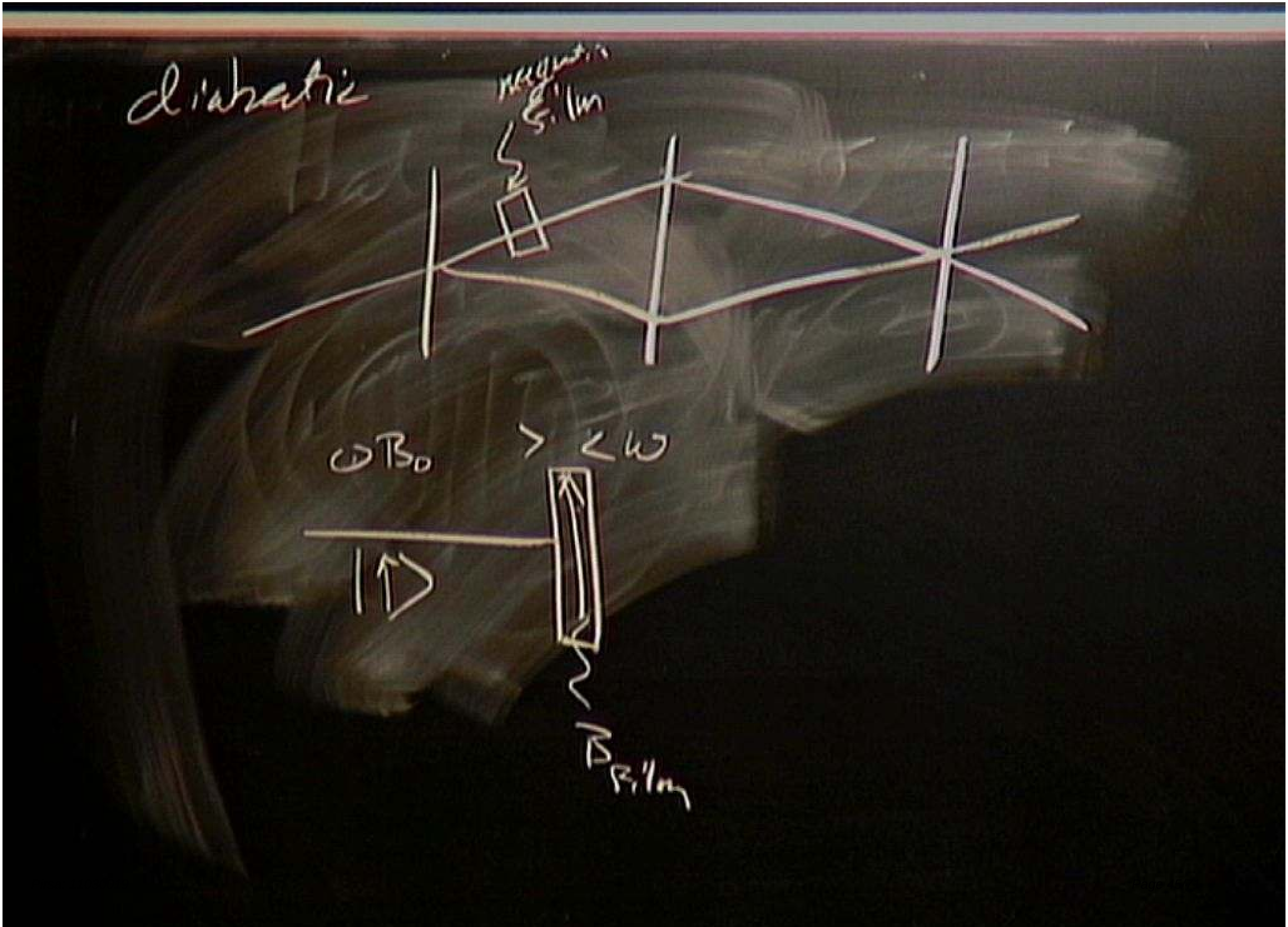
$$\frac{d\mathcal{H}}{dt} \ll \omega_{\text{[illegible]}}$$

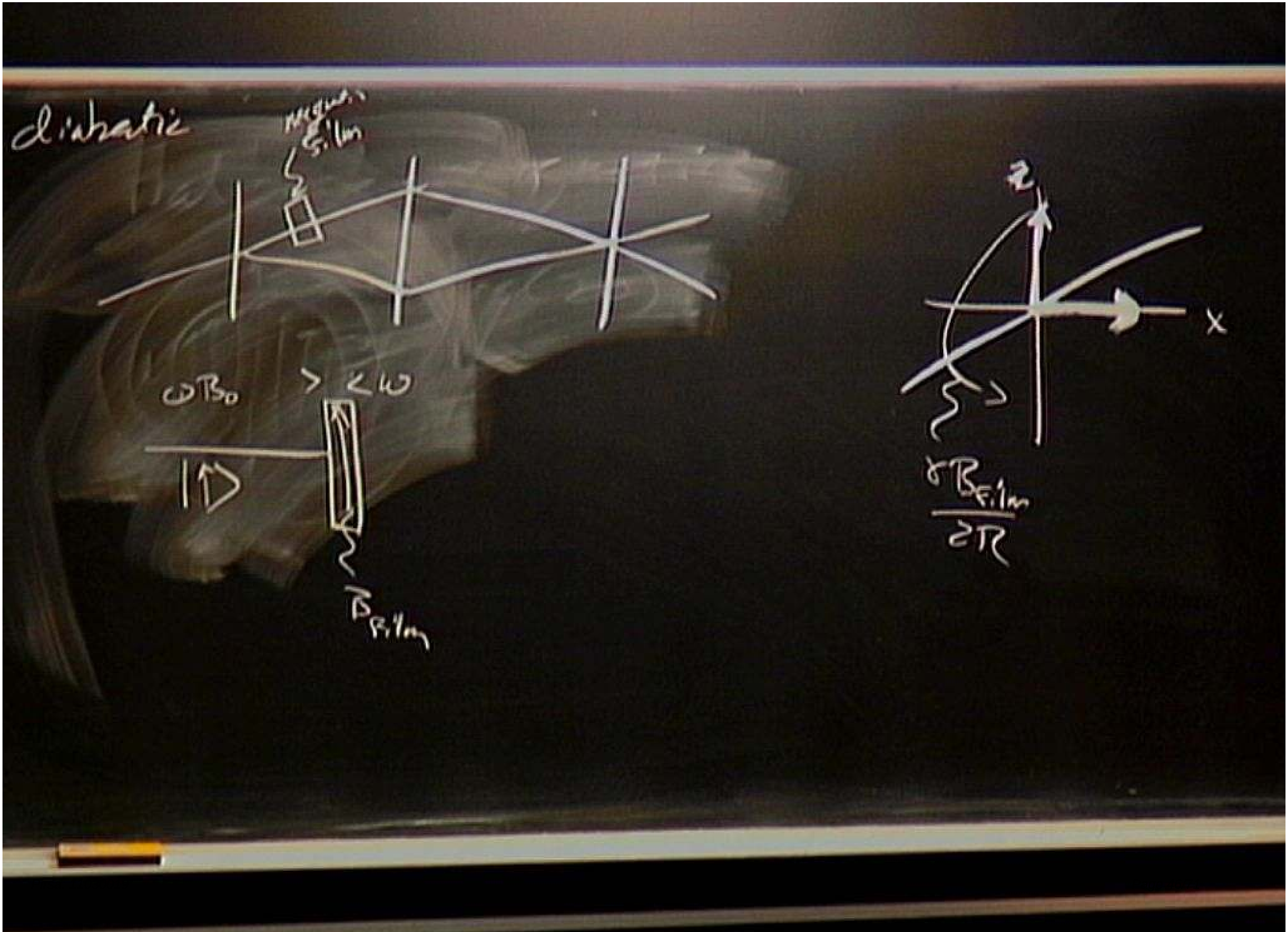


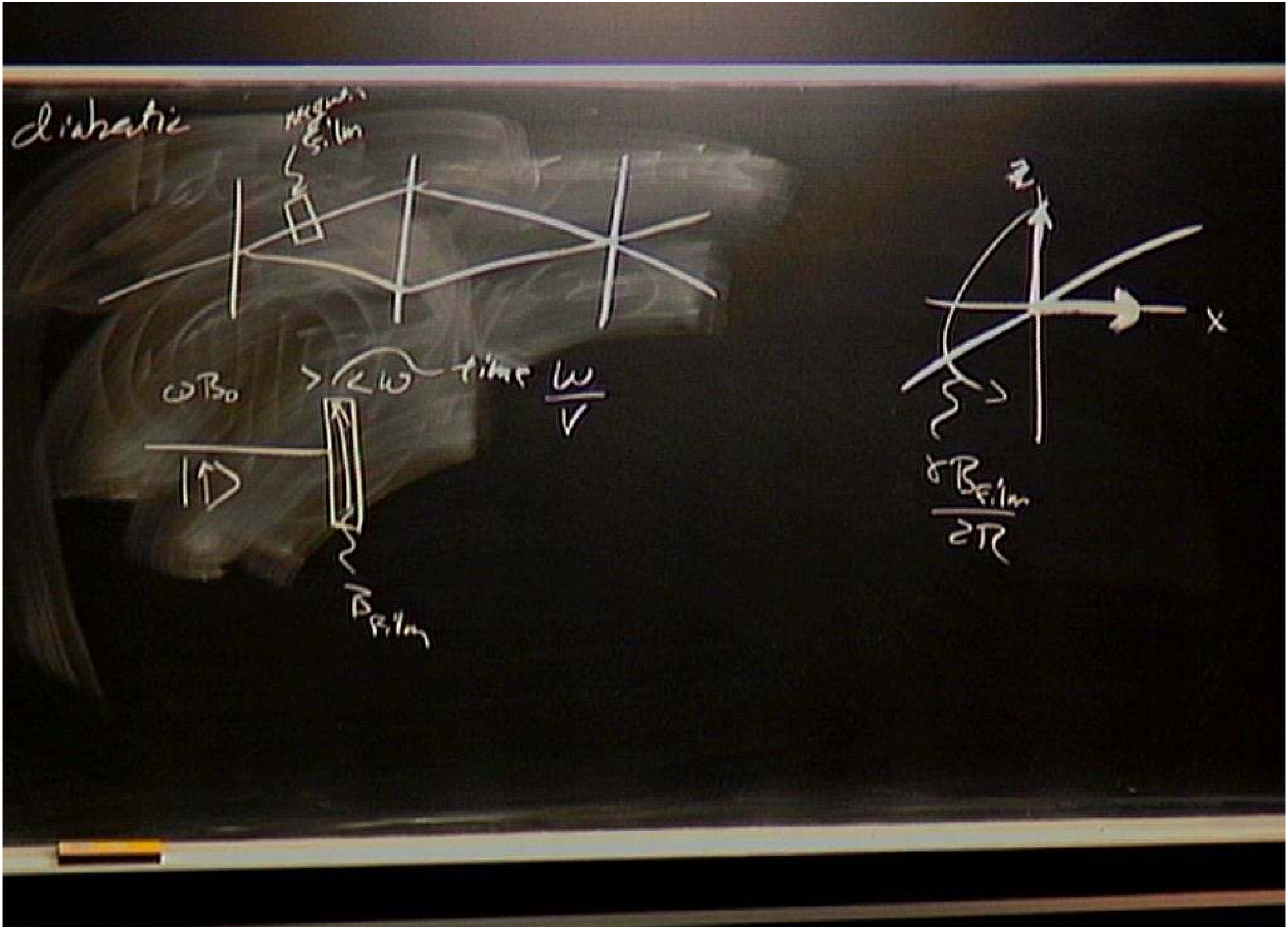
$$|\uparrow 0\rangle \xrightarrow{[illegible]} \tfrac{1}{\sqrt{2}}\left(|\uparrow 0\rangle + |\uparrow 1\rangle\right) \xrightarrow{\text{slow}} \tfrac{1}{\sqrt{2}}\left(|\downarrow 0\rangle + |\uparrow 1\rangle\right)$$

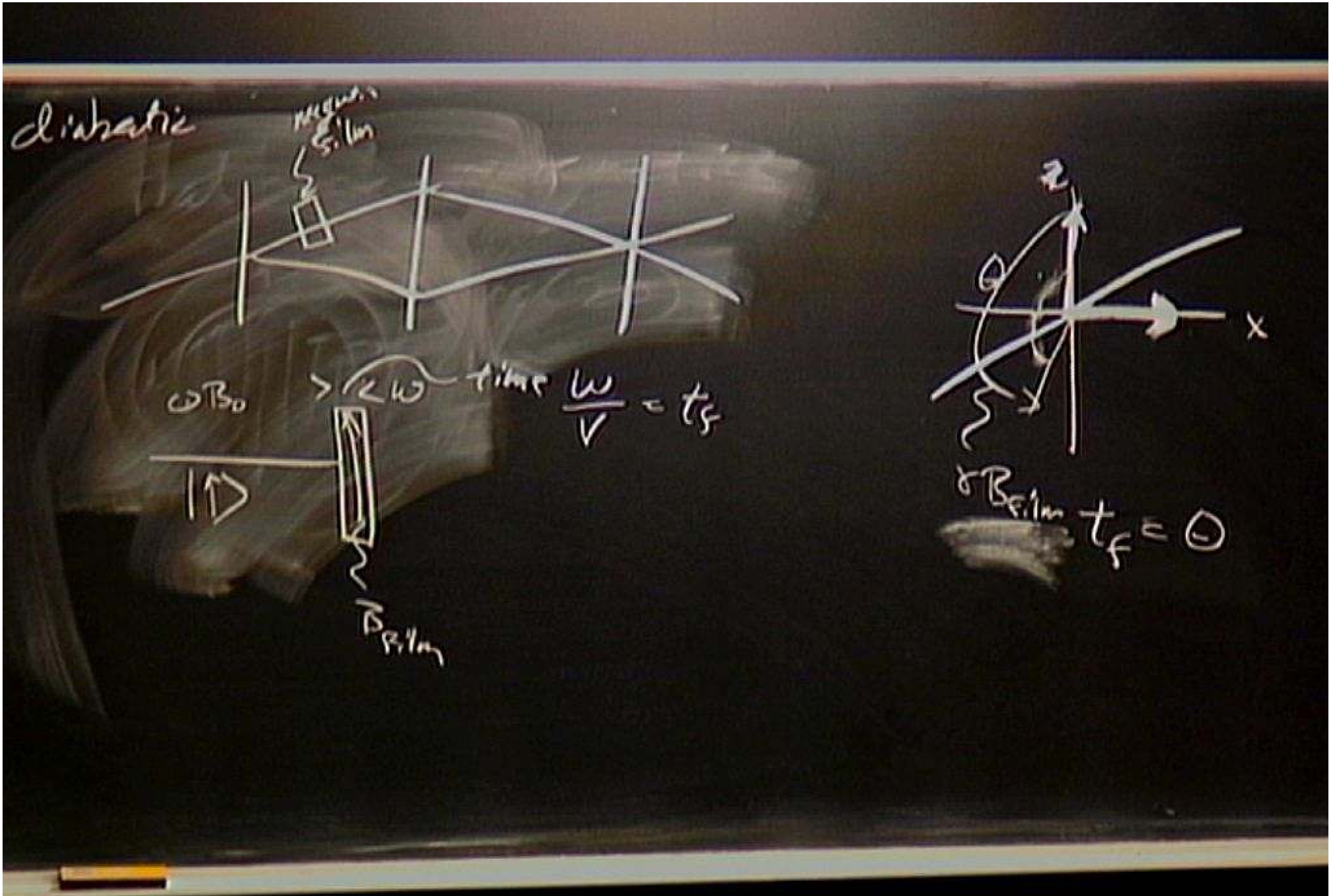

diabatic

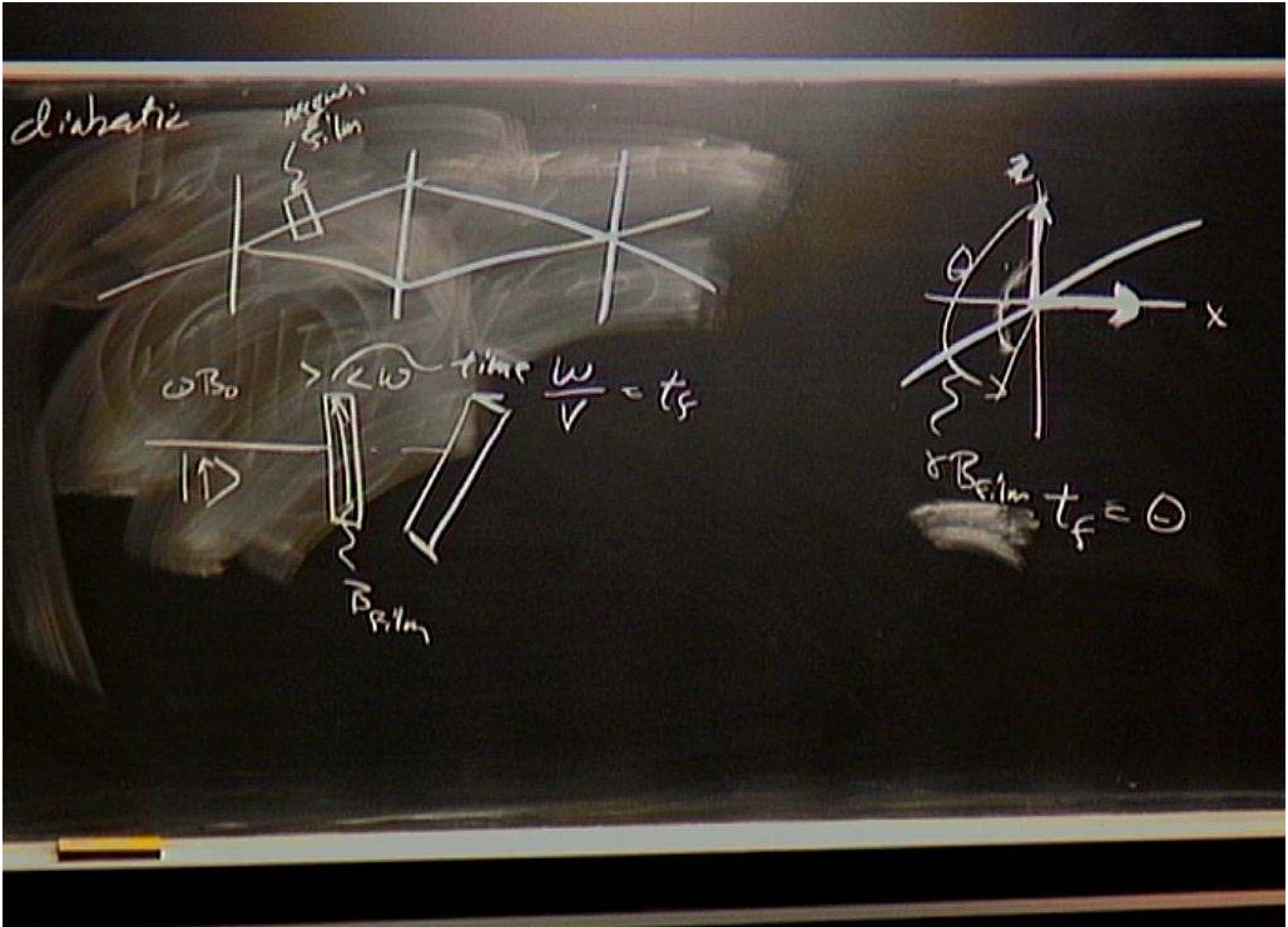

diabatic
negative film
$\odot B_0$
B_{film}

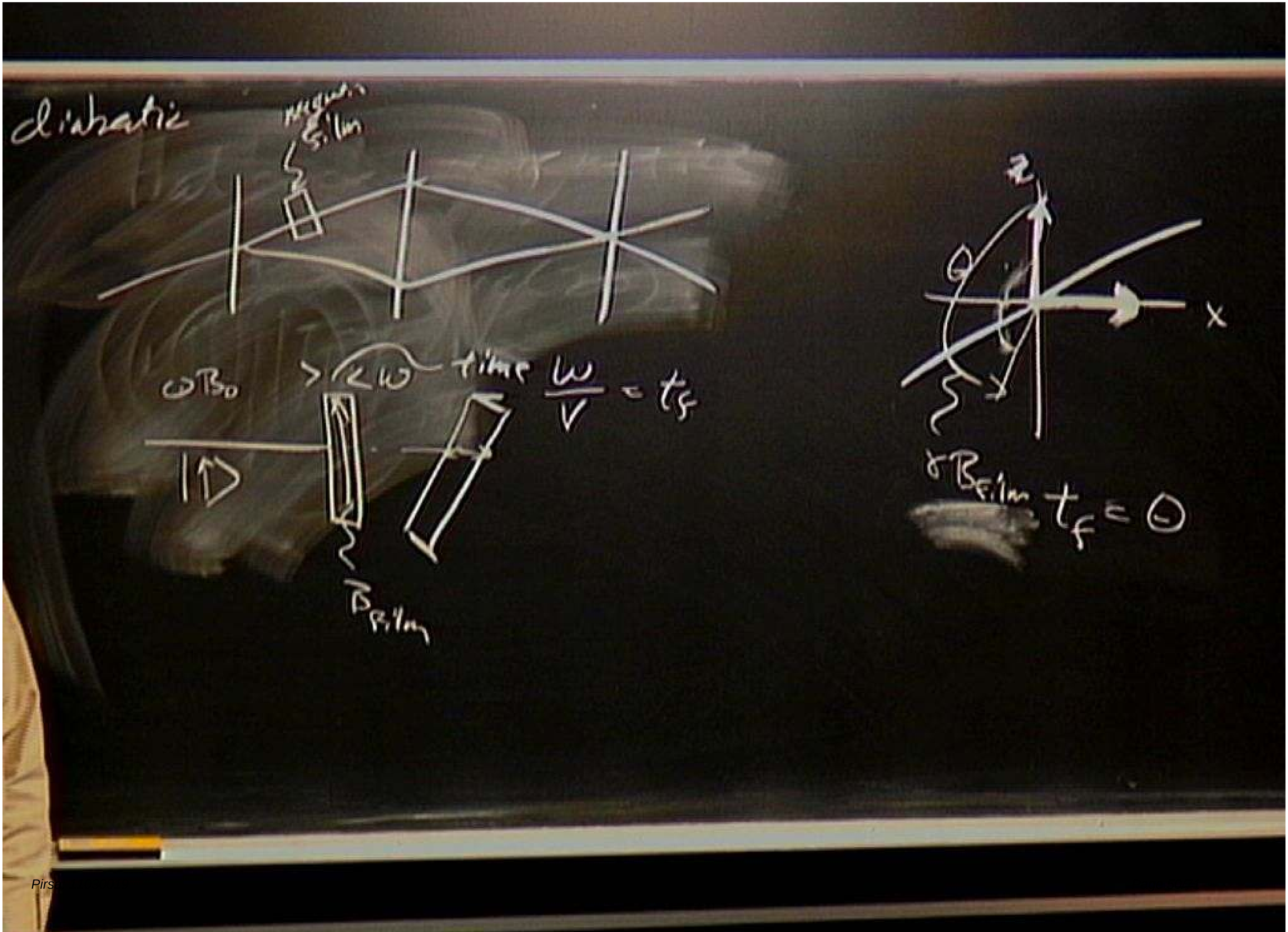

diabatic
magnetic film
B film


diabatic
1D
B_film
z
x
δB_film / ∂R

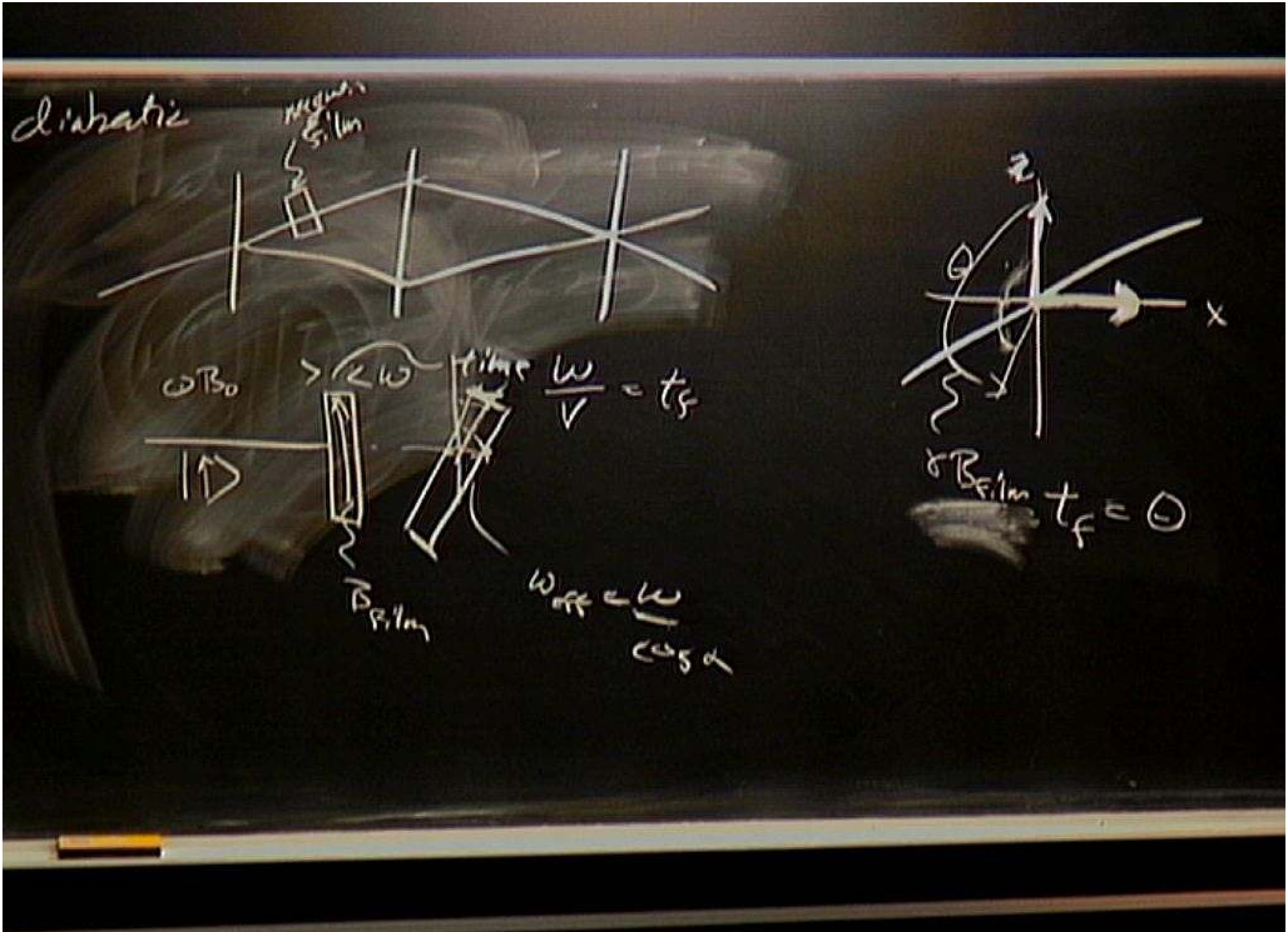

diabatic
magnetic film
ωB_0
time
$\frac{w}{v}$
1D
B_{film}
z
x
$\frac{\gamma B_{film}}{2\pi}$


diabatic
time
w/v = t_f
1D
z
x
t_f = θ

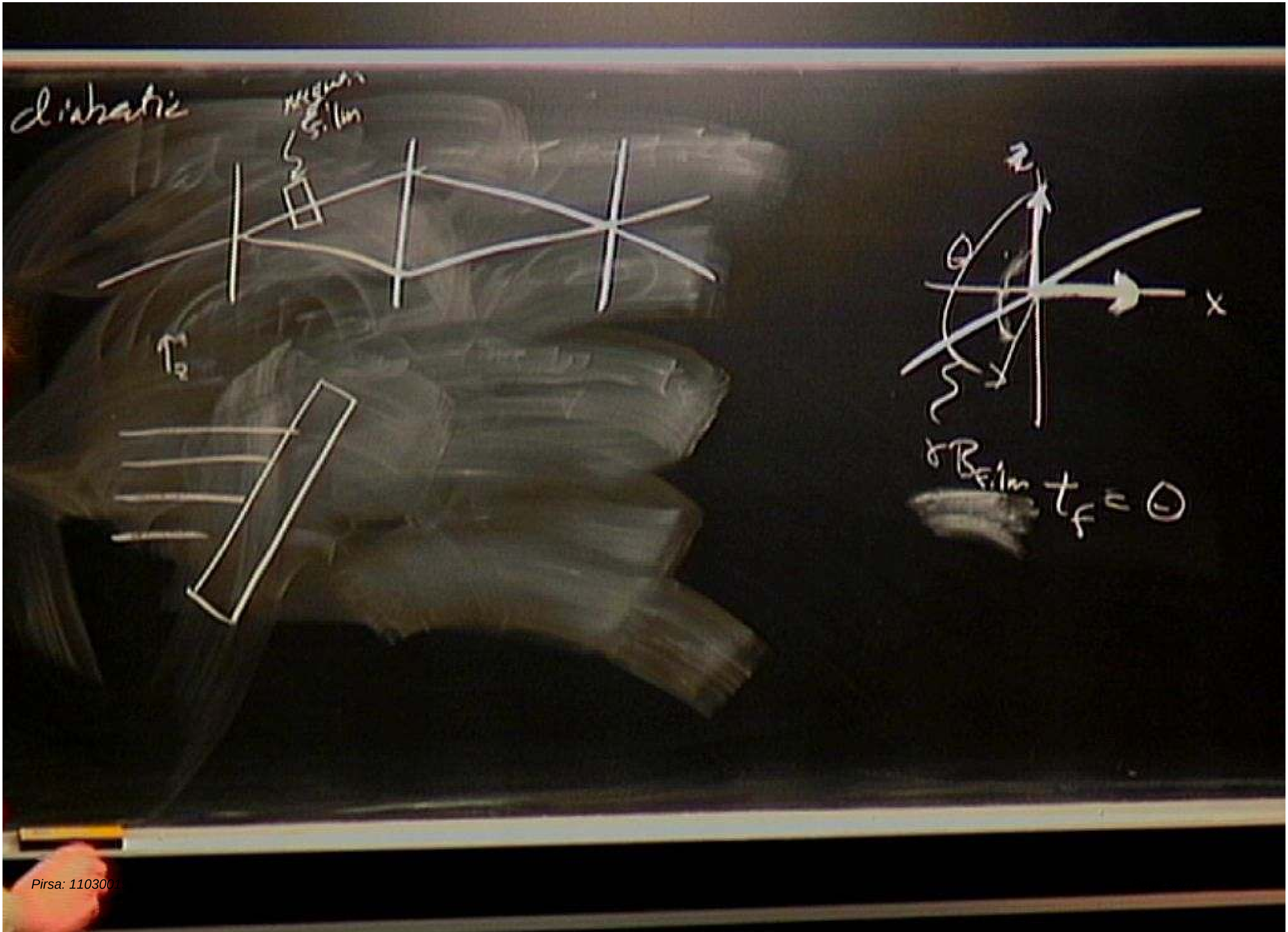

diabatic
time
1D
z
x

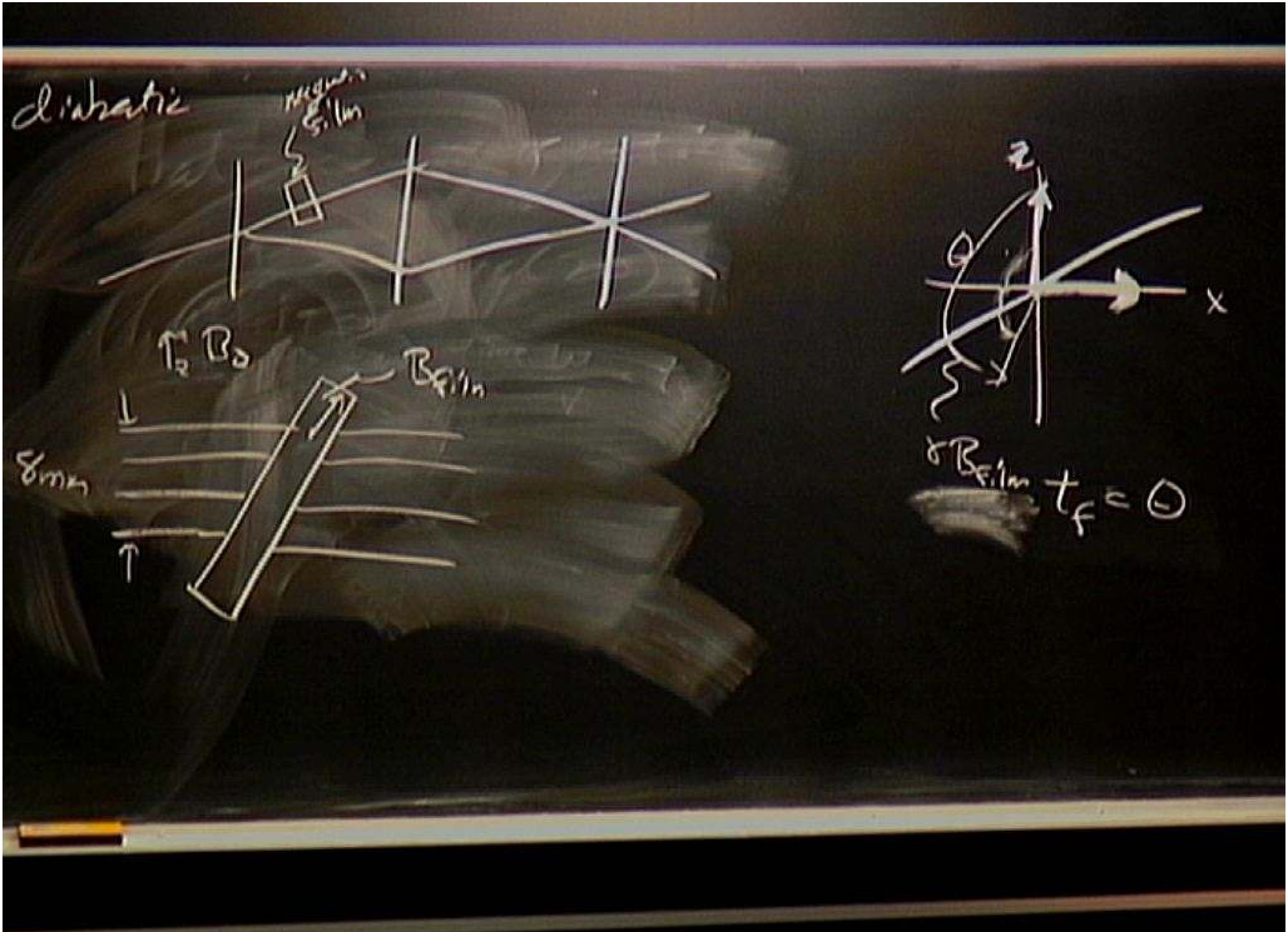


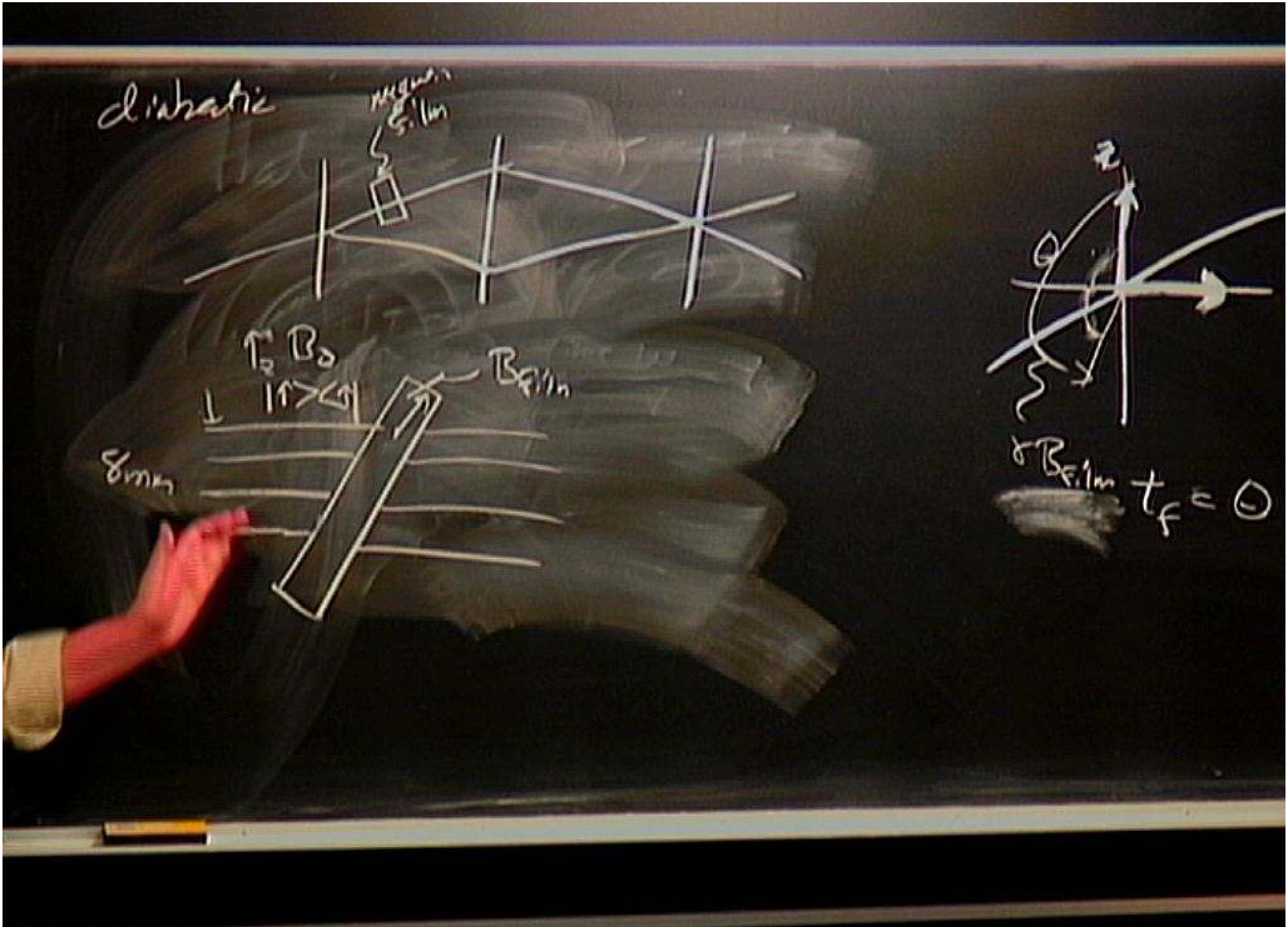
diabatic
time
1D
z
x

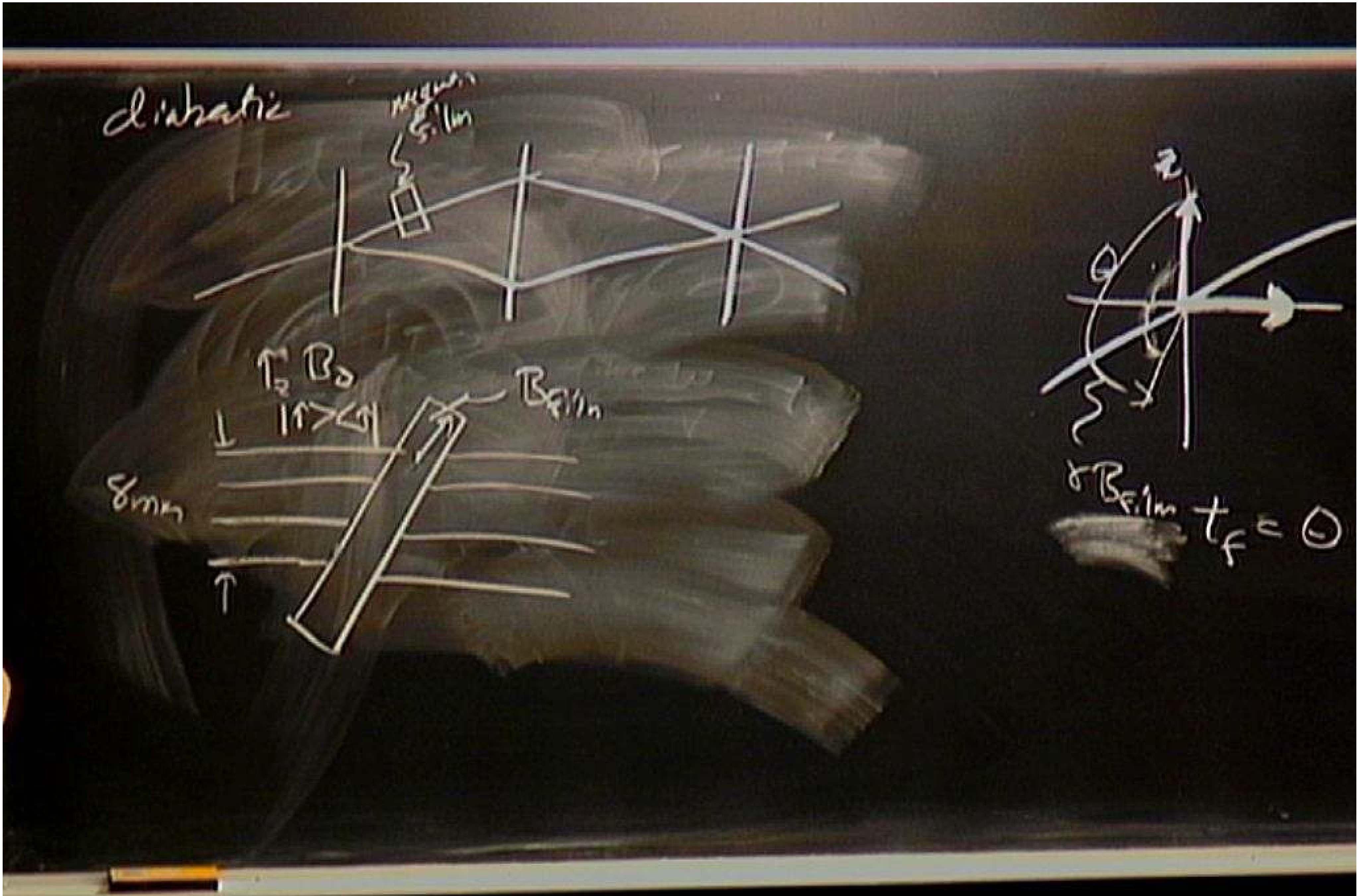


diabatic
magnetic film
ωB_0
time
$\frac{w}{v} = t_f$
B_{film}
$w_{eff} = \frac{w}{\cos \alpha}$
z
x
θ
$\delta B_{film} t_f = \Theta$

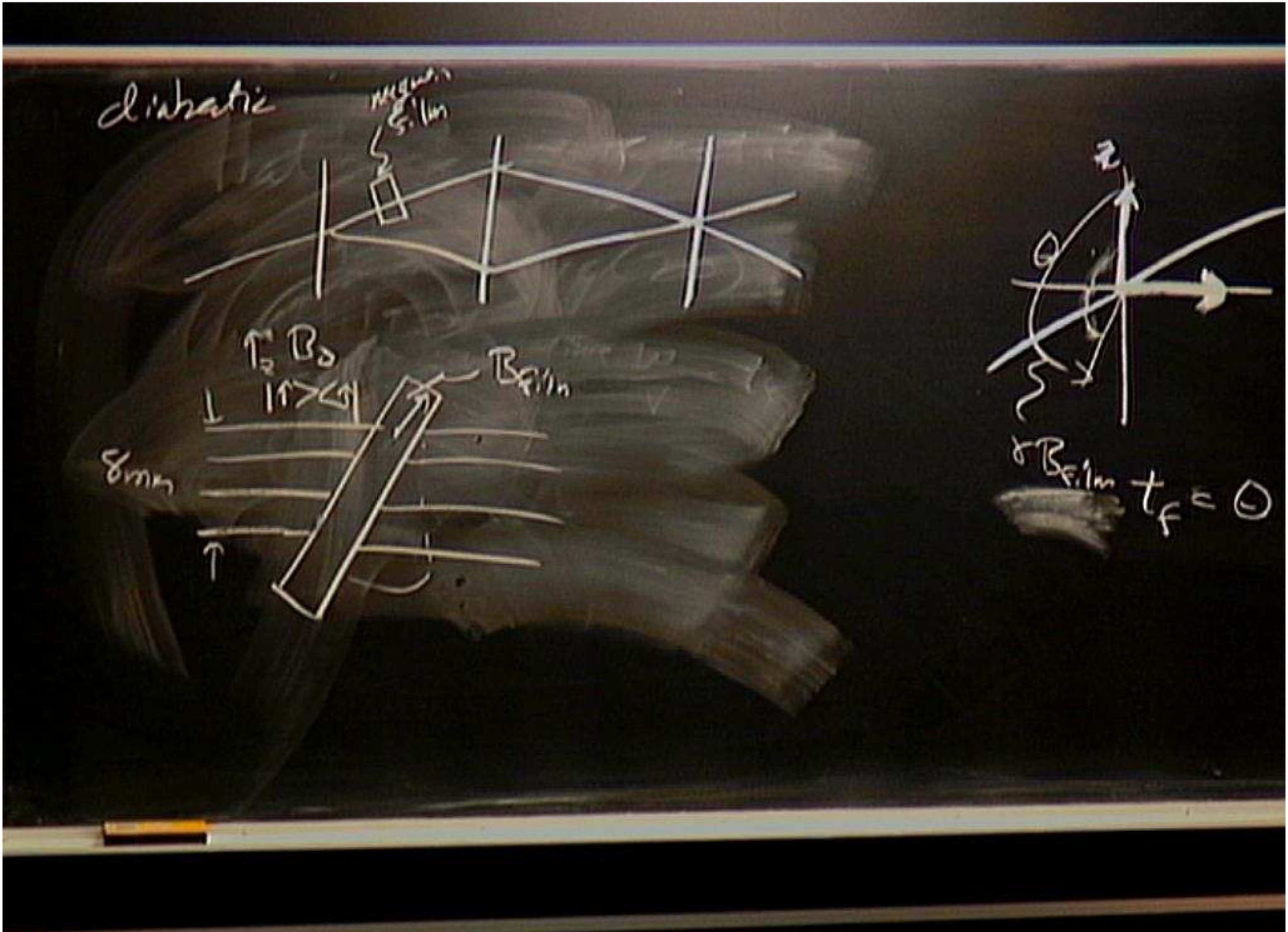

diabatic
z
x

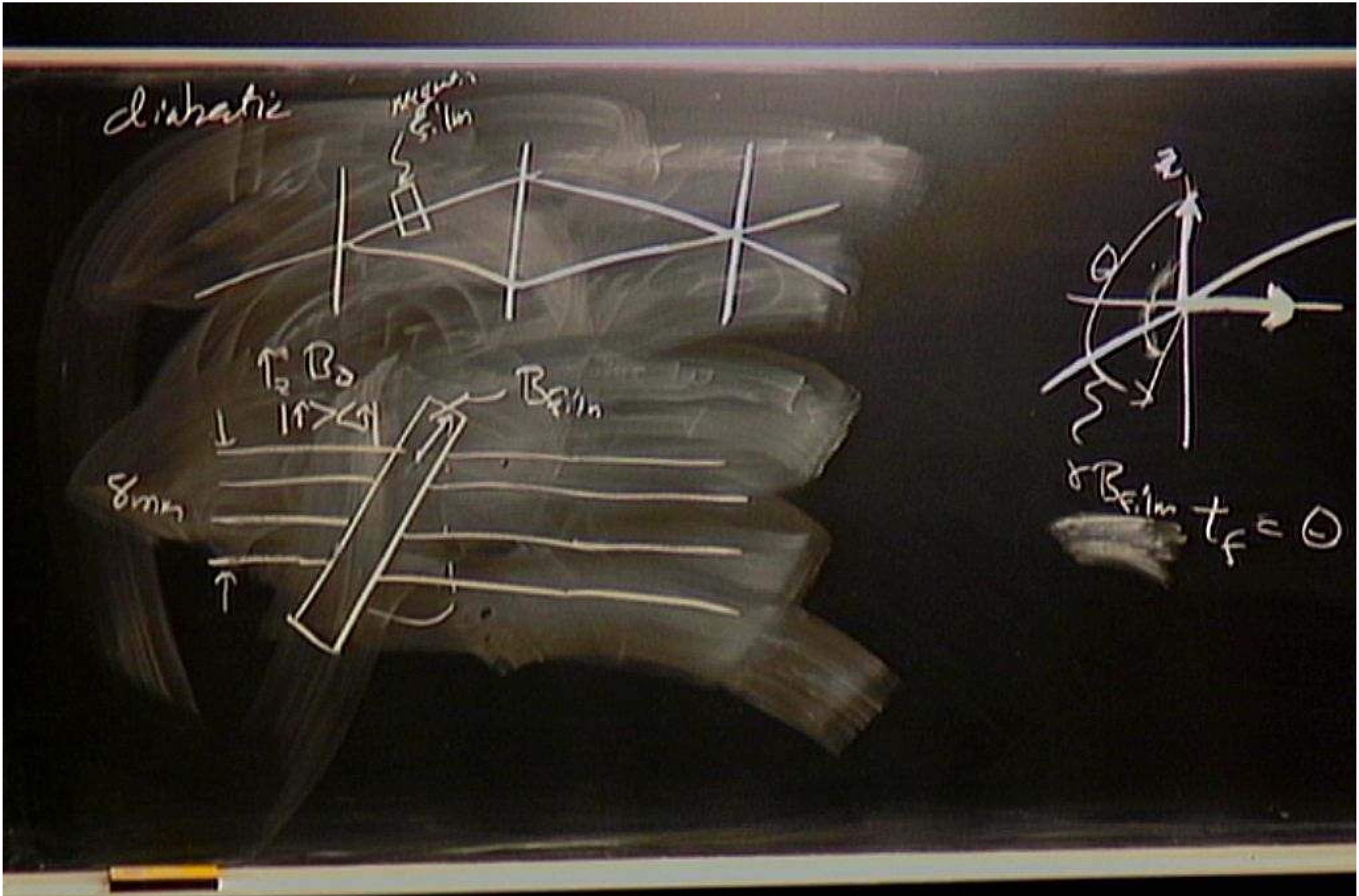

diabatic
magnetic film
B_0
B_{film}
8mm
z
x
θ
δB_{film} $t_f = \Theta$

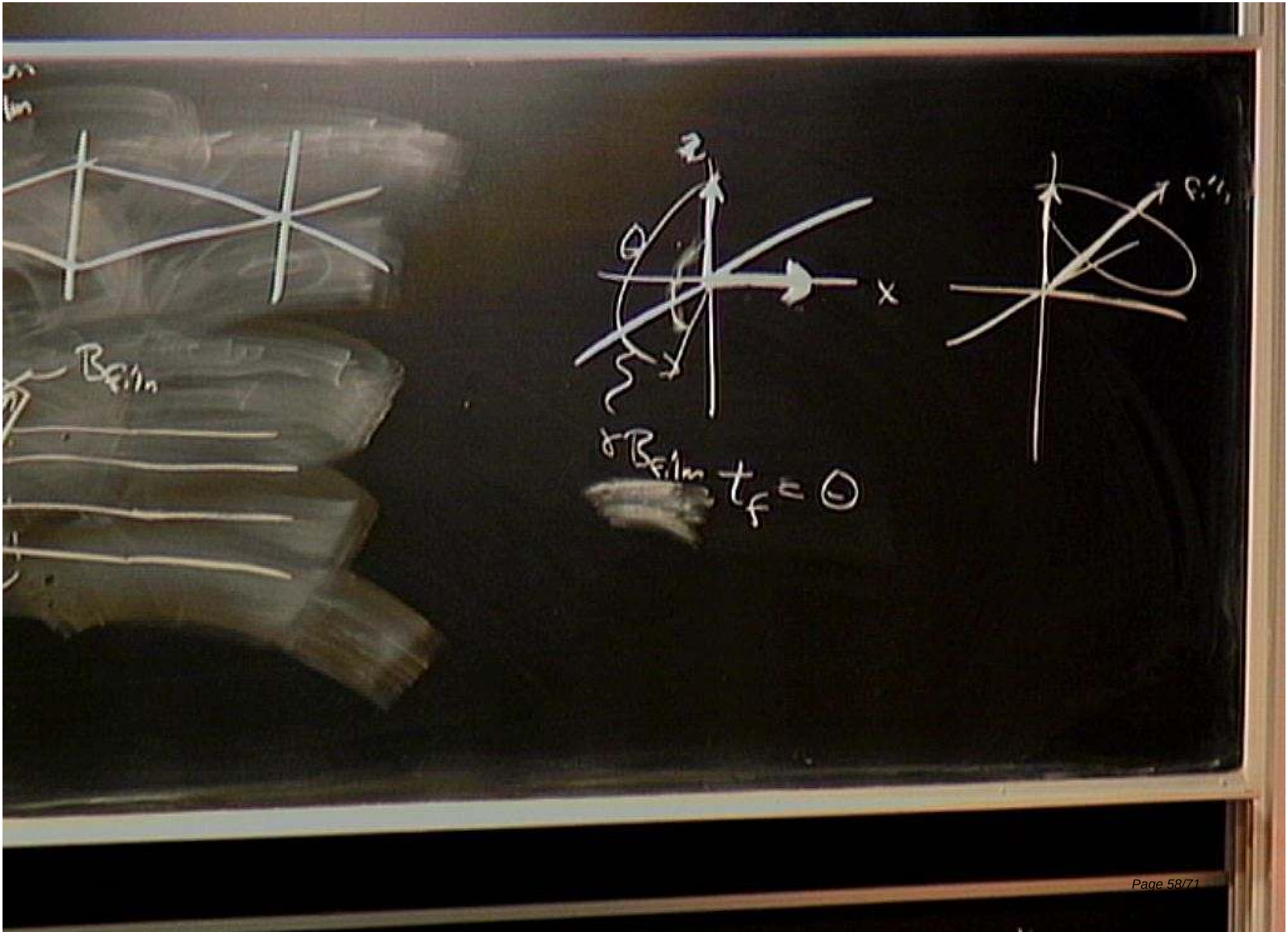

diabatic
8mm
t_F = Θ

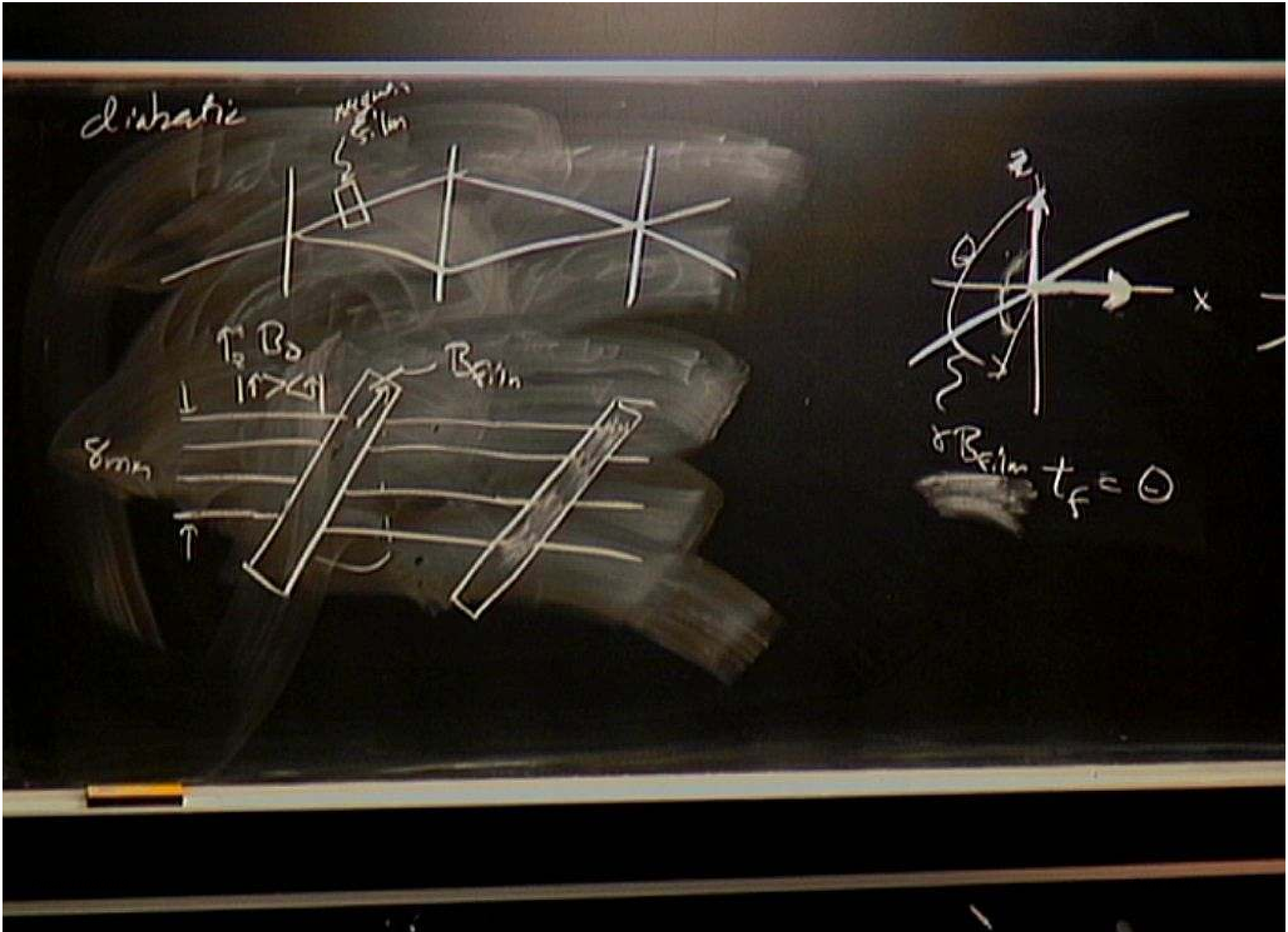


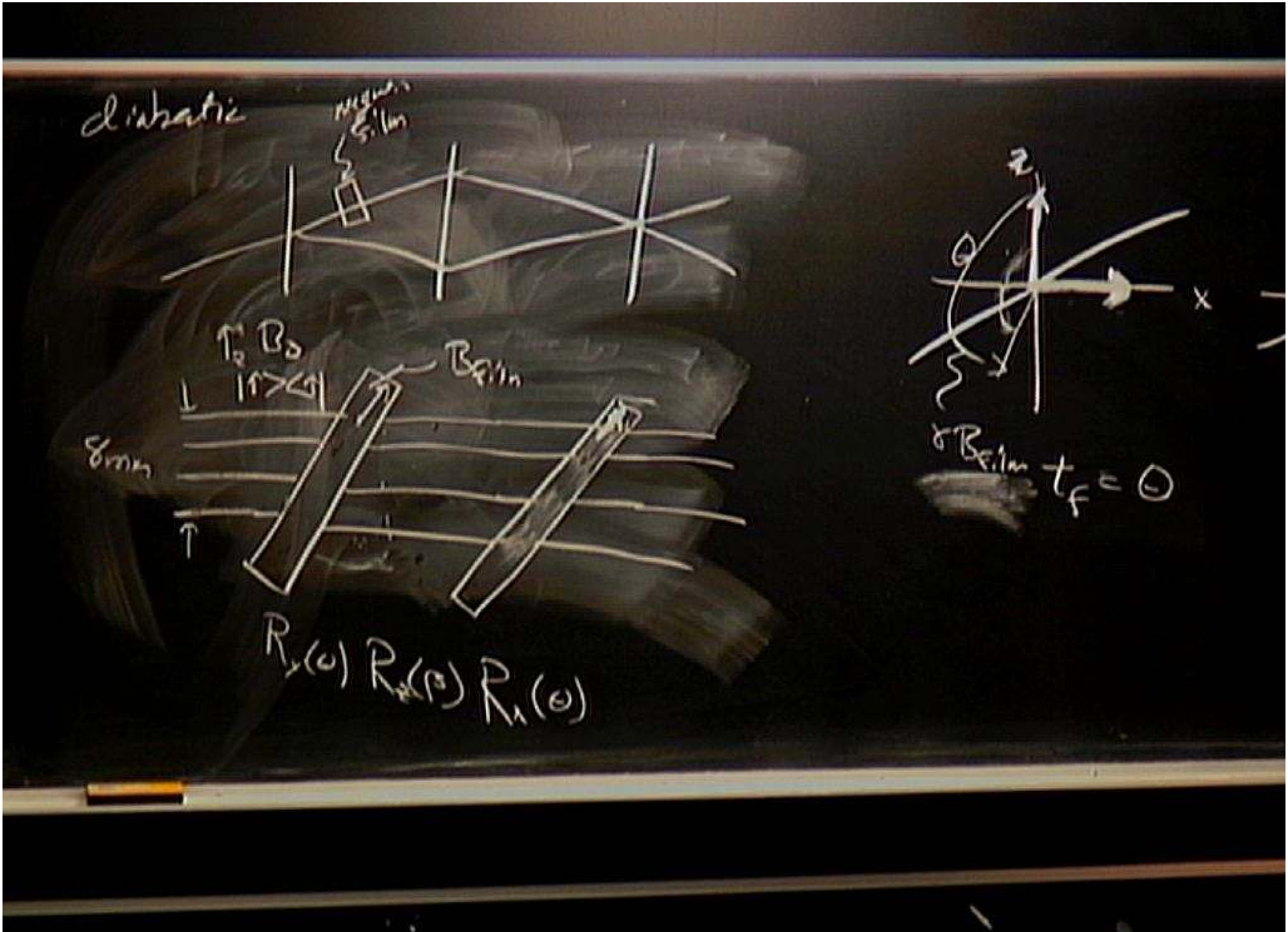
diabatic
B₀
B_film
8mm
t_f = θ


diabatic
B_0
B_{film}
8mm
z
$\delta B_{film} t_f = \Theta$


diabatic
B film
8mm
z
x
t_F = θ


z
θ
x


diabatic
8mm
x
z

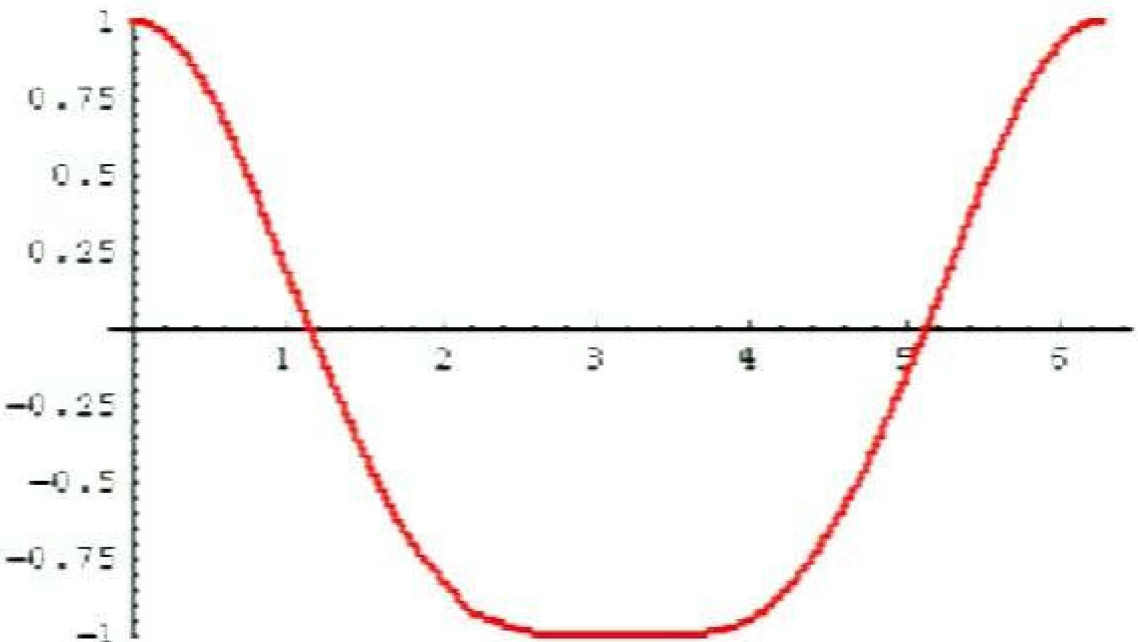

diabatic
8mm
z
x
Rx(θ)

Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help

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]}}]
```



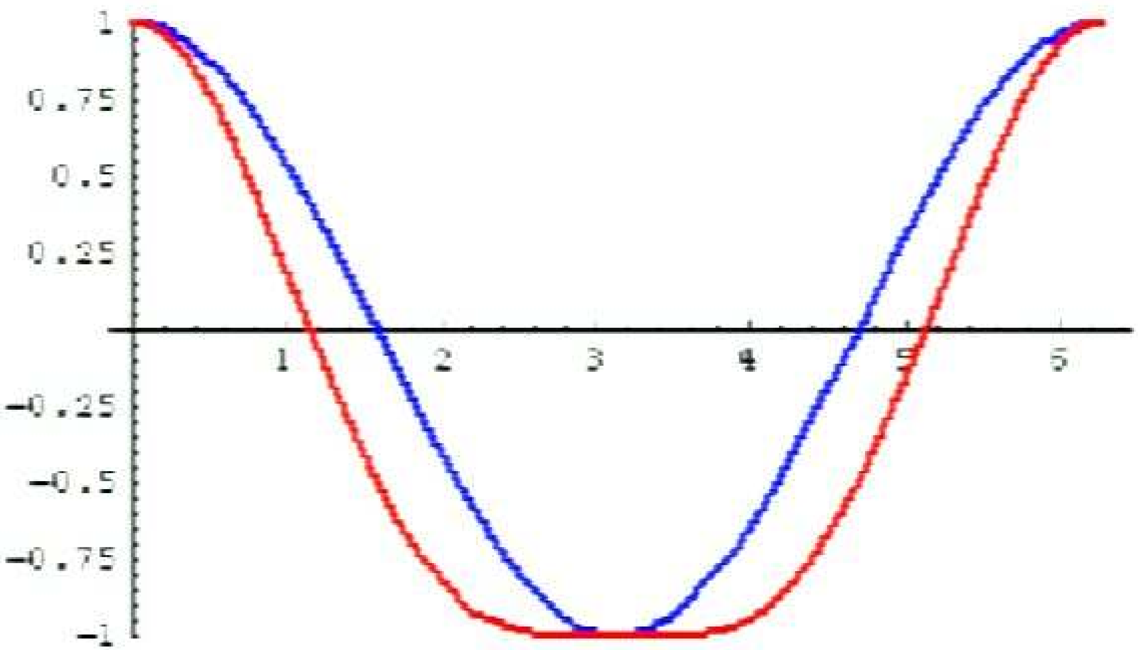
- Graphics -

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


Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help

QE Lec 6 Composite Rot.nb

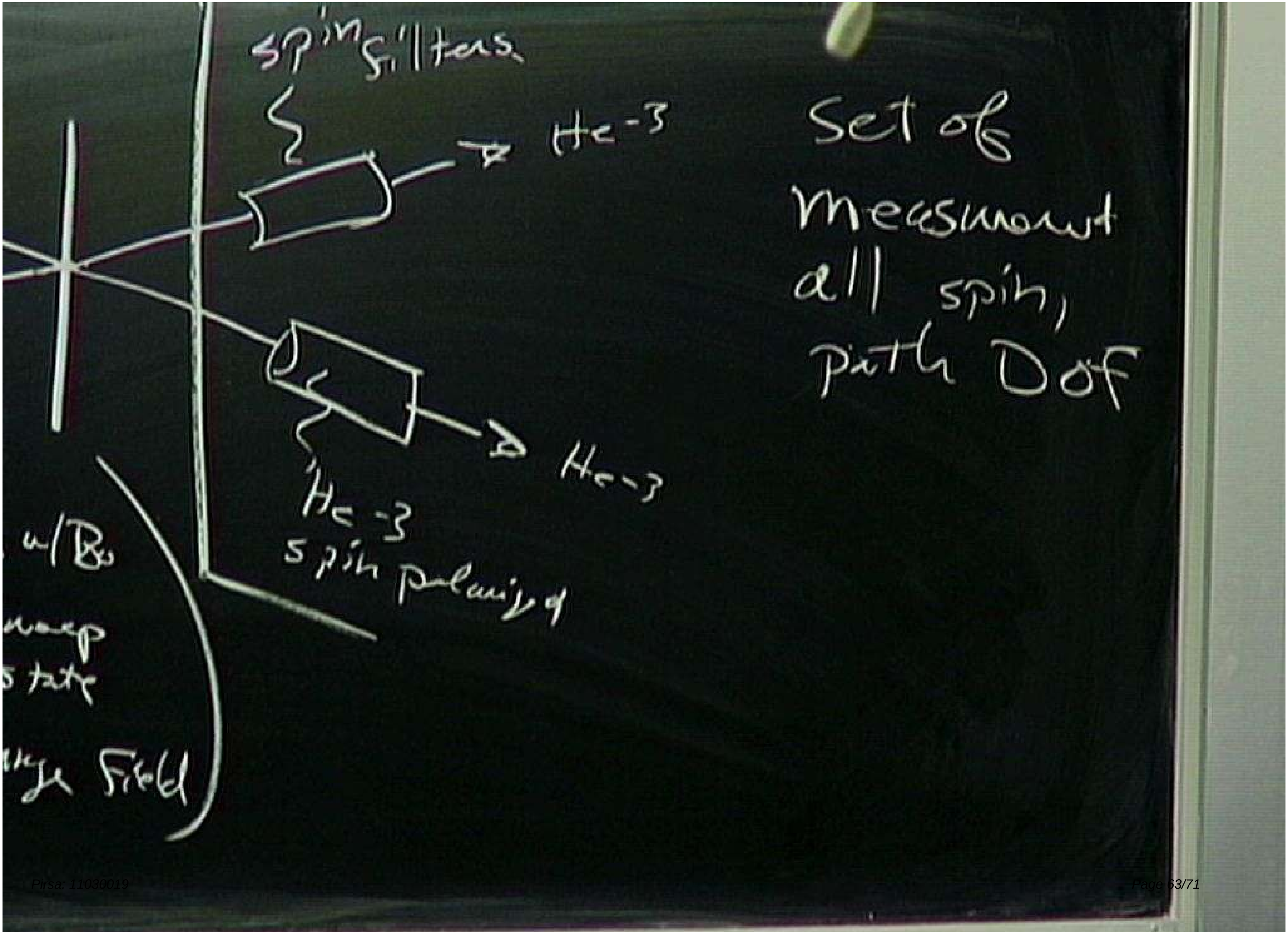
```
Show[p1, p2]
```

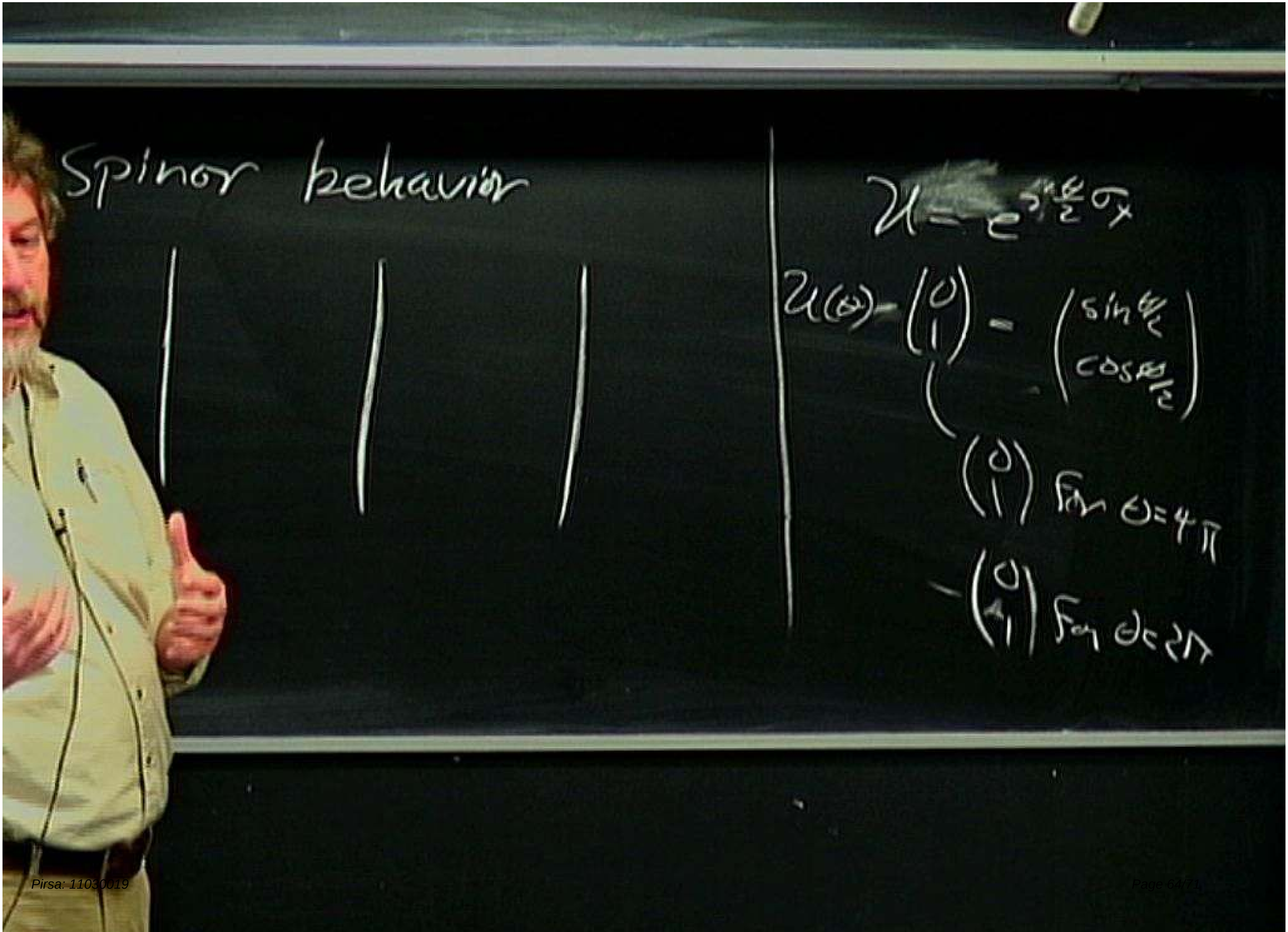


- Graphics -

```
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 polarized
Set of
measurement
all spin,
path DOF
w/ B0
state
Field

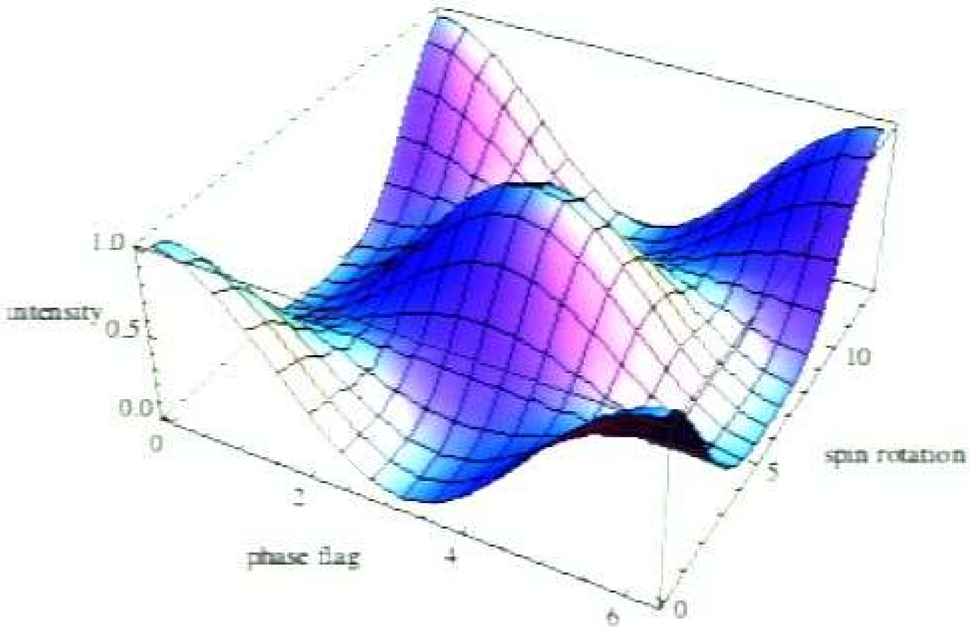

Spinor behavior
U(θ) (0 1) = (sin θ/2 cos θ/2)
(0 1) for θ=4π
−(0 1) for θ=2π

Mathematica File Edit Insert Format Cell Graphics Evaluation Palettes Window Help

QE Lec 6.nb

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

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



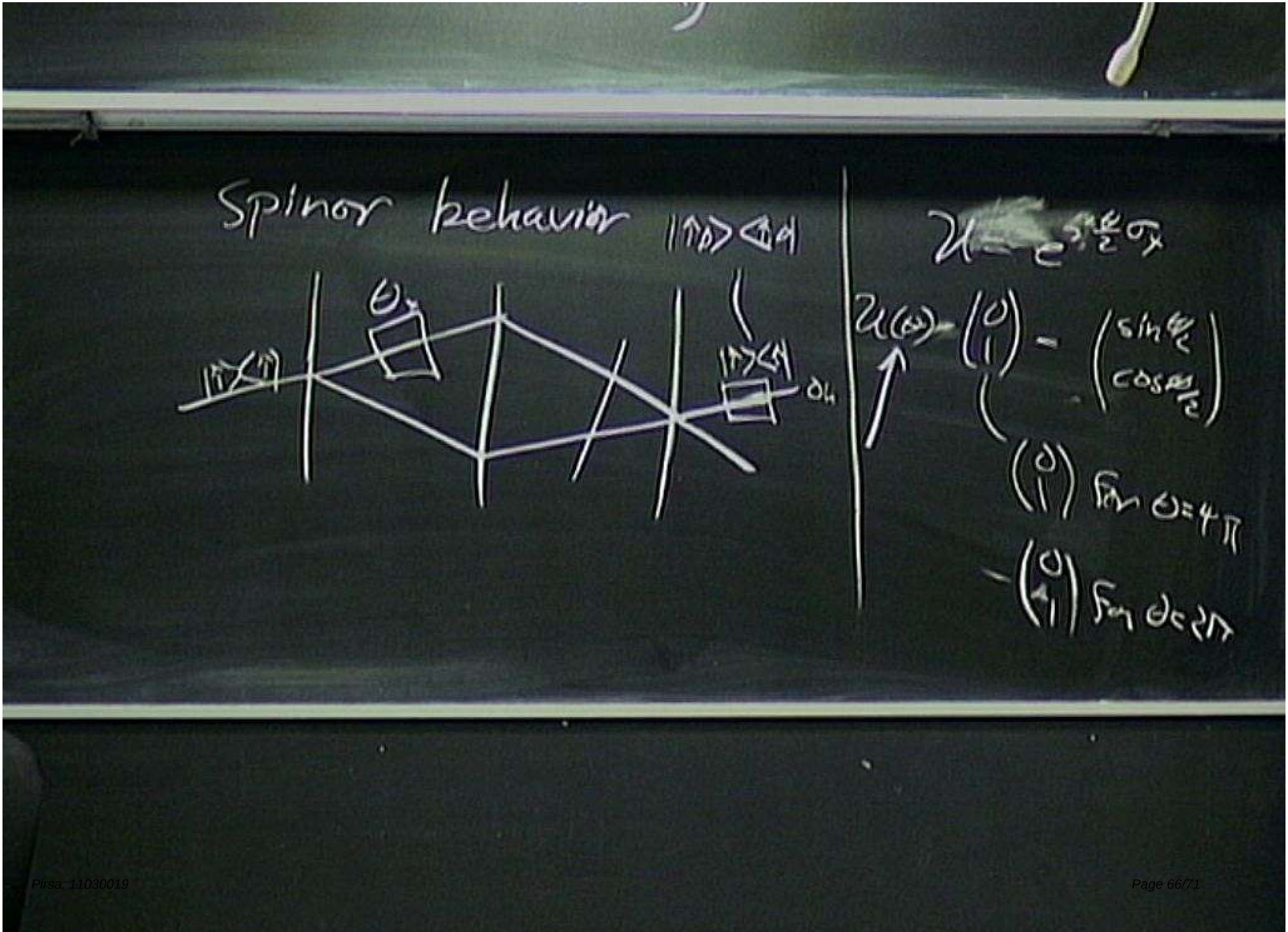
H-Beam with spin up filter

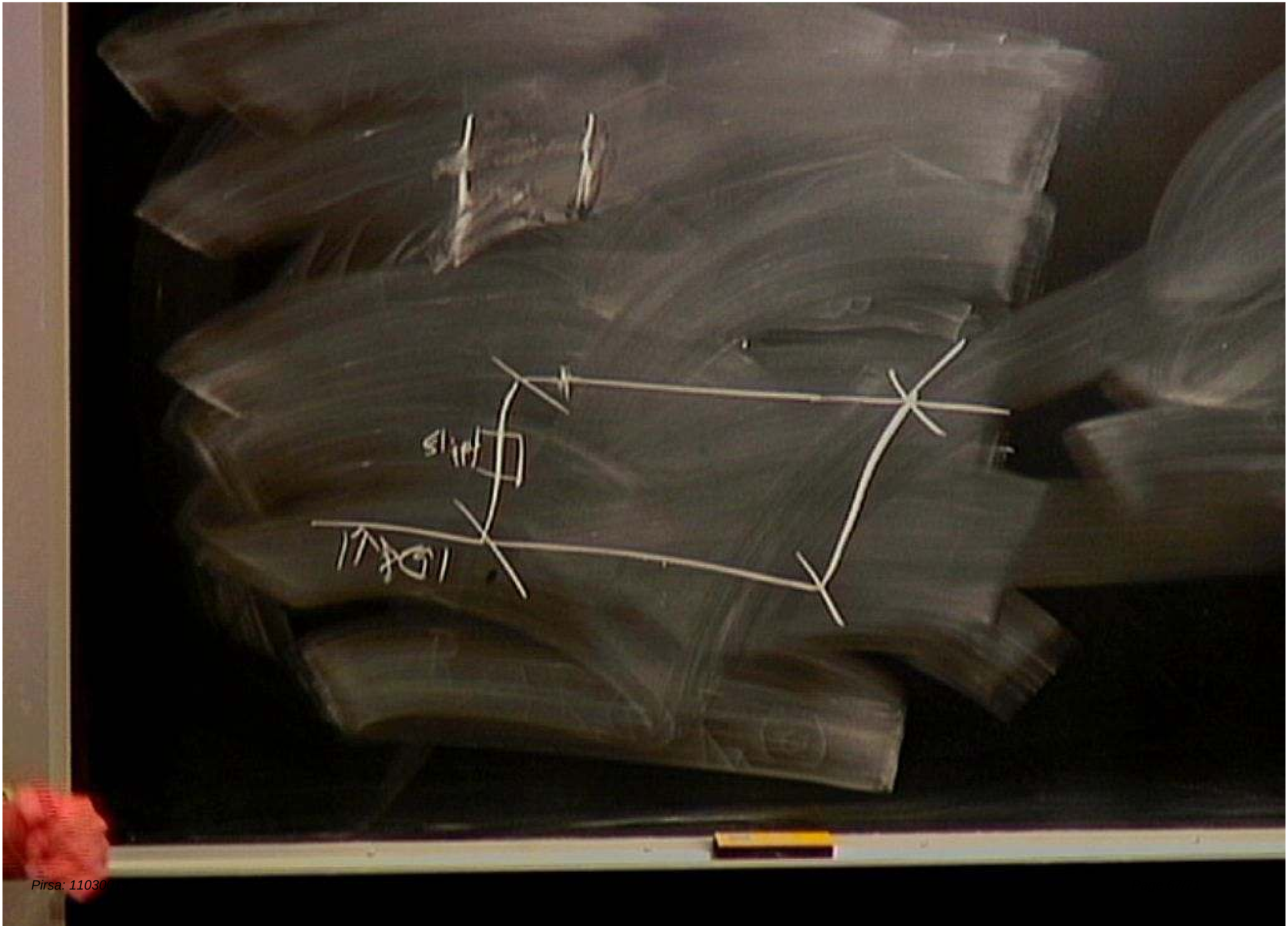
```
MHup[t_, a_] := Tr[Uzpdown . resls[t, a]]
```

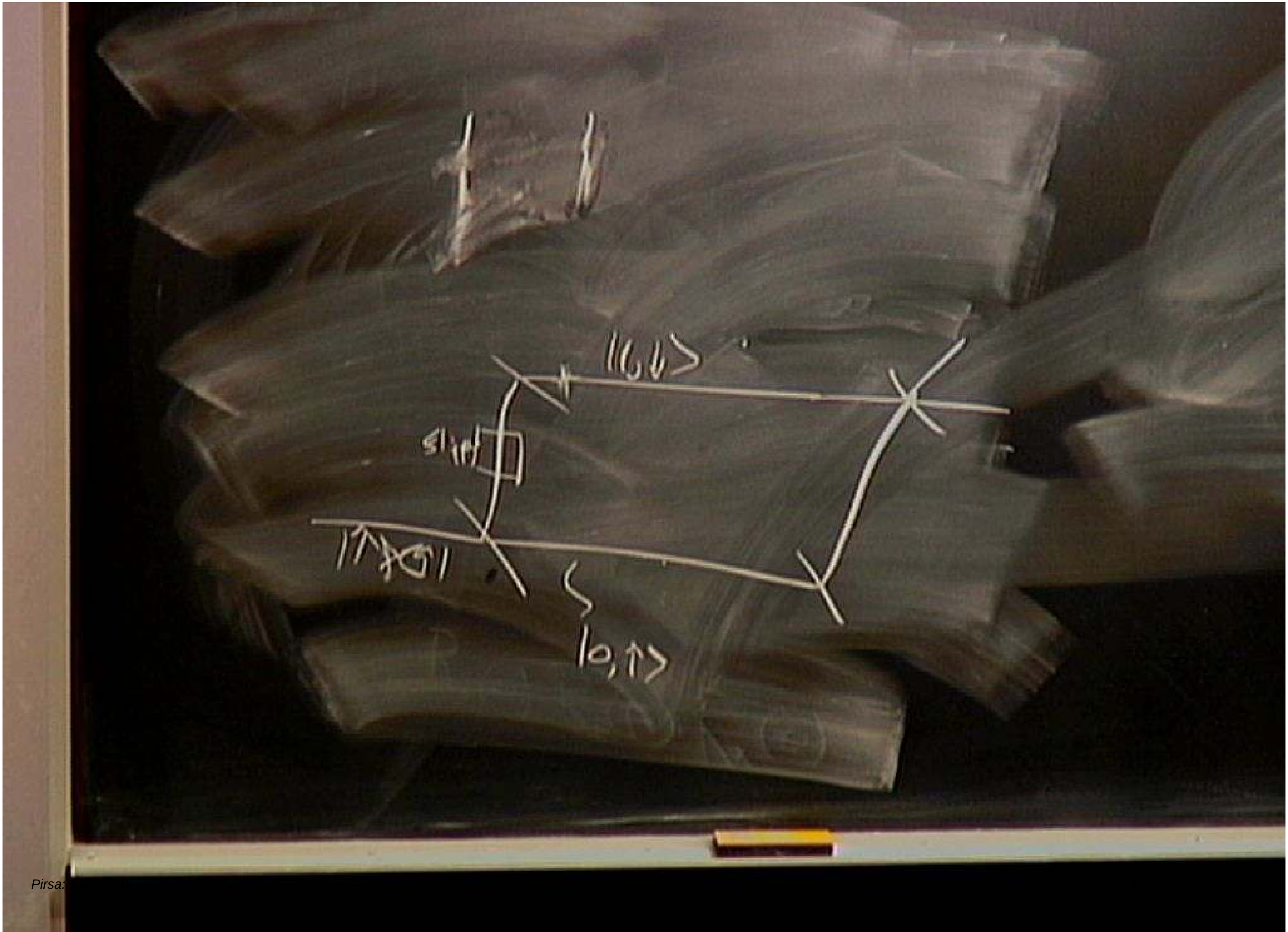
```
MHup[t, a]
```

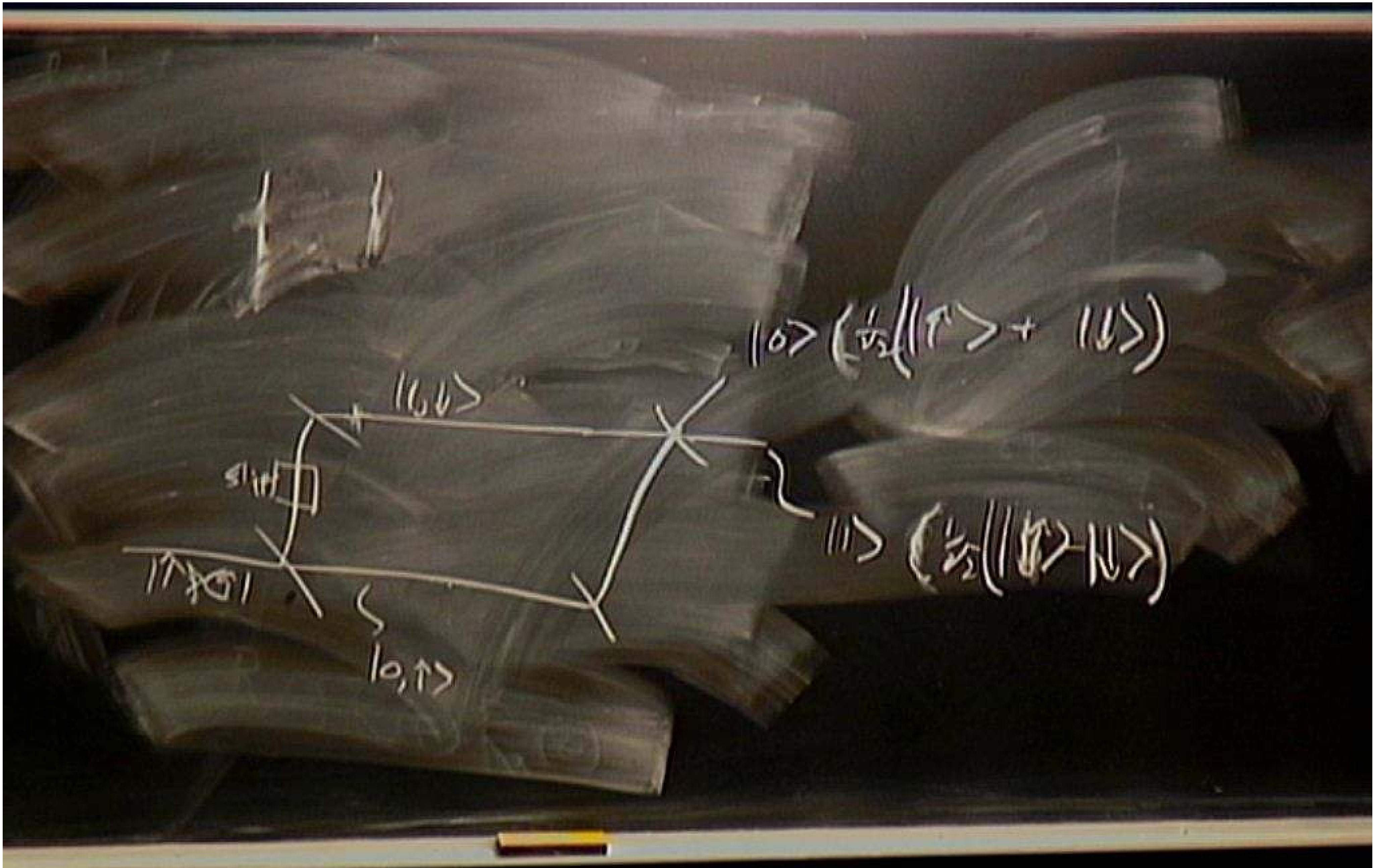
$\frac{1}{8}\left(3 - 2\,\mathrm{Cos}\left[a - \frac{t}{2}\right] - 2\,\mathrm{Cos}\left[a + \frac{t}{2}\right] - \mathrm{Cos}[t]\right)$

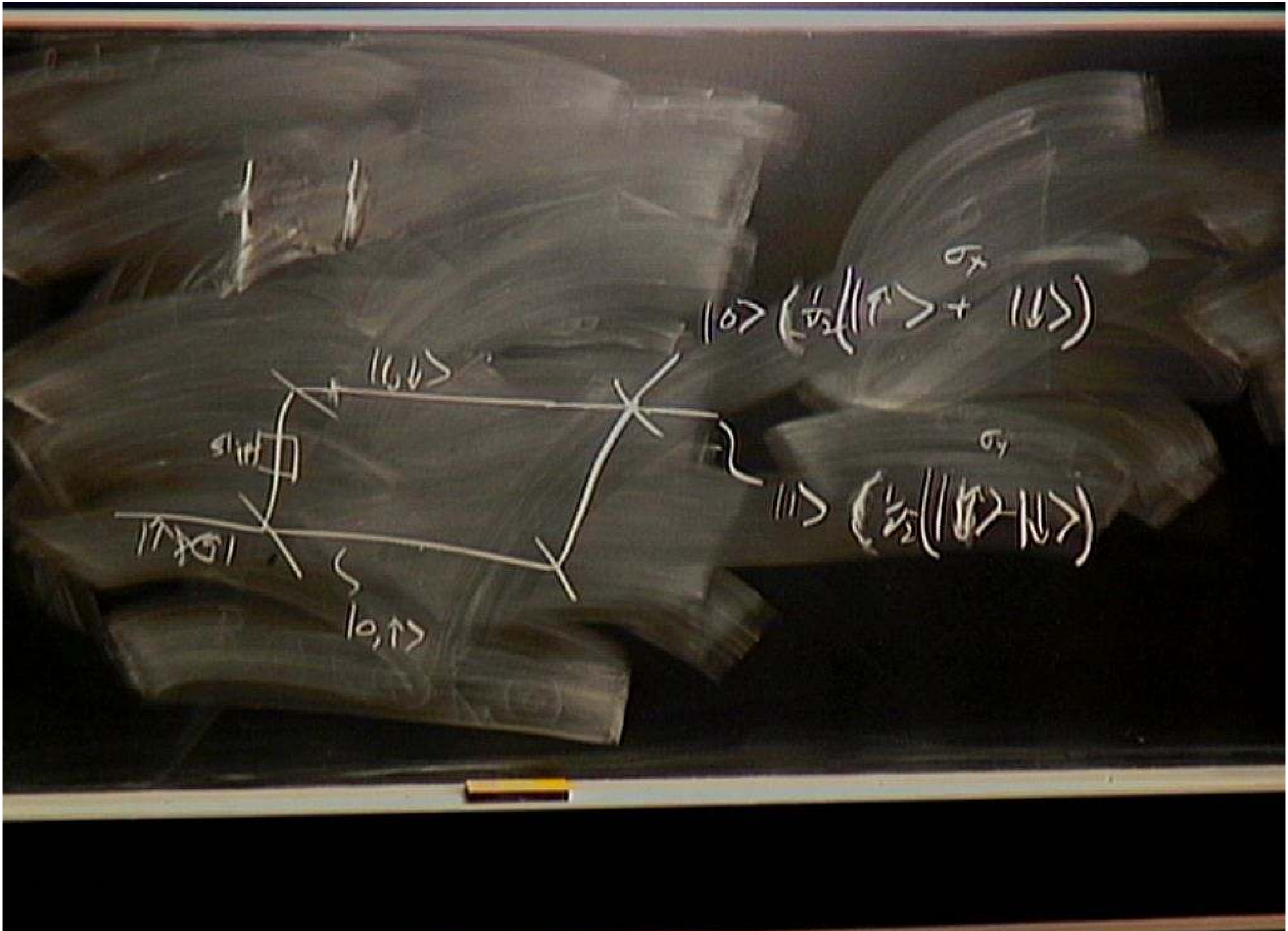
```
Plot3D[MHup[t, a], {a, 0, 2 π}, {t, 0, 4 π},
 {AxesLabel → {"phase flag", "spin rotation", "intensity"}}]
```


Spinor behavior
for θ=4π
for θ=2π

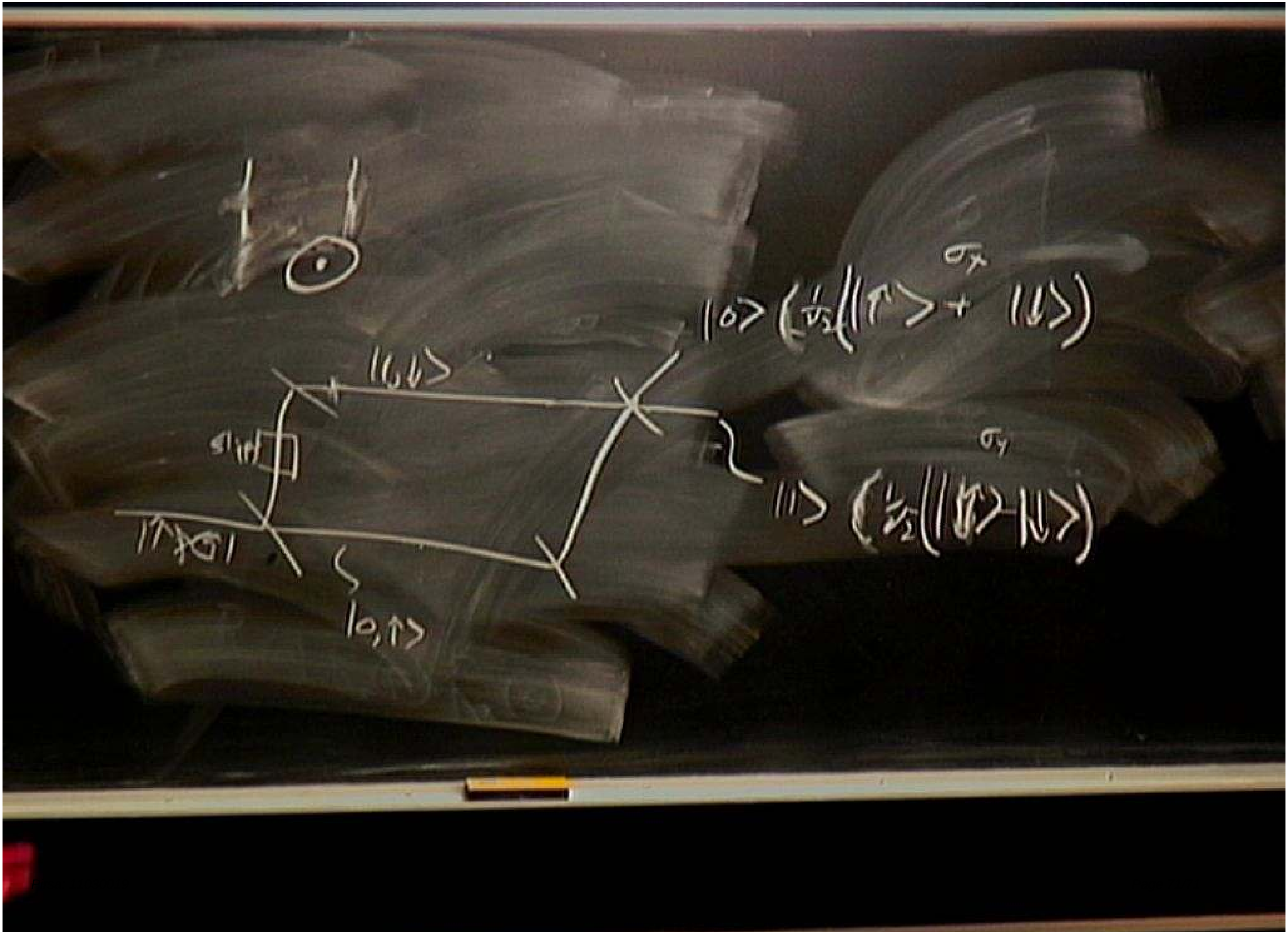



|1,↓>
|0,↑>


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



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


σ_x
$|0\rangle \left(\frac{1}{\sqrt{2}}(|\uparrow\rangle + |\downarrow\rangle)\right)$
$|1,\downarrow\rangle$
σ_y
$|1\rangle \left(\frac{1}{\sqrt{2}}(|\uparrow\rangle - |\downarrow\rangle)\right)$
$|0,\uparrow\rangle$