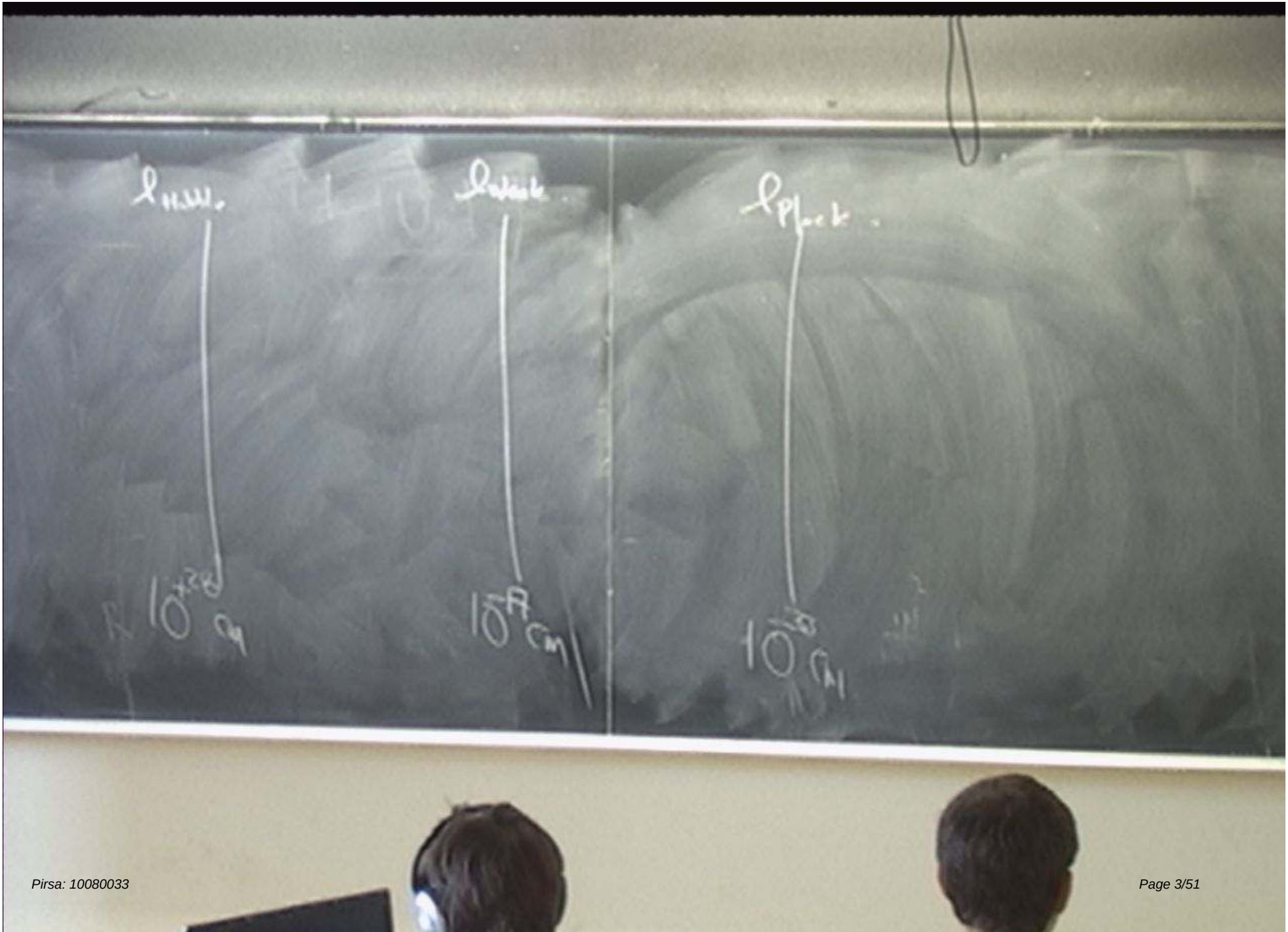
Title: PSI 2010 - Theoretical Physics - Lecture 1B

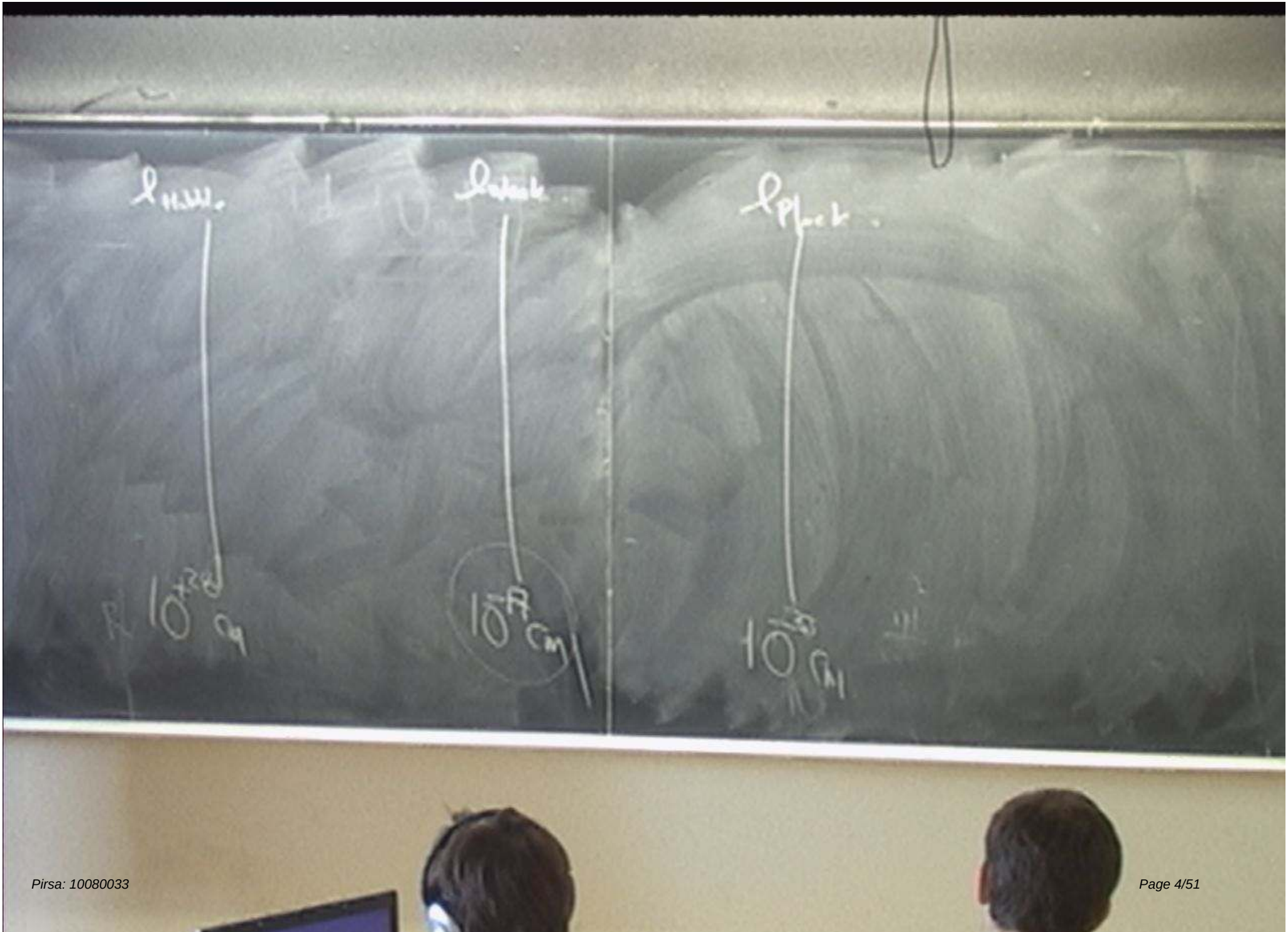
Date: Aug 23, 2010 10:30 AM

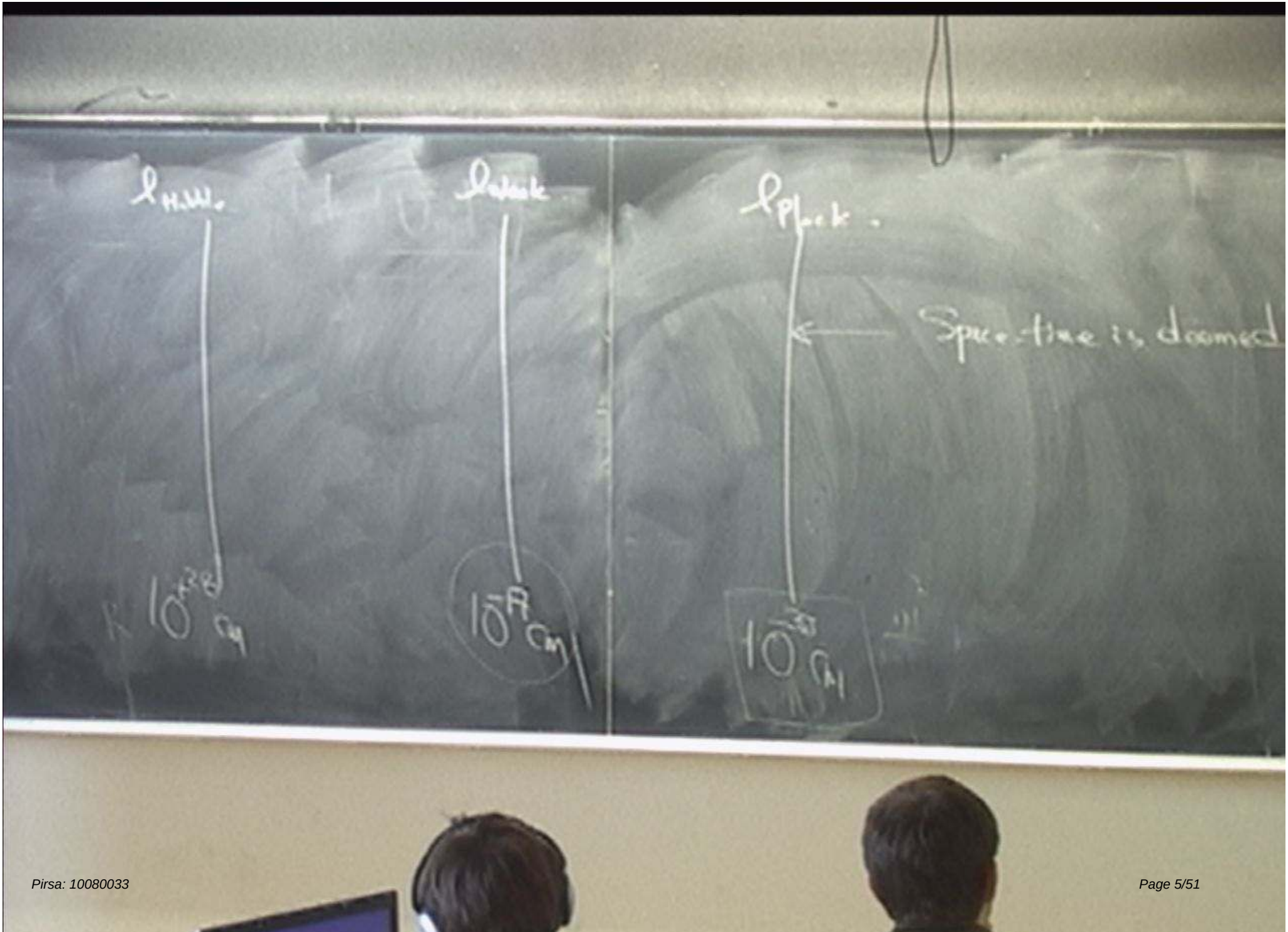
URL: http://pirsa.org/10080033

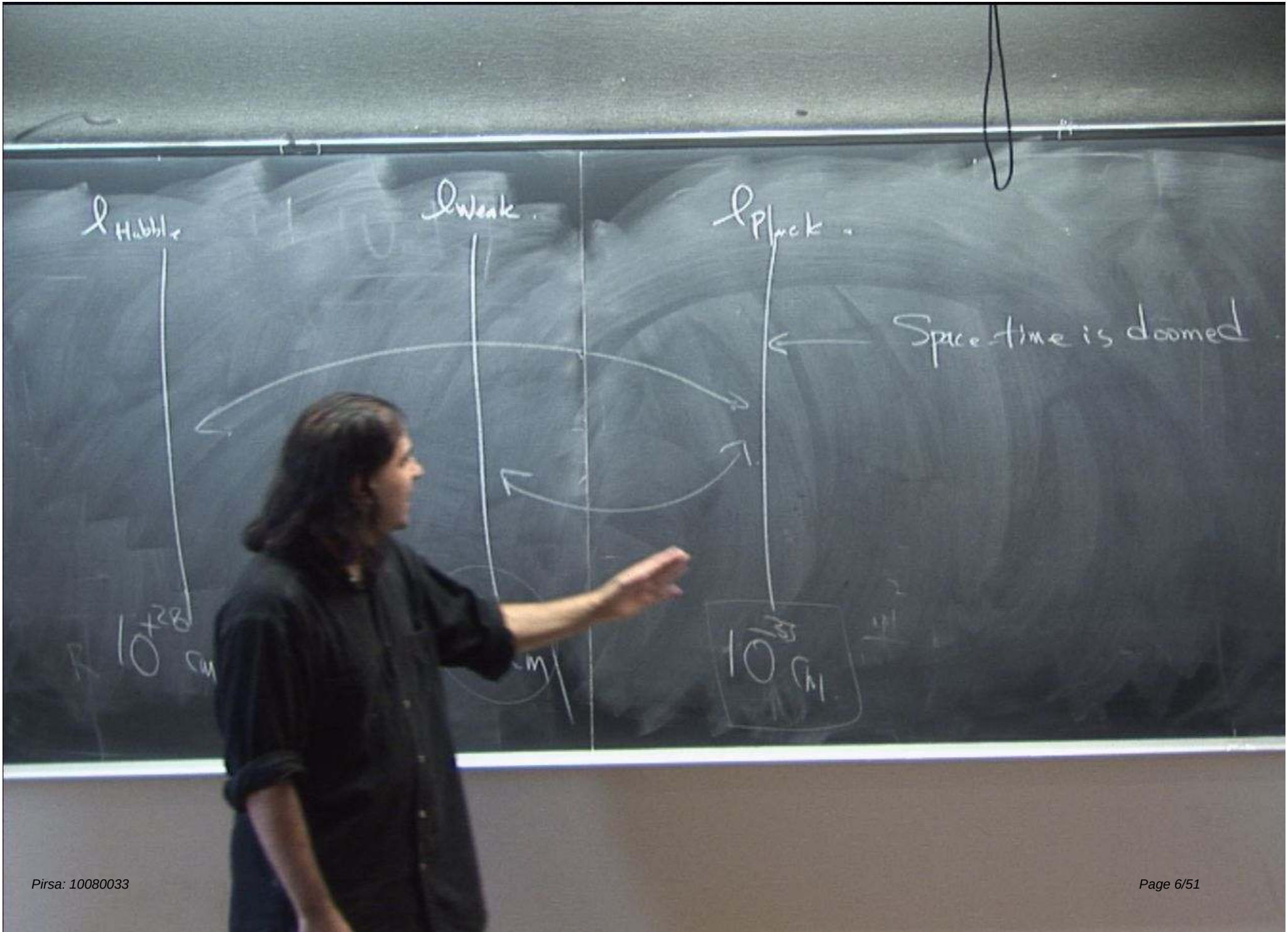
Abstract:

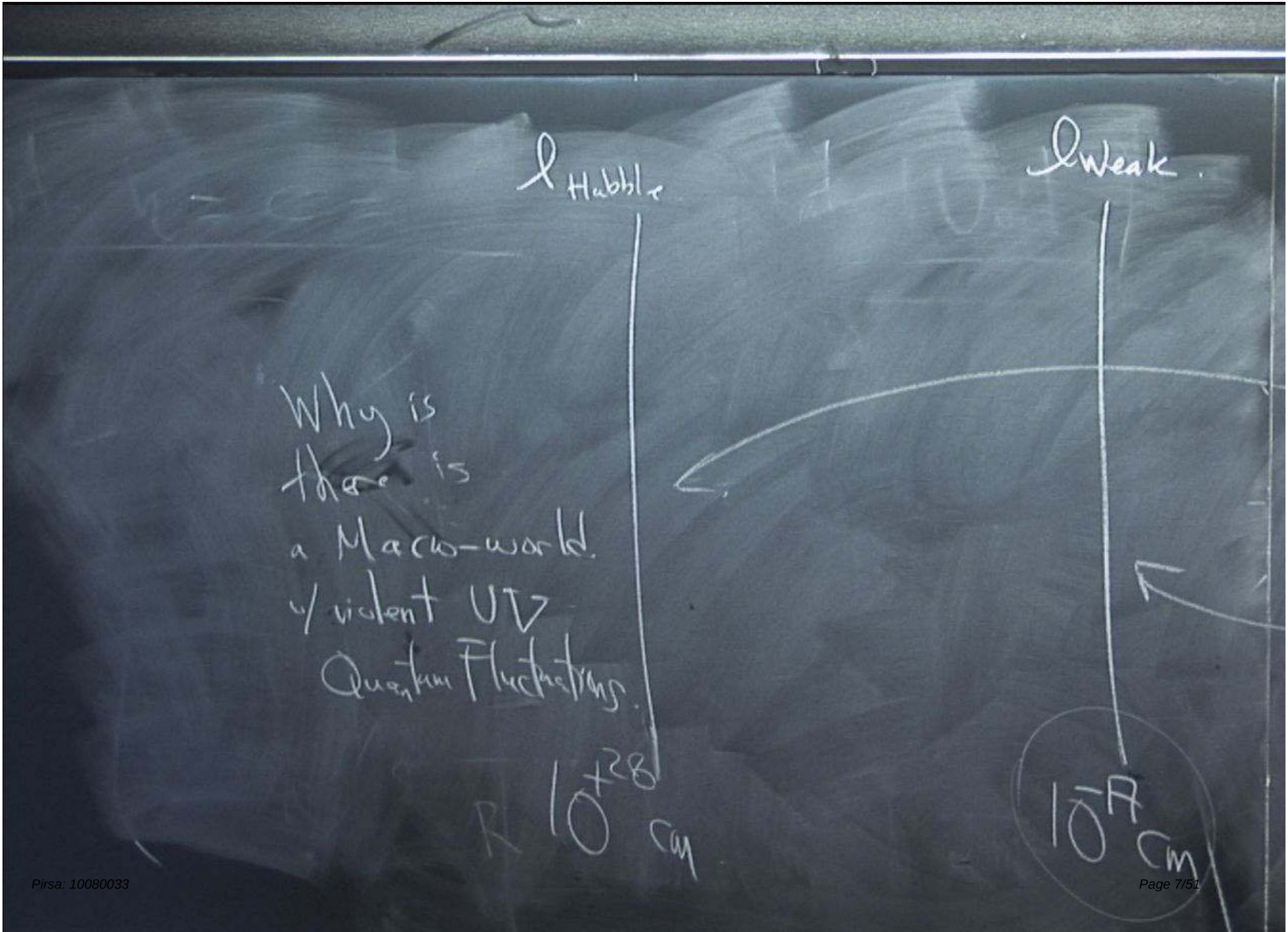
PERIMETER INSTITUTE FOR THEORETICAL PHYSICS



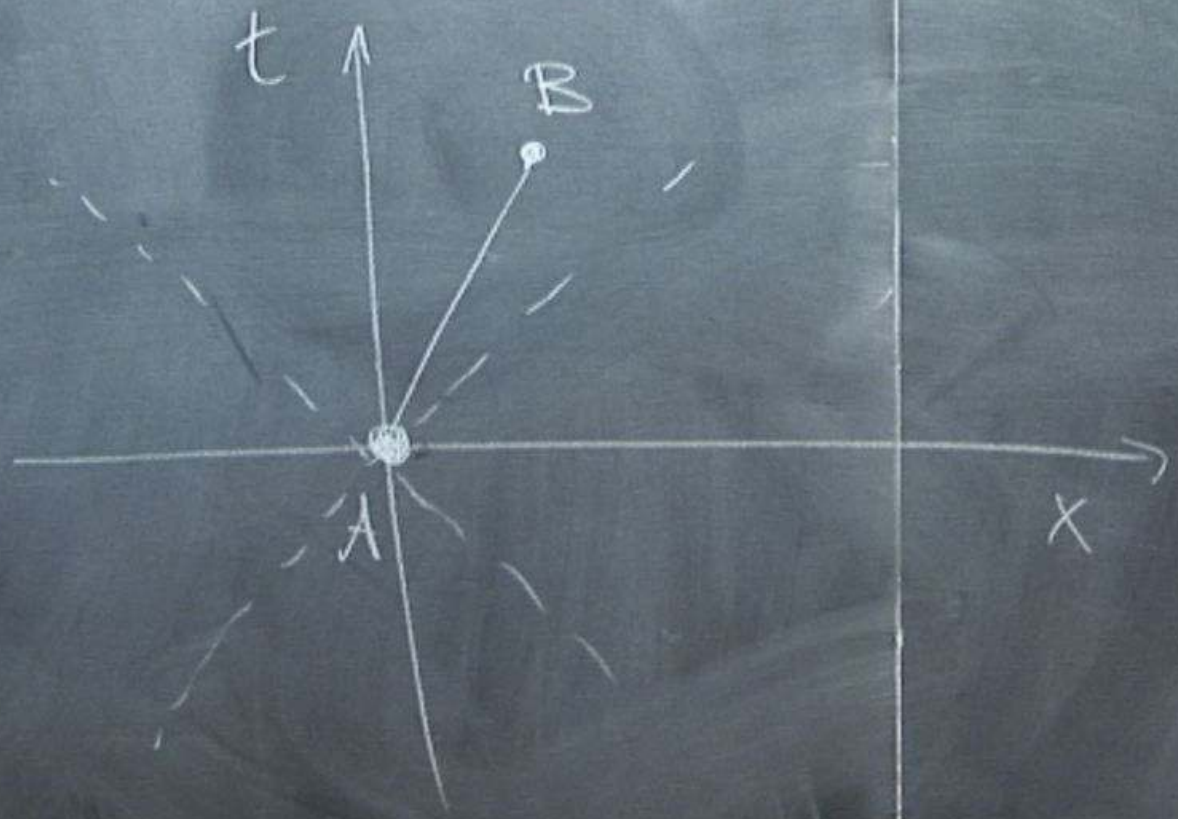



Space-time is doomed

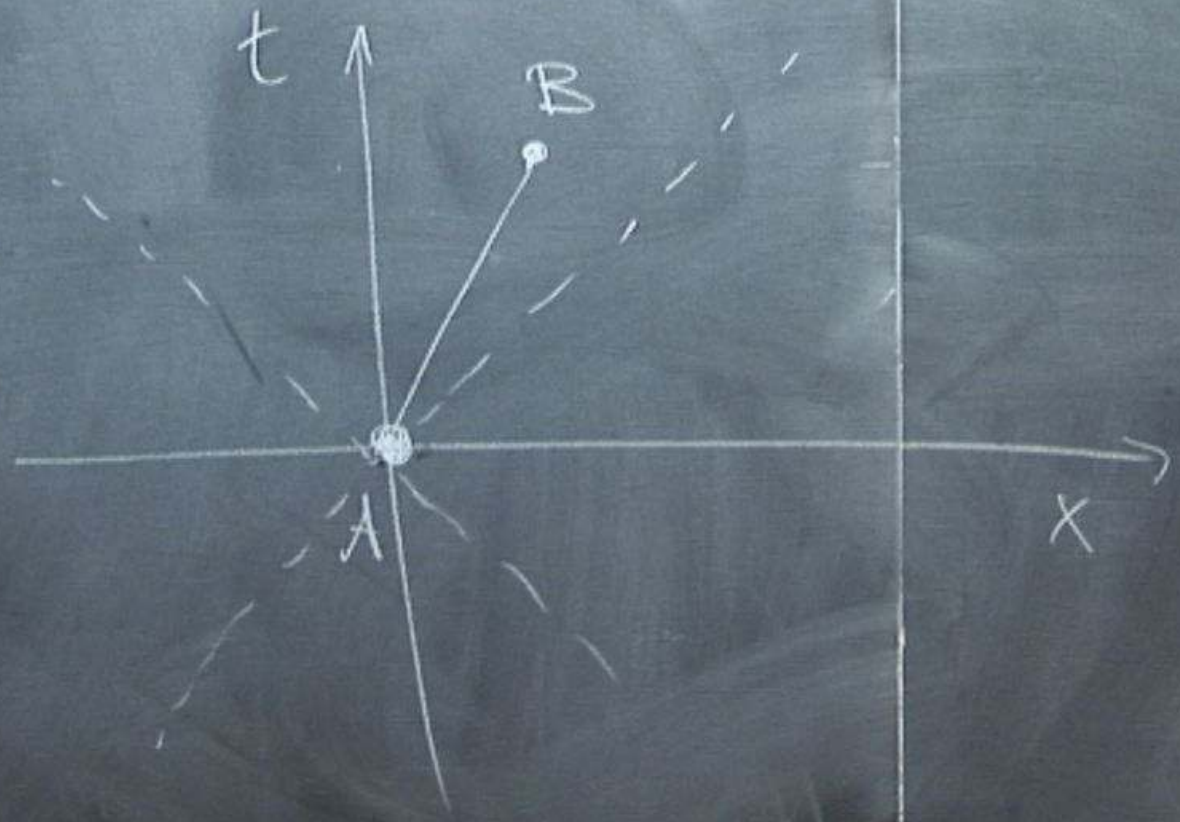

ℓ_{Hubble}
ℓ_{Weak}
ℓ_{Planck}
Space-time is doomed
10^{+28} cm
10^{-33} cm

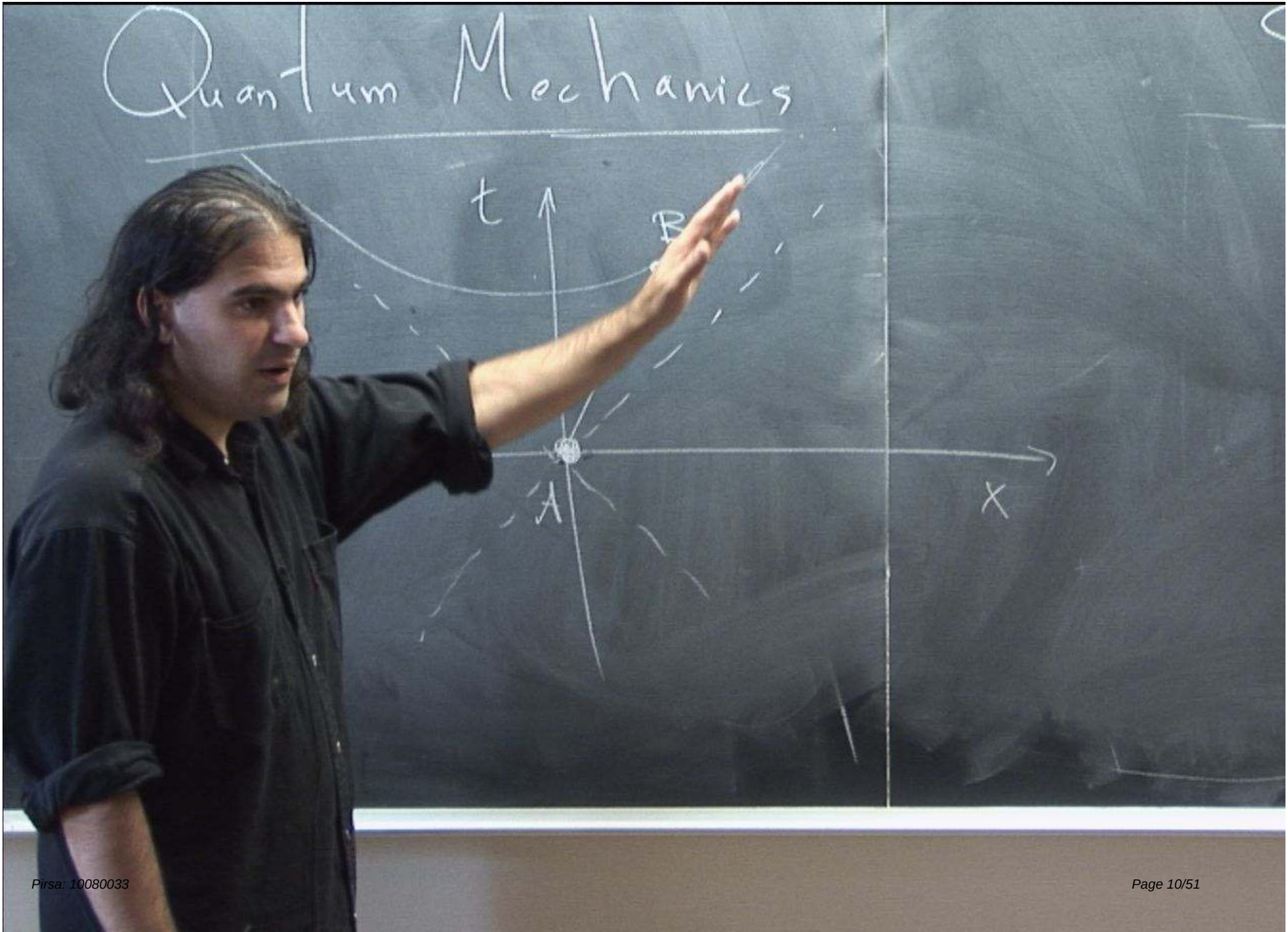

ℓ_{Hubble}
ℓ_{weak}
Why is there is a Macro-world w/ violent UV Quantum Fluctuations.
10^{+28} cm
10^{-8} cm

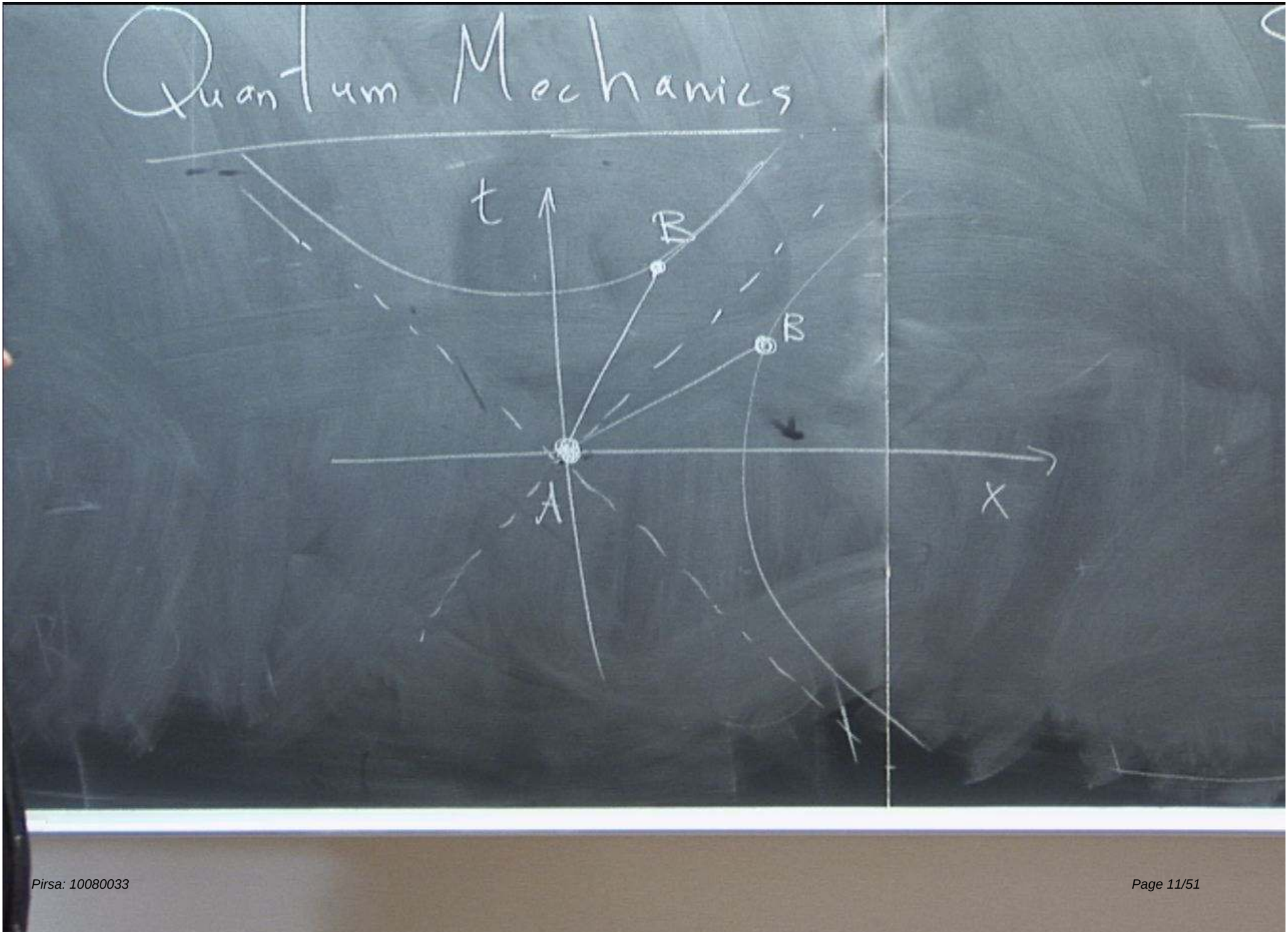
Quantum Mechanics

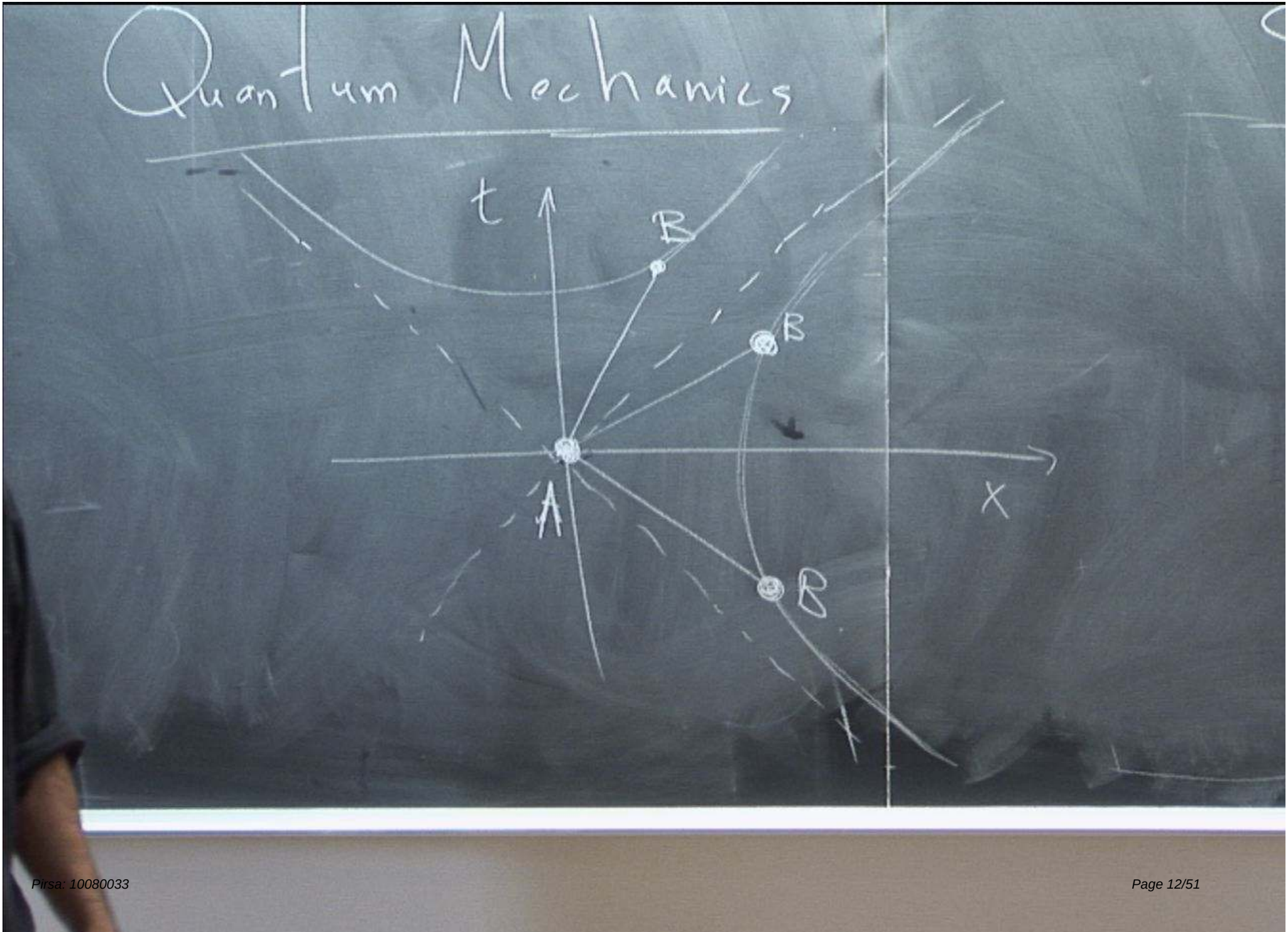


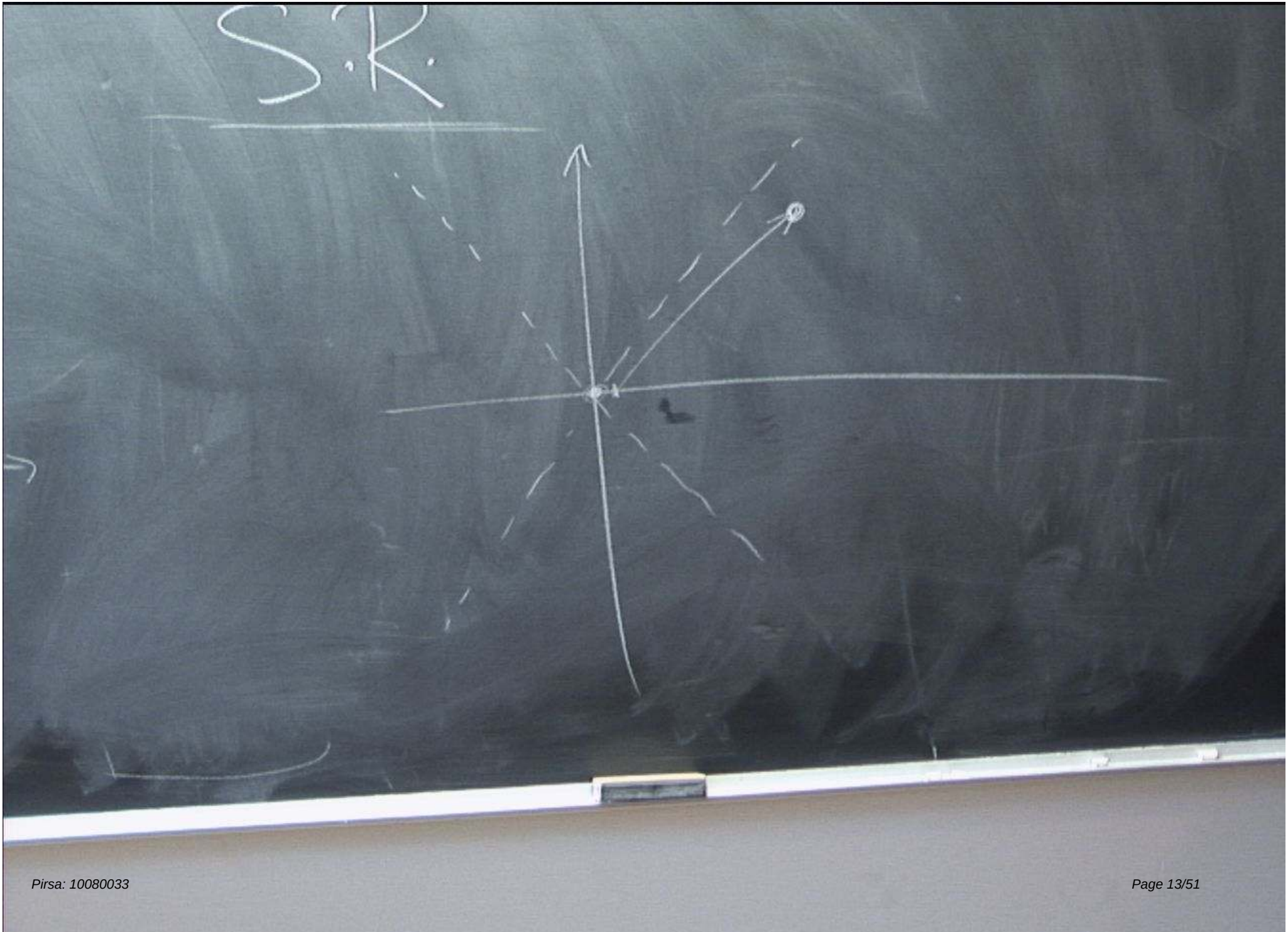
Quantum Mechanics

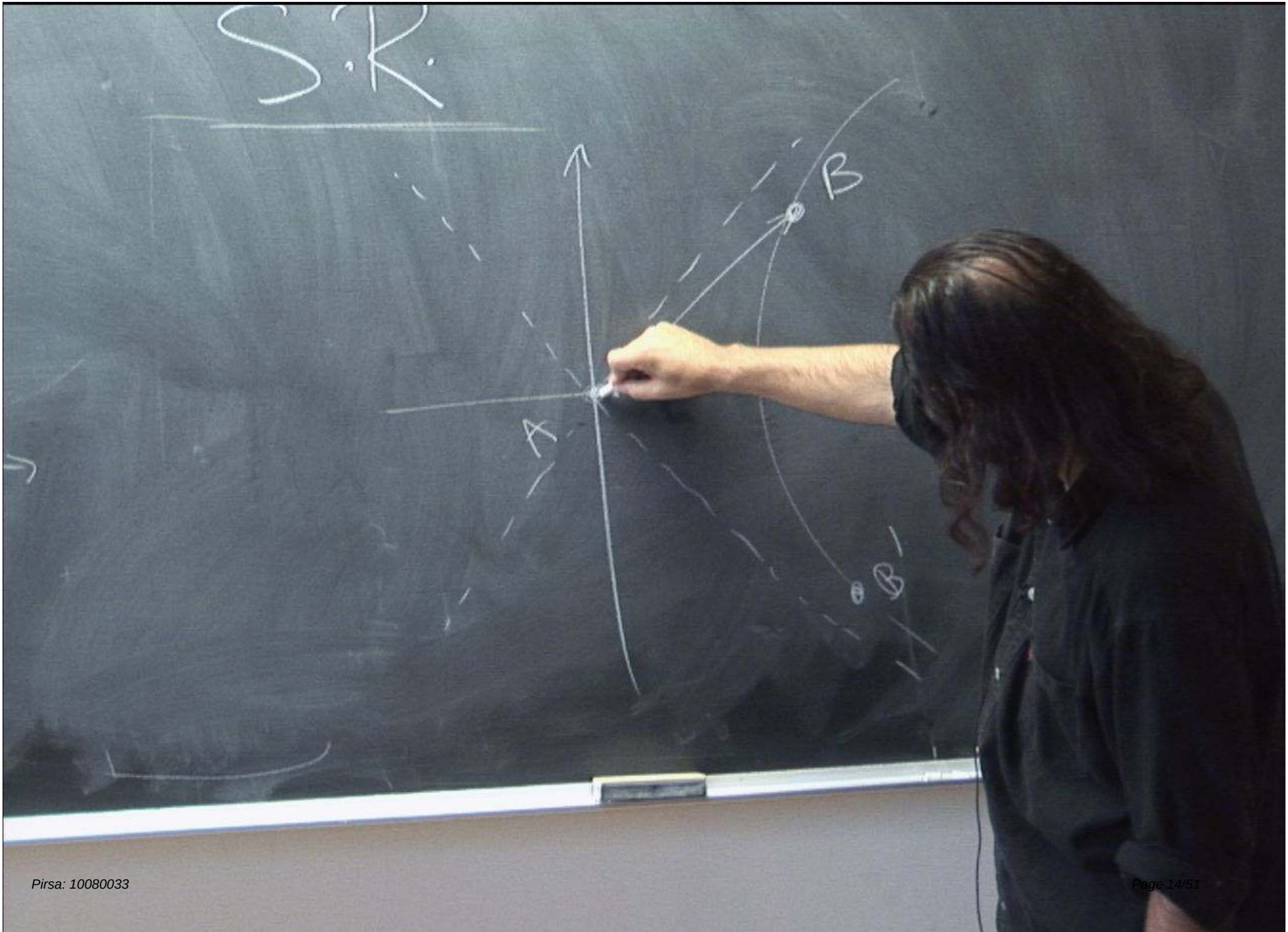


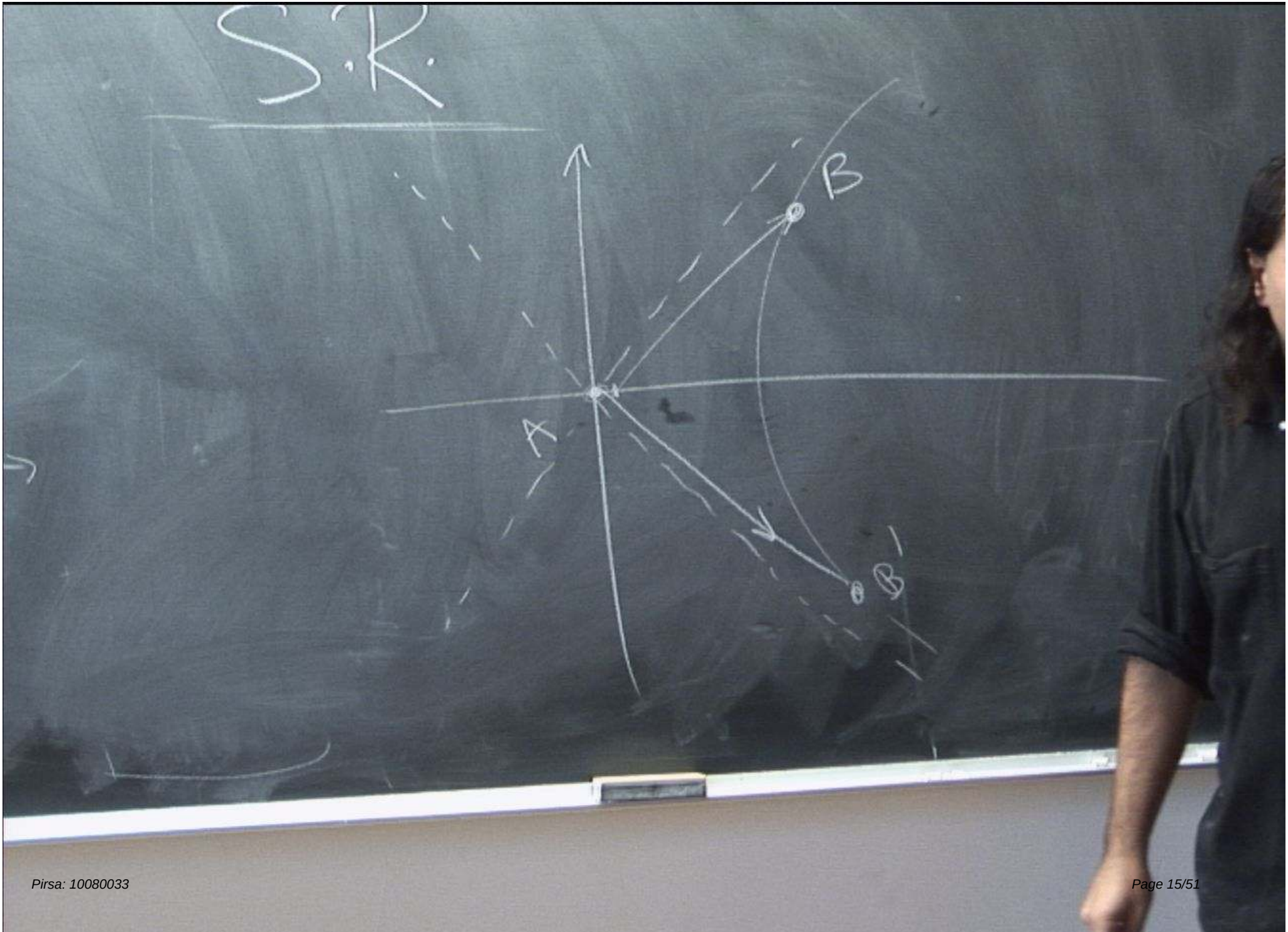

Quantum Mechanics
t
B
A
x

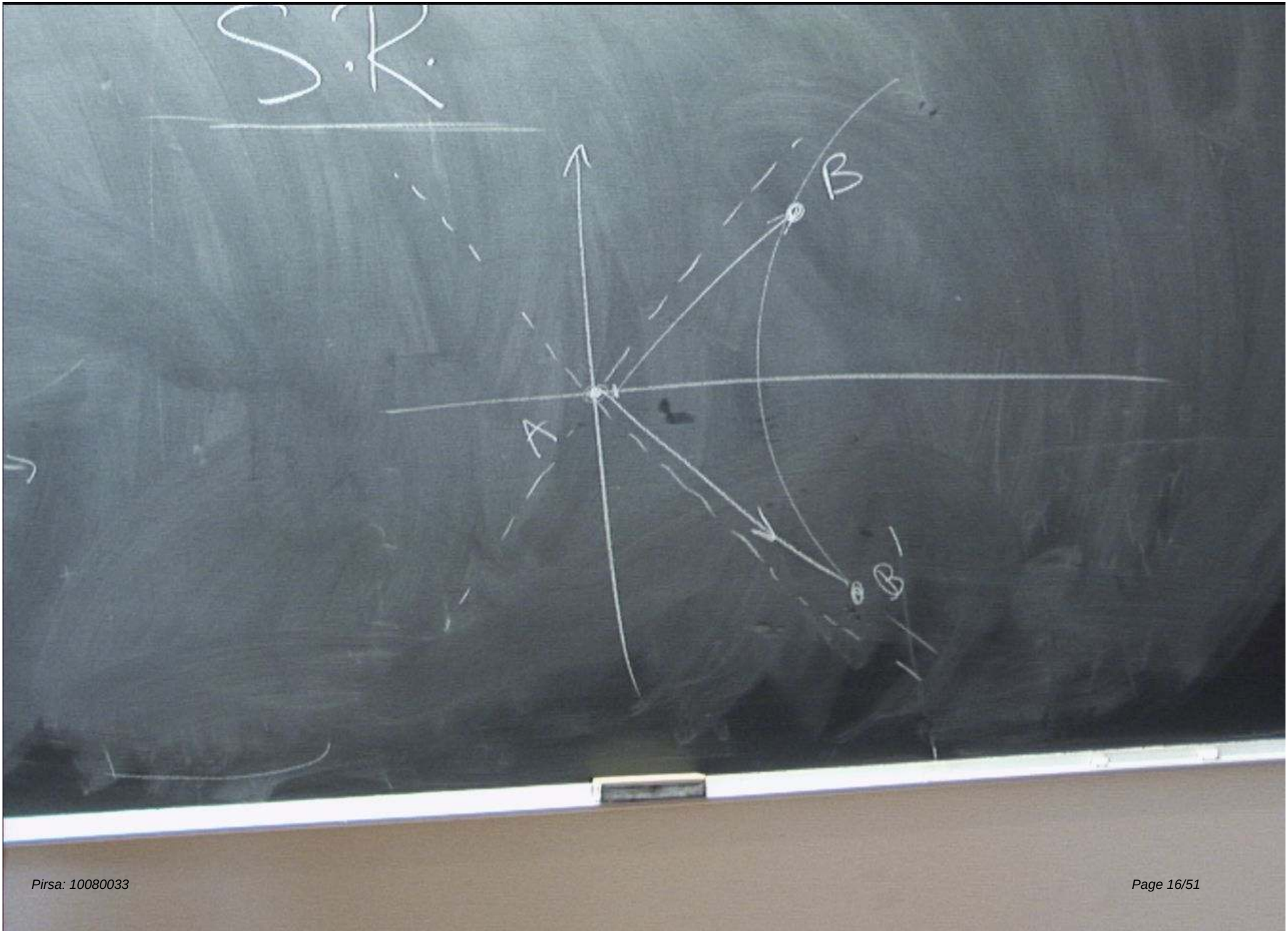

Quantum Mechanics
t
B
B
A
X

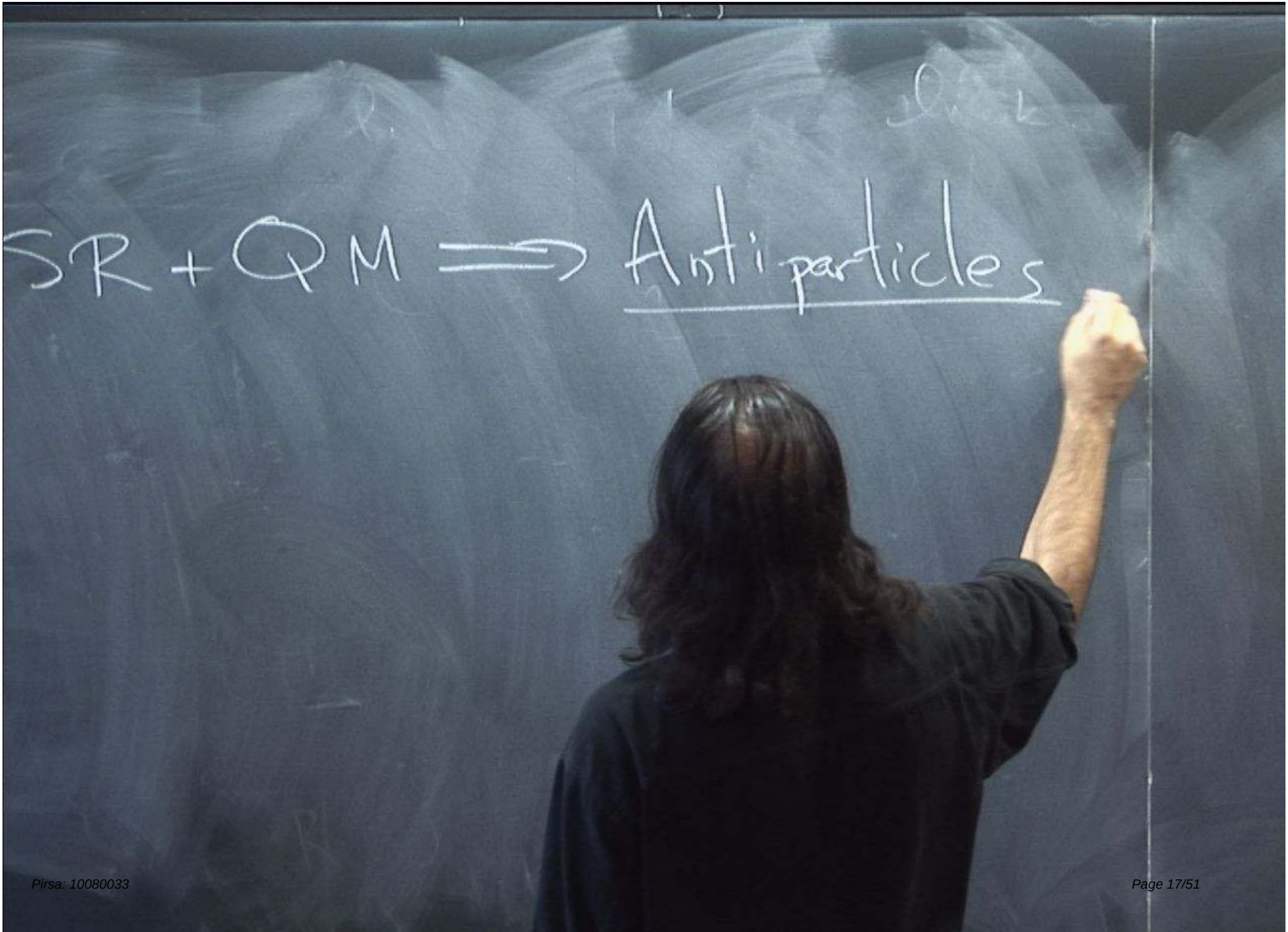

Quantum Mechanics
t
B
B
B
A
X


S.R.


S.R.
B
A
B

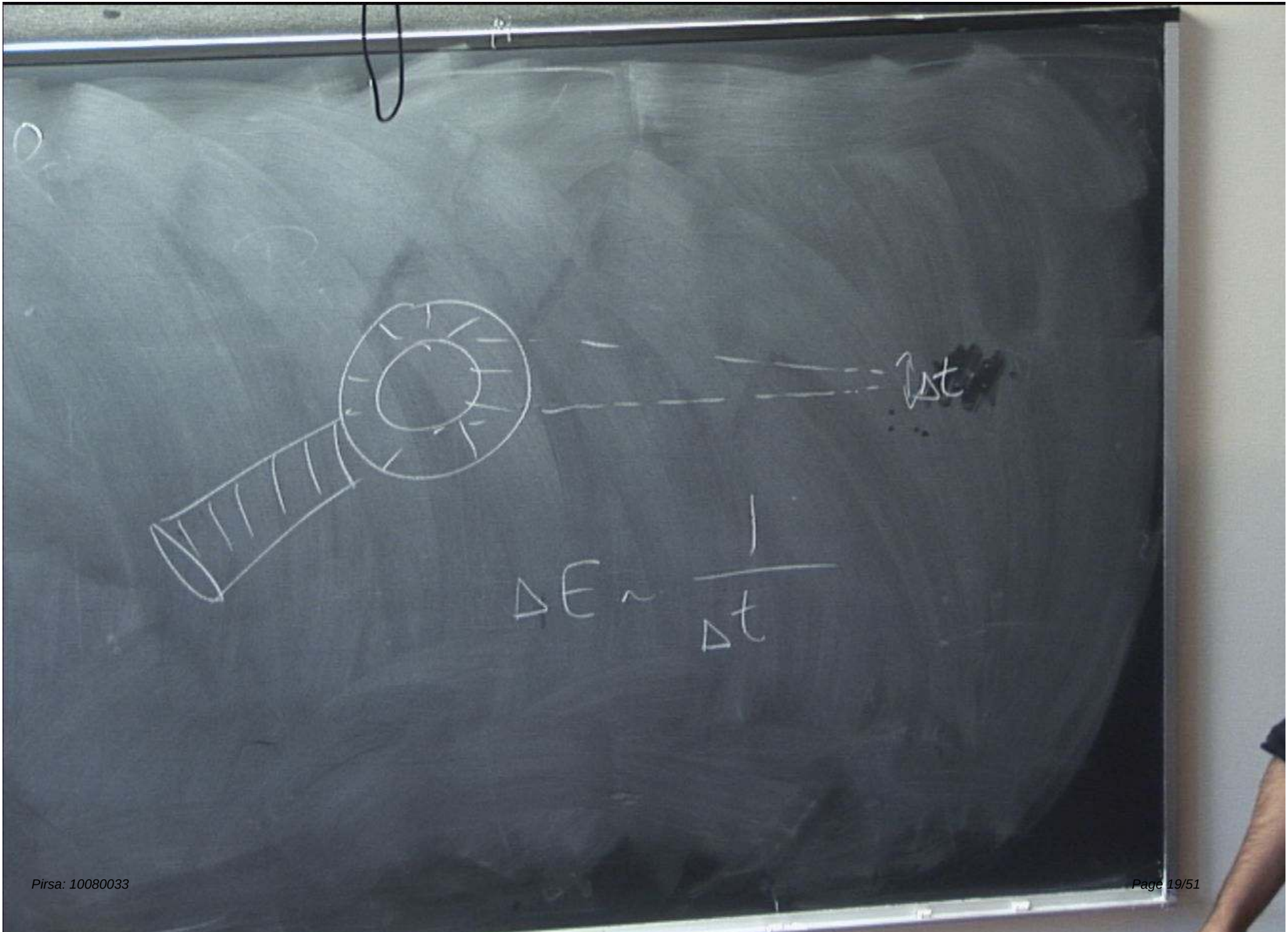

S.R.
B
A
B'


S.R.
B
A
B'


SR + QM ⟹ Anti-particles

SR + QM $\Longrightarrow$ Anti-particles

$\Longrightarrow$ Vacuum is exciting!

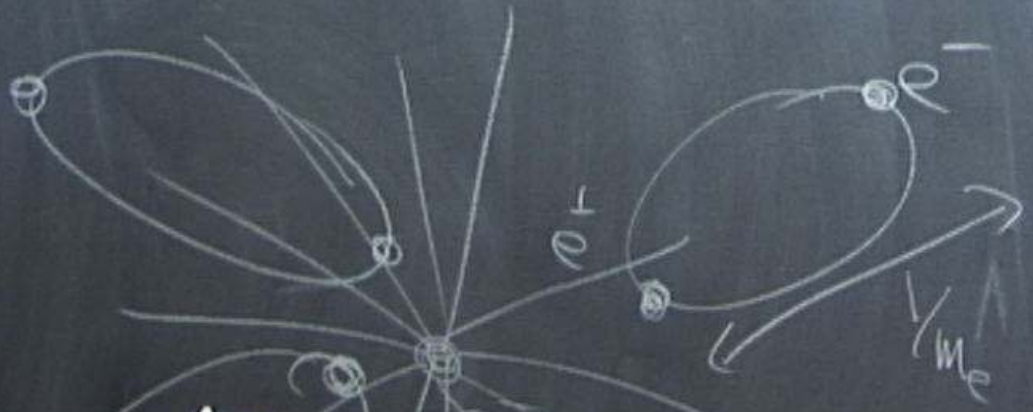

Δt
$\Delta E \sim \frac{1}{\Delta t}$

$$\Delta E \sim \frac{1}{\Delta t}$$

$$\Delta E \geq 2m_e \qquad \Delta t \sim \frac{1}{m_e}$$

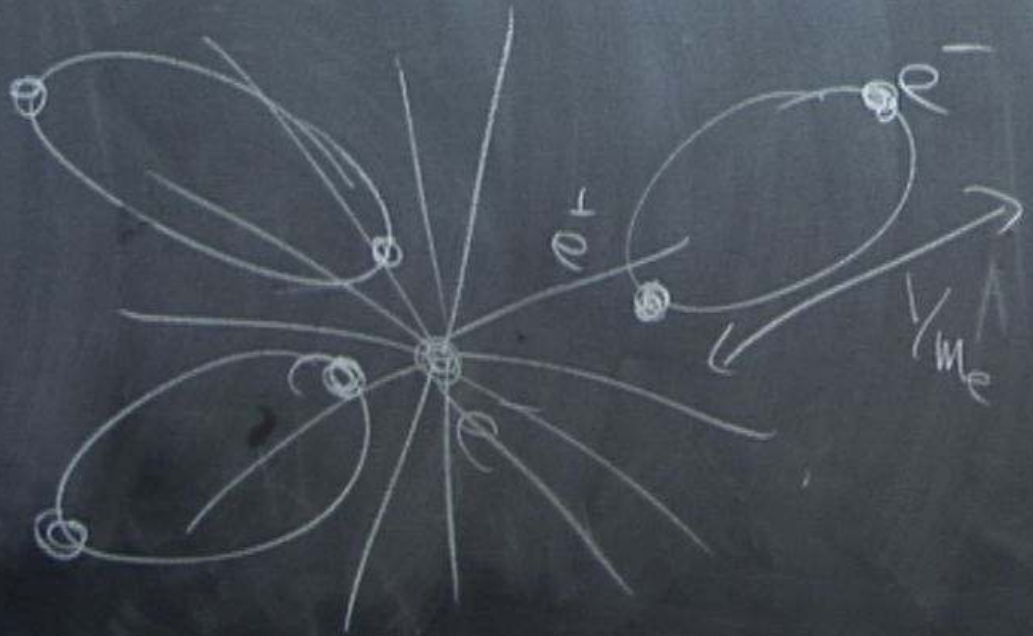
SR + QM ⟹ Anti-particles

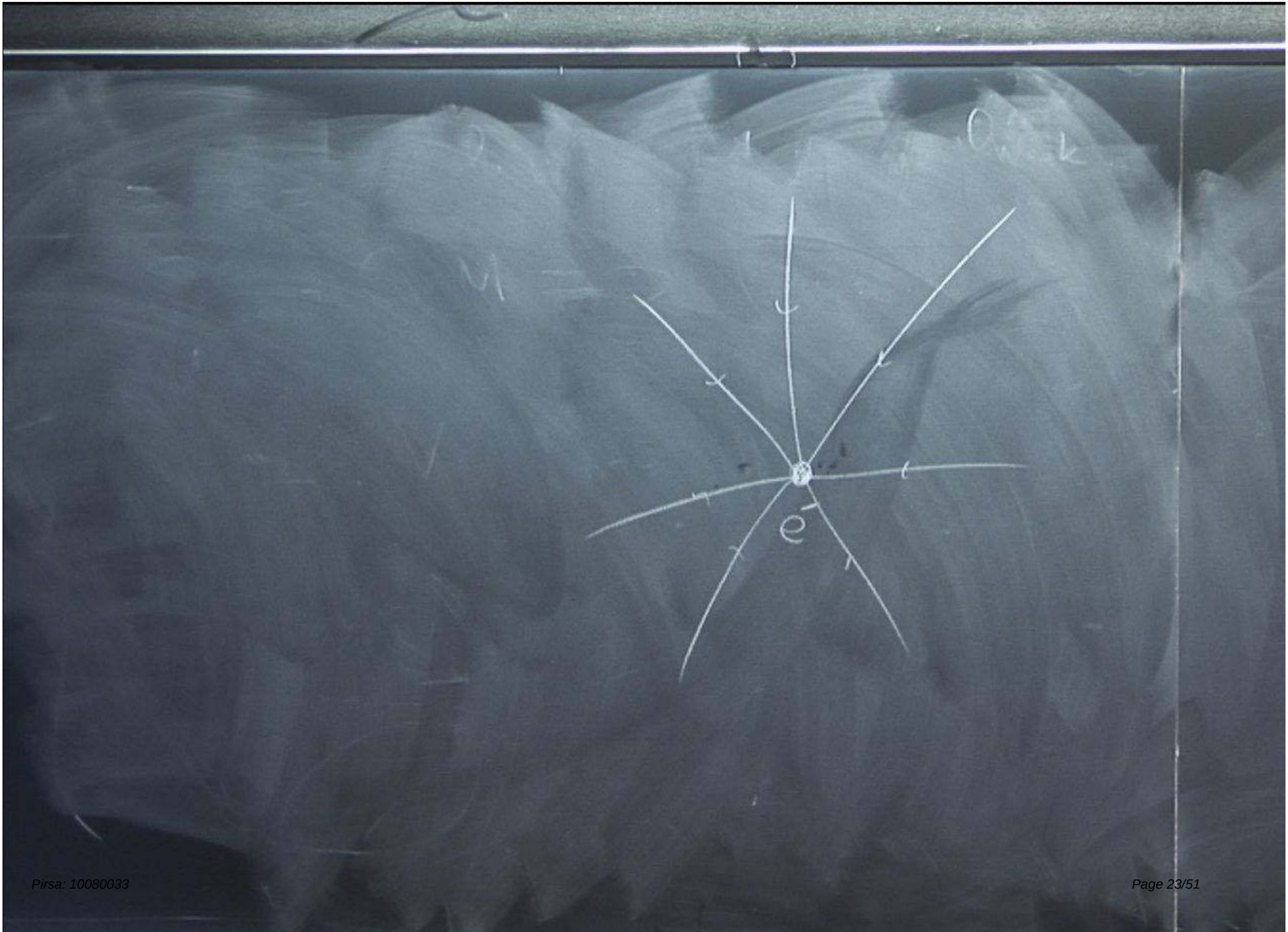
⟹ Vacuum is exciting!

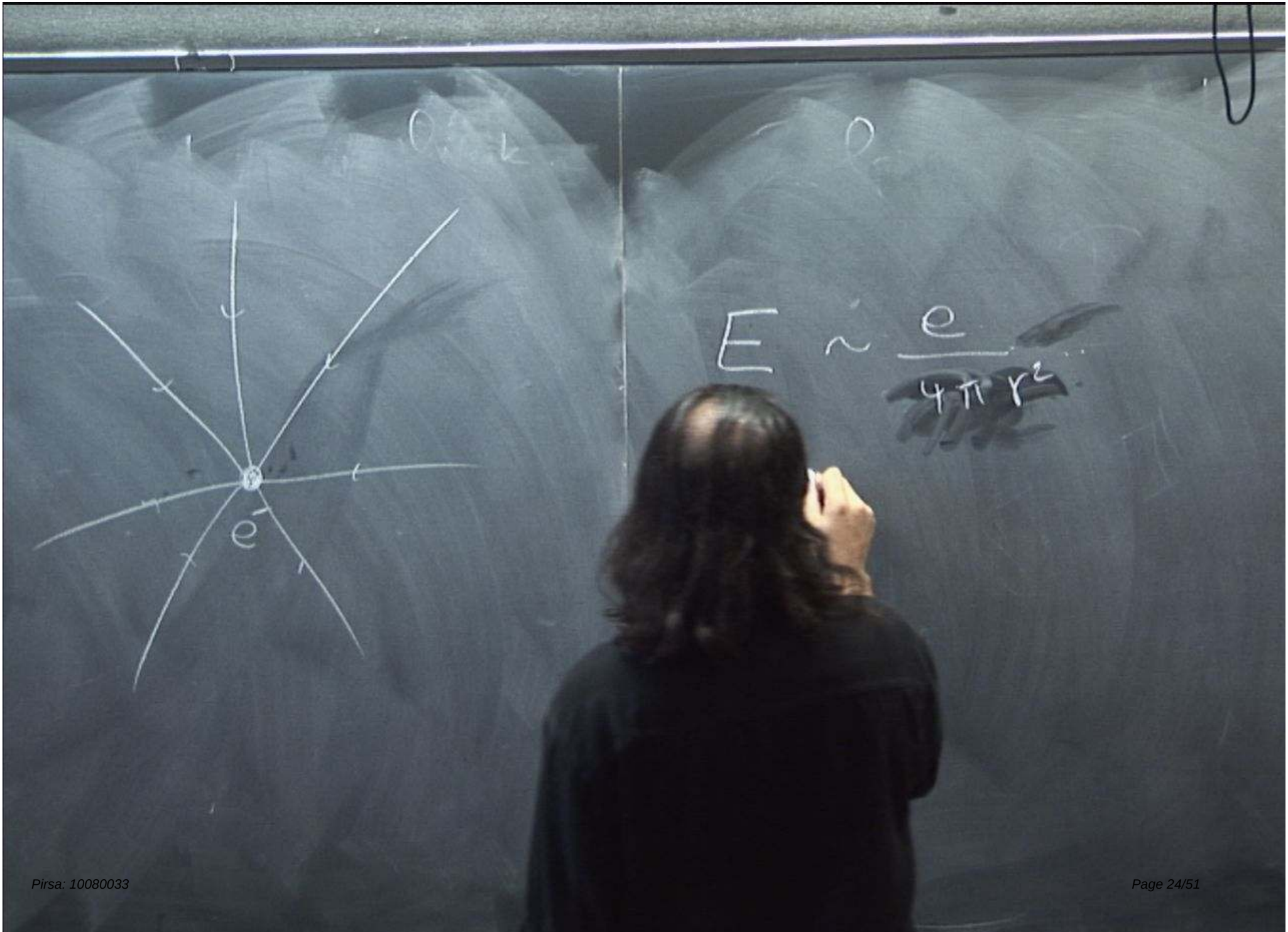


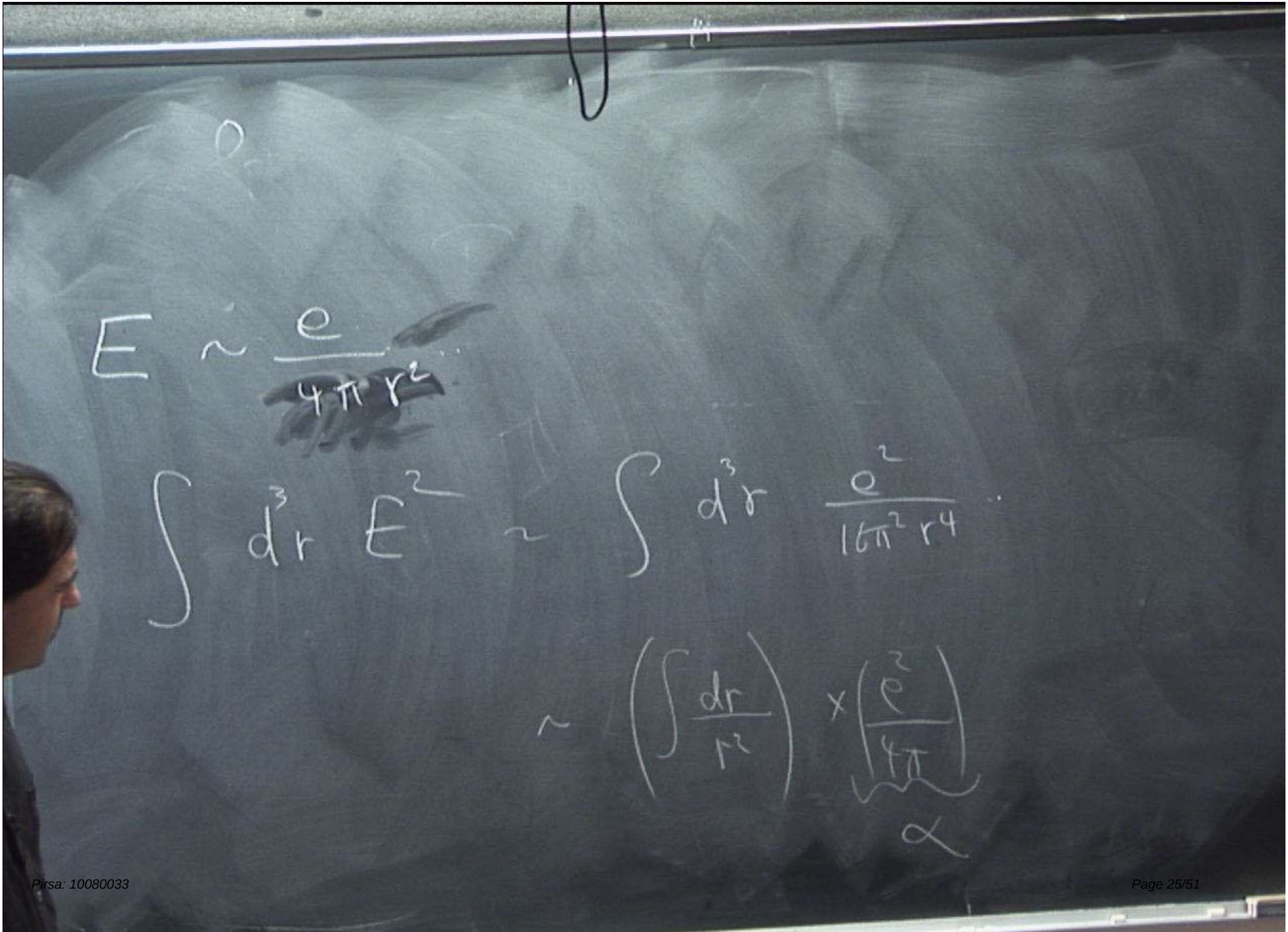
SR + QM ⟹ Anti-particles

⟹ Vacuum is exciting!





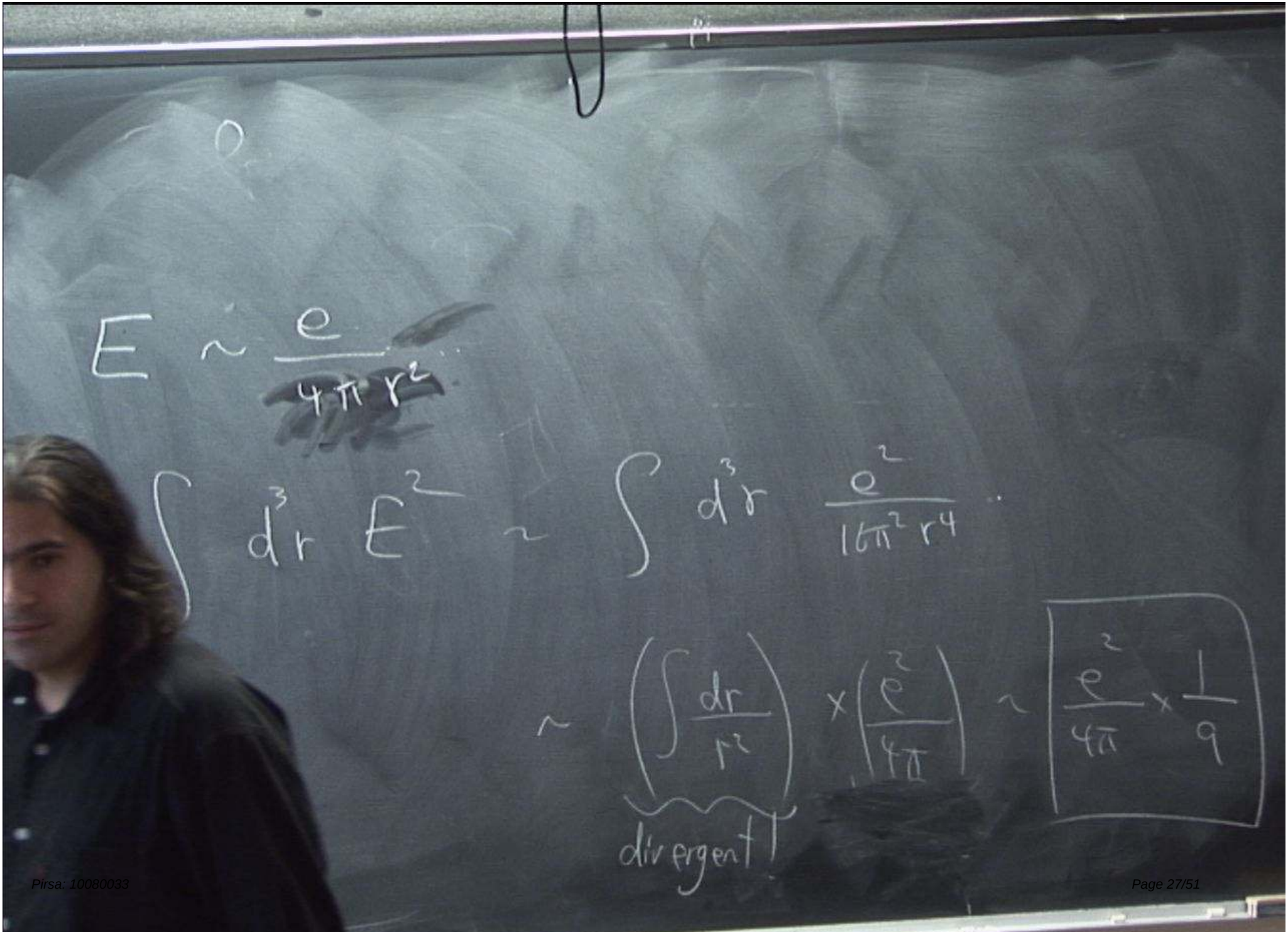

e⁻
E ~ e / 4π r²


$E \sim \frac{e}{4\pi r^2}$
$\int d^3r\, E^2 \sim \int d^3r\, \frac{e^2}{16\pi^2 r^4}$
$\sim \left(\int \frac{dr}{r^2}\right) \times \left(\frac{e^2}{4\pi}\right)$
α

$$E \sim \frac{e}{4\pi r^2}$$

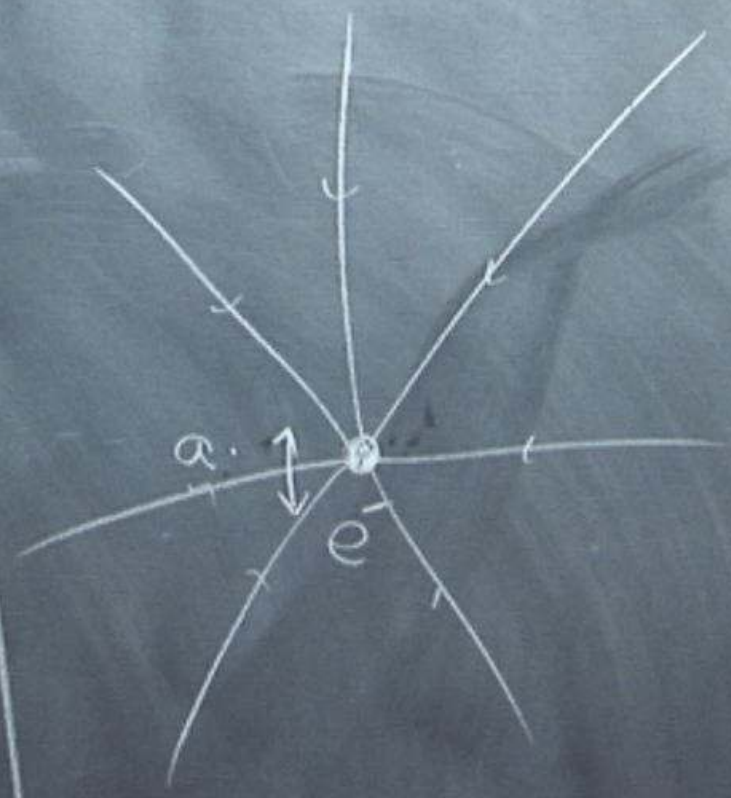
$$\int d^3r\, E^2 \sim \int d^3r\, \frac{e^2}{16\pi^2 r^4}$$

$$\sim \underbrace{\left(\int \frac{dr}{r^2}\right)}_{\text{divergent!}} \times \left(\frac{e^2}{4\pi}\right)$$


$E \sim \frac{e}{4\pi r^2}$
$\int d^3r\, E^2 \sim \int d^3r\, \frac{e^2}{16\pi^2 r^4}$
$\sim \underbrace{\left(\int \frac{dr}{r^2}\right)}_{\text{divergent!}} \times \left(\frac{e^2}{4\pi}\right) \sim \boxed{\frac{e^2}{4\pi} \times \frac{1}{9}}$

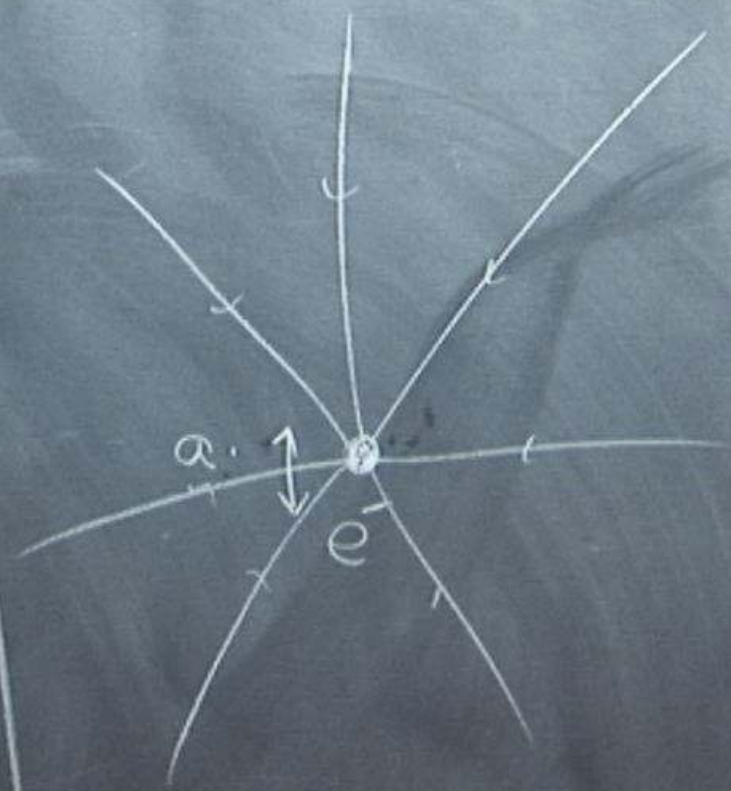
$$\frac{e^2}{4\pi}\frac{1}{a_{cl}} \sim m_e c^2$$

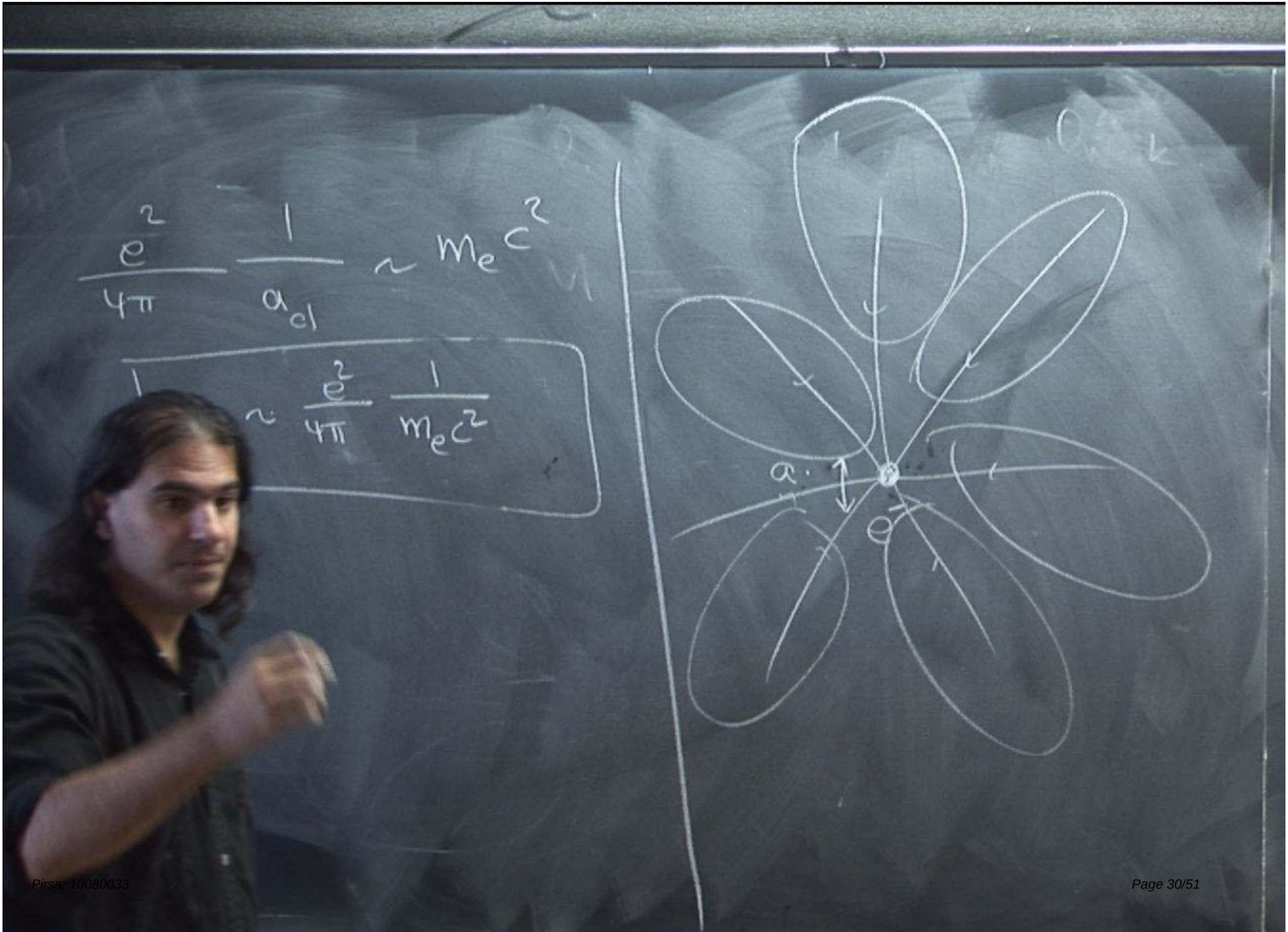
$$a_{cl} \sim \frac{m_e c^2}{\frac{4\pi}{e^2}}$$

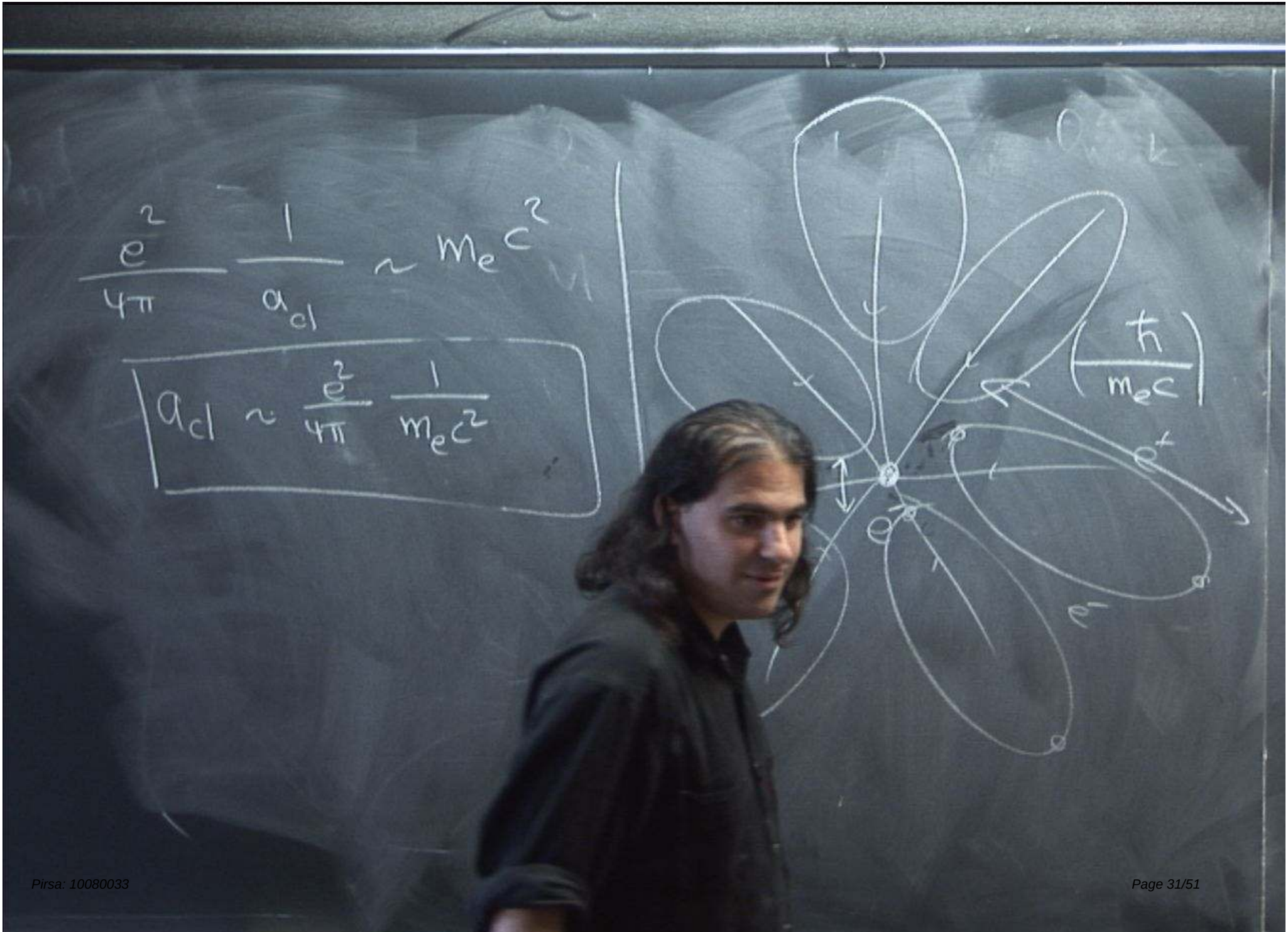


$$\frac{e^2}{4\pi}\frac{1}{a_{cl}} \sim m_e c^2$$

$$\boxed{a_{cl} \sim \frac{e^2}{4\pi}\frac{1}{m_e c^2}}$$



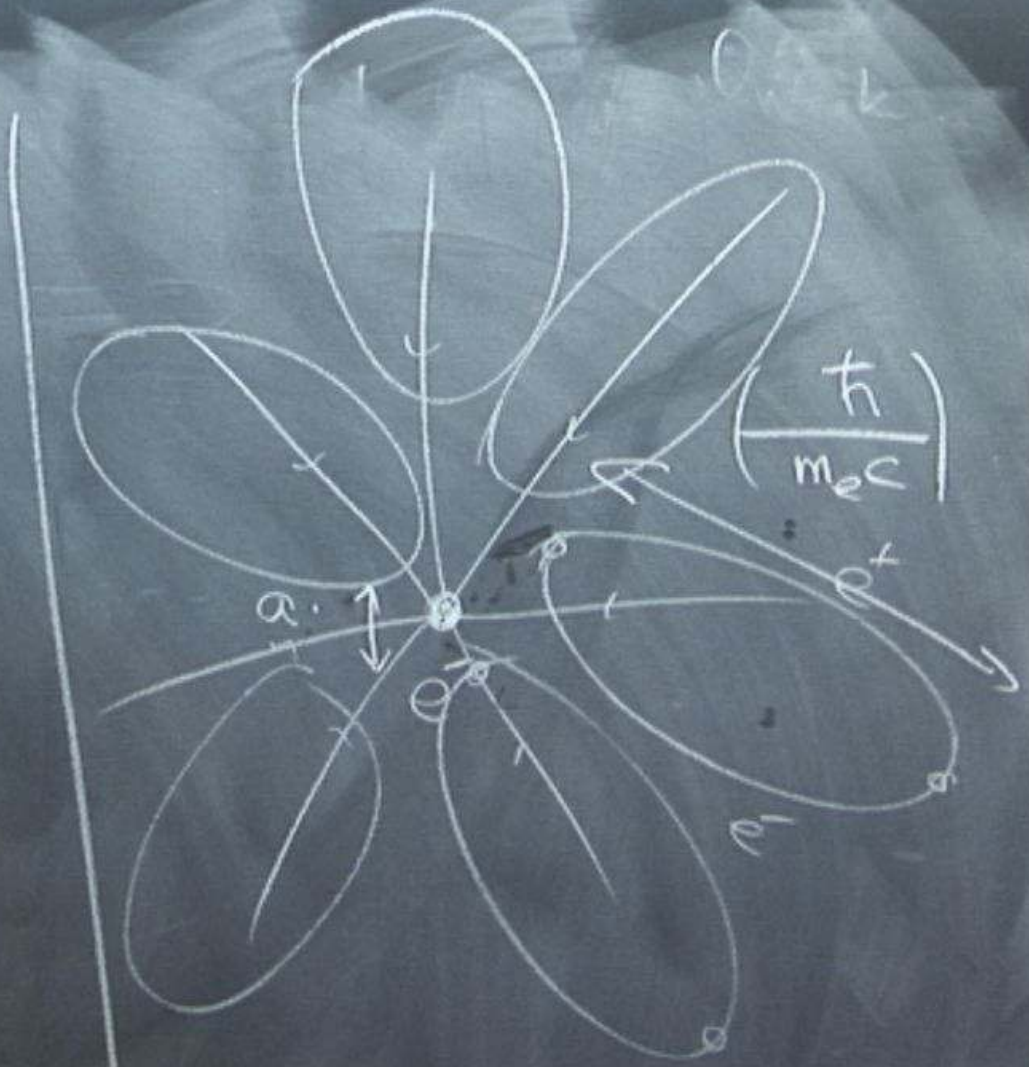

$\frac{e^2}{4\pi}\frac{1}{a_{cl}} \sim m_e c^2$
$\sim \frac{e^2}{4\pi}\frac{1}{m_e c^2}$


$\frac{e^2}{4\pi}\frac{1}{a_{cl}} \sim m_e c^2$
$a_{cl} \sim \frac{e^2}{4\pi}\frac{1}{m_e c^2}$
$\left(\frac{\hbar}{m_e c}\right)$
e^-
e^+

$$\frac{e^2}{4\pi}\frac{1}{a_{cl}} \sim m_e c^2$$

$$a_{cl} \sim \frac{e^2}{4\pi}\frac{1}{m_e c^2}$$

$$a_{cl} \sim \frac{\hbar}{m_e c}$$



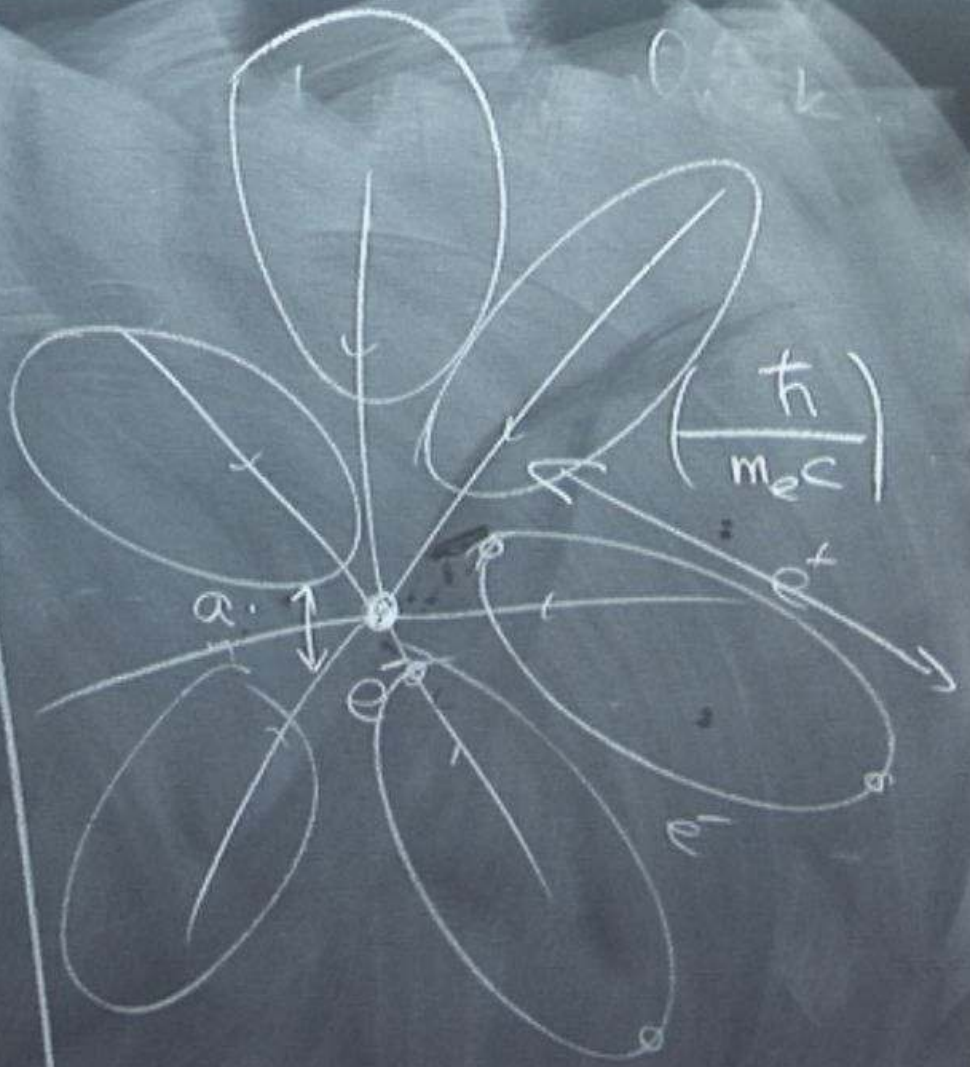
$$\frac{e^2}{4\pi}\frac{1}{a_{cl}} \sim m_e c^2$$

$$\boxed{a_{cl} \sim \frac{e^2}{4\pi}\frac{1}{m_e c^2}}$$

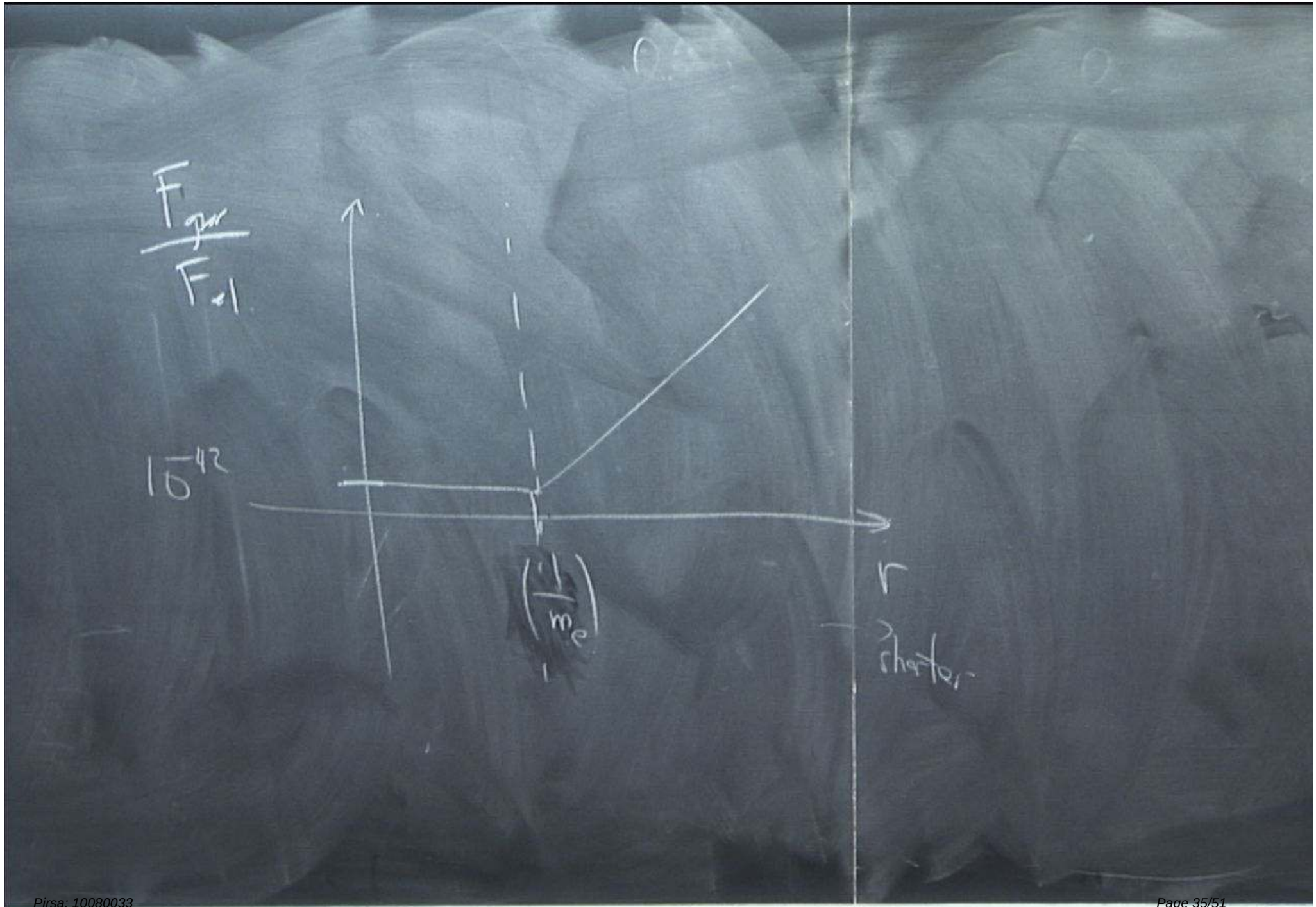
$$a_{\text{actual}} \sim \frac{\hbar}{m_e c}$$

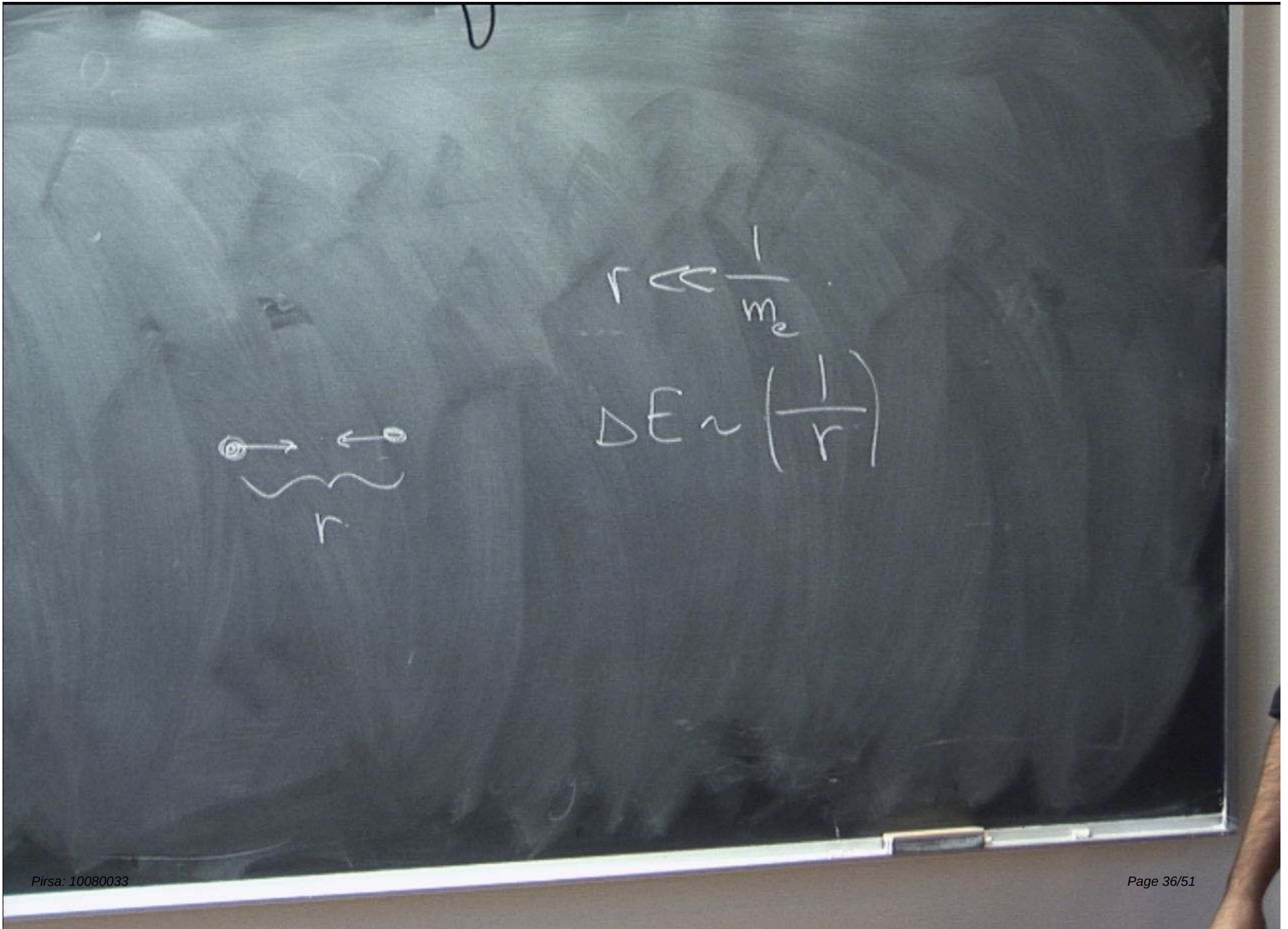
$$\frac{a_{act}}{a_{cl}} \sim \frac{\hbar}{m_e c} \times \frac{m_e c^2}{\frac{e^2}{4\pi}}$$

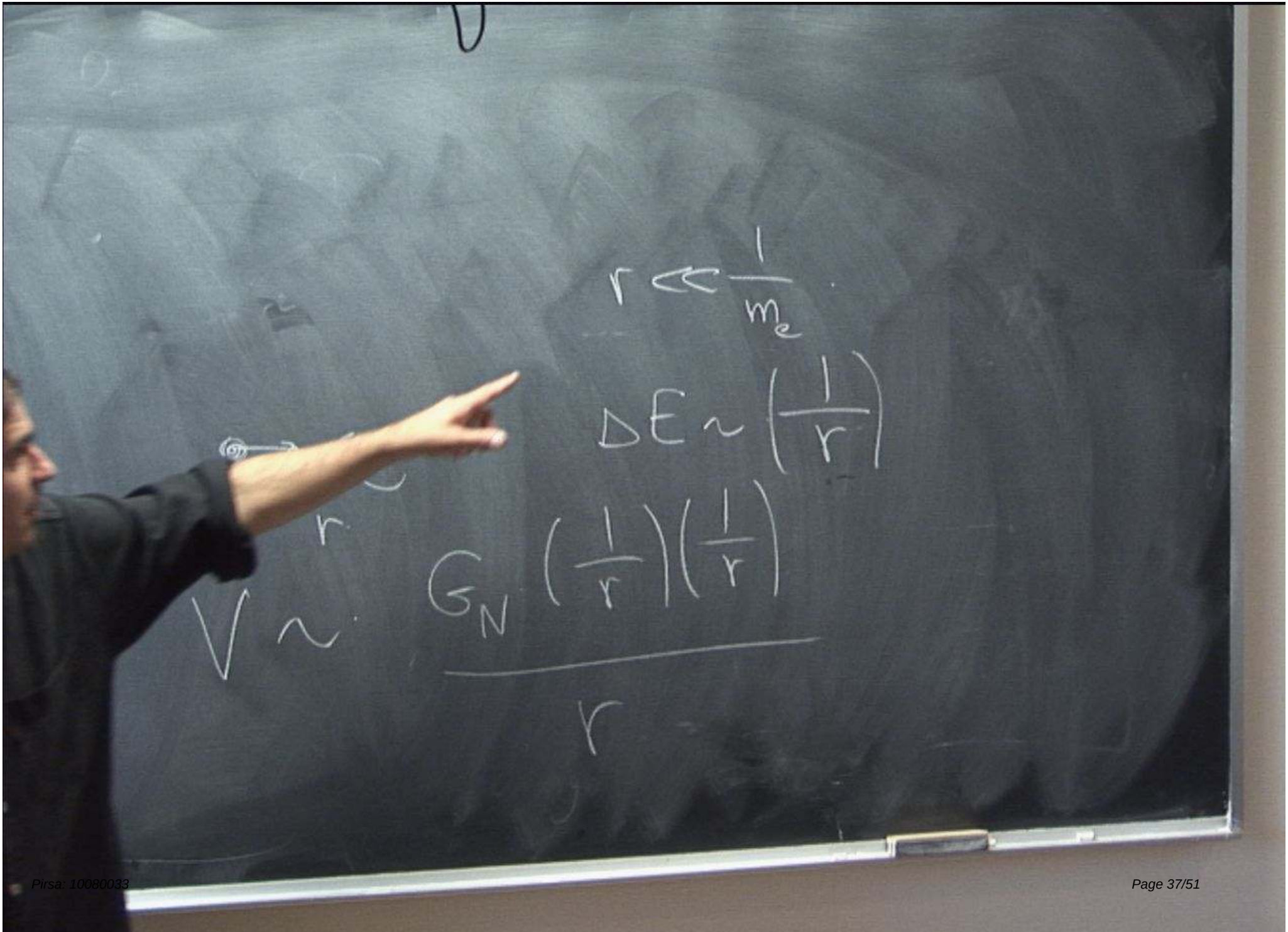
$$\sim \frac{1}{e^2/4\pi\hbar c} = 1/\alpha.$$

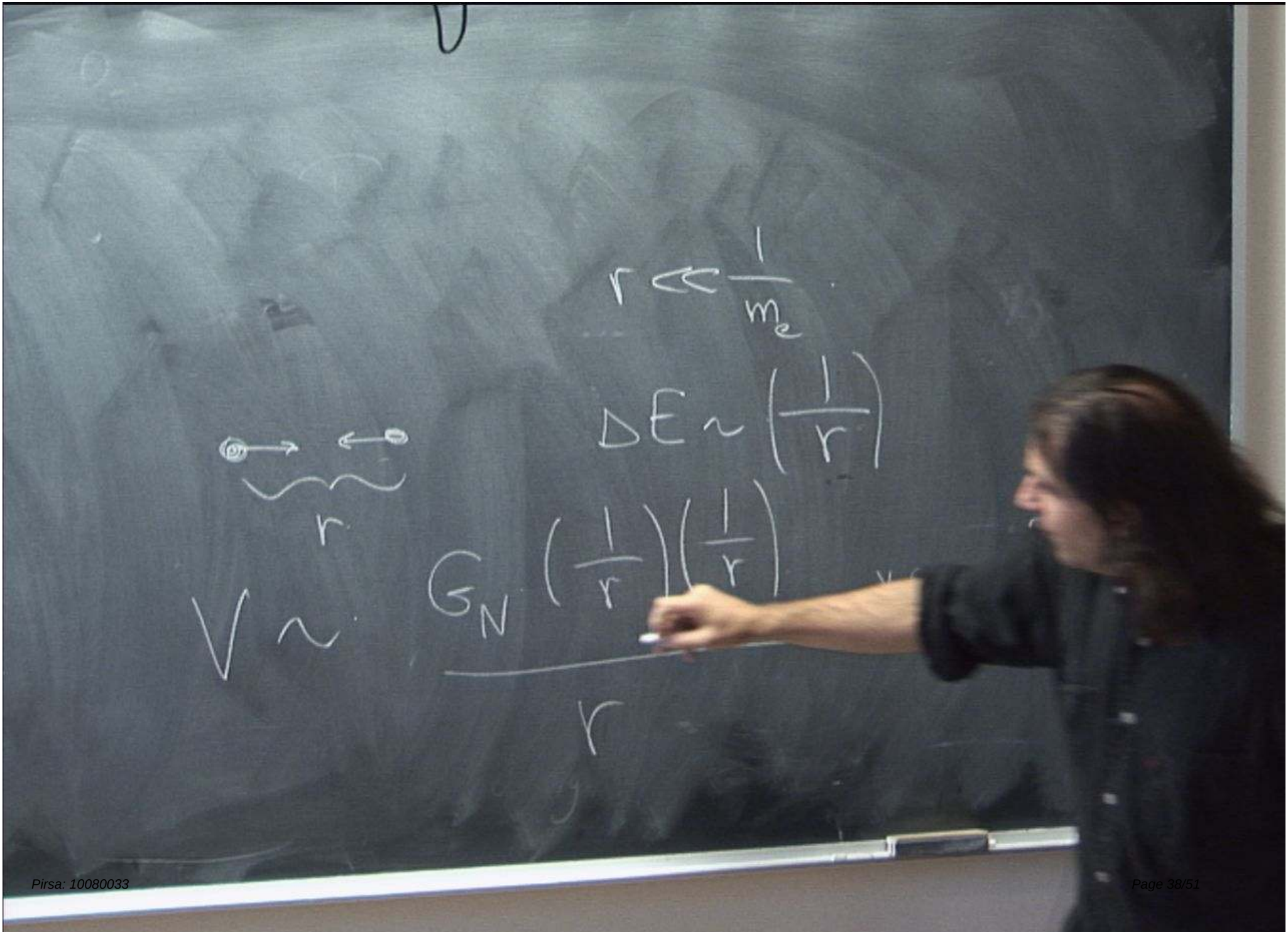


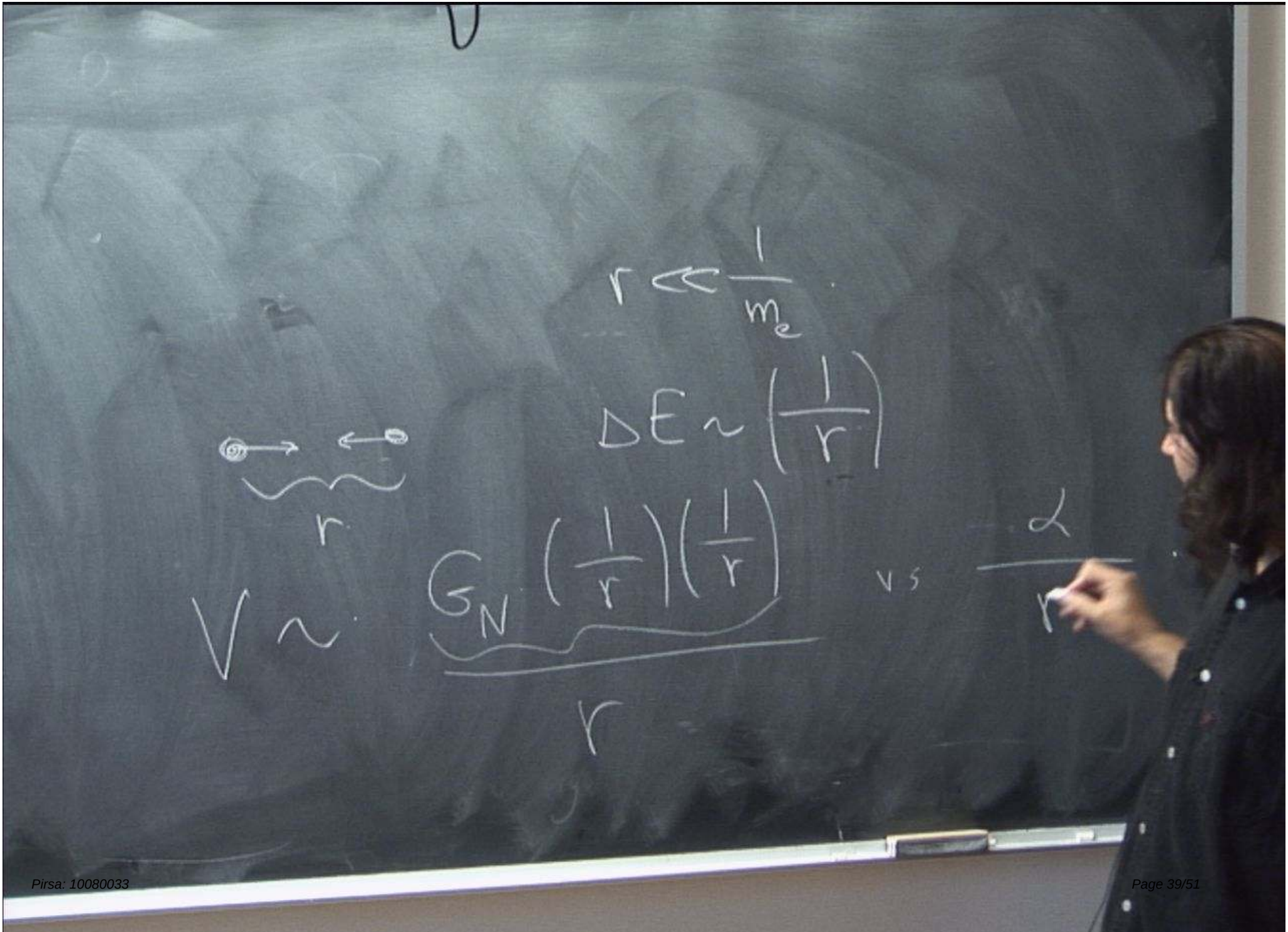
r

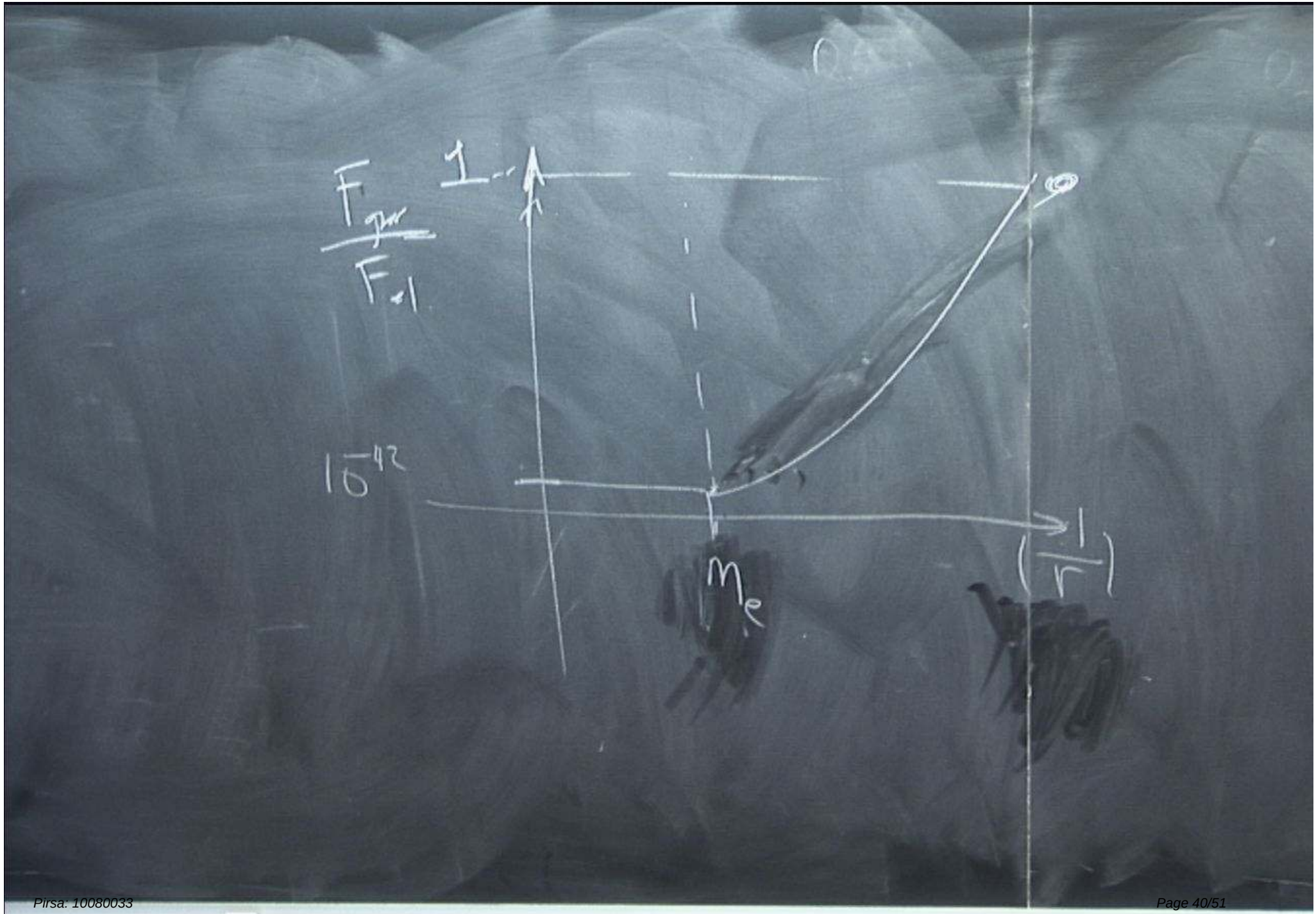

$\frac{F_{grav}}{F_{el}}$
10^{42}
$\left(\frac{1}{m_e}\right)$
r
Charles

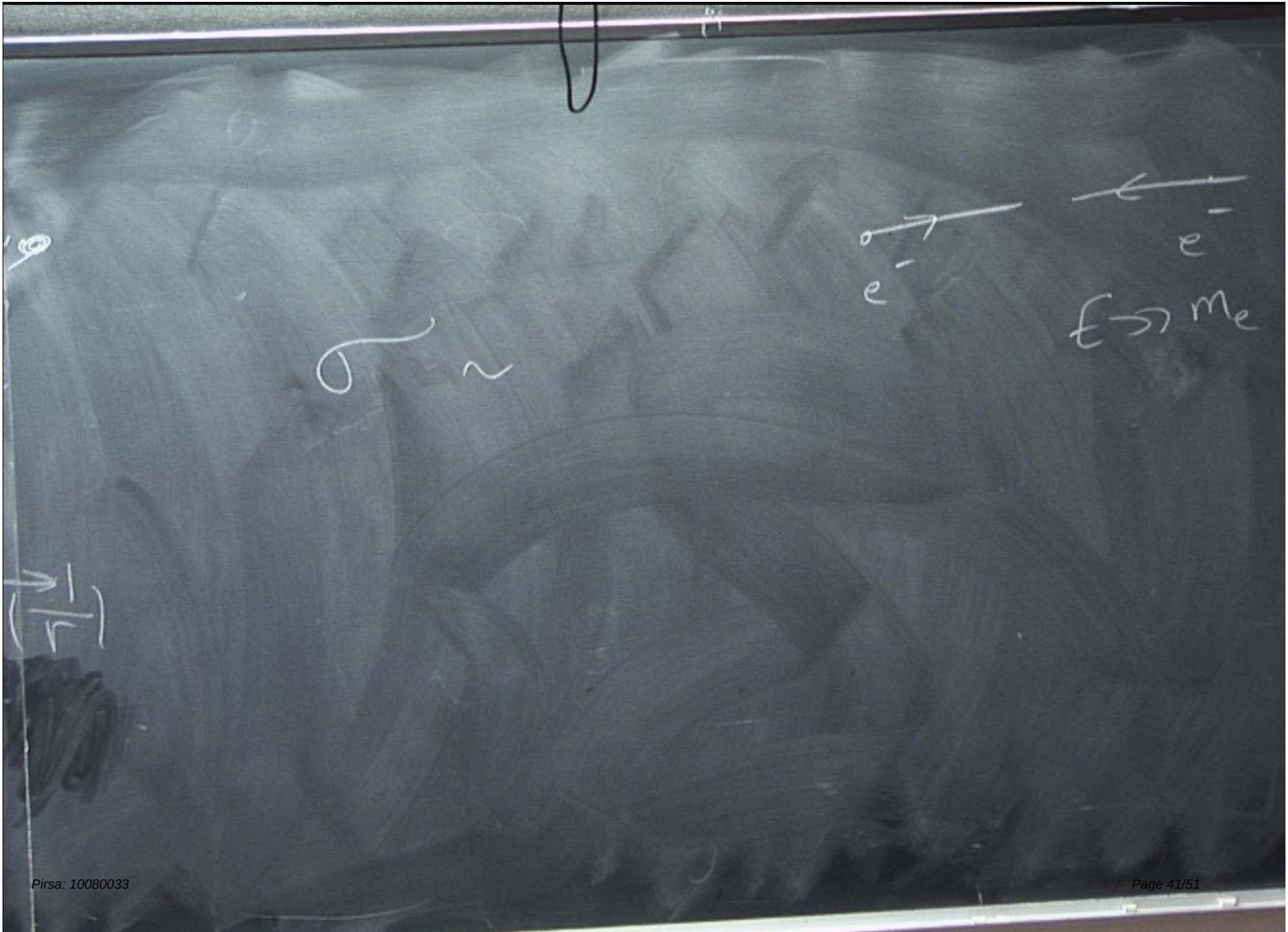

$r \ll \frac{1}{m_e}$
$\Delta E \sim \left(\frac{1}{r}\right)$
r

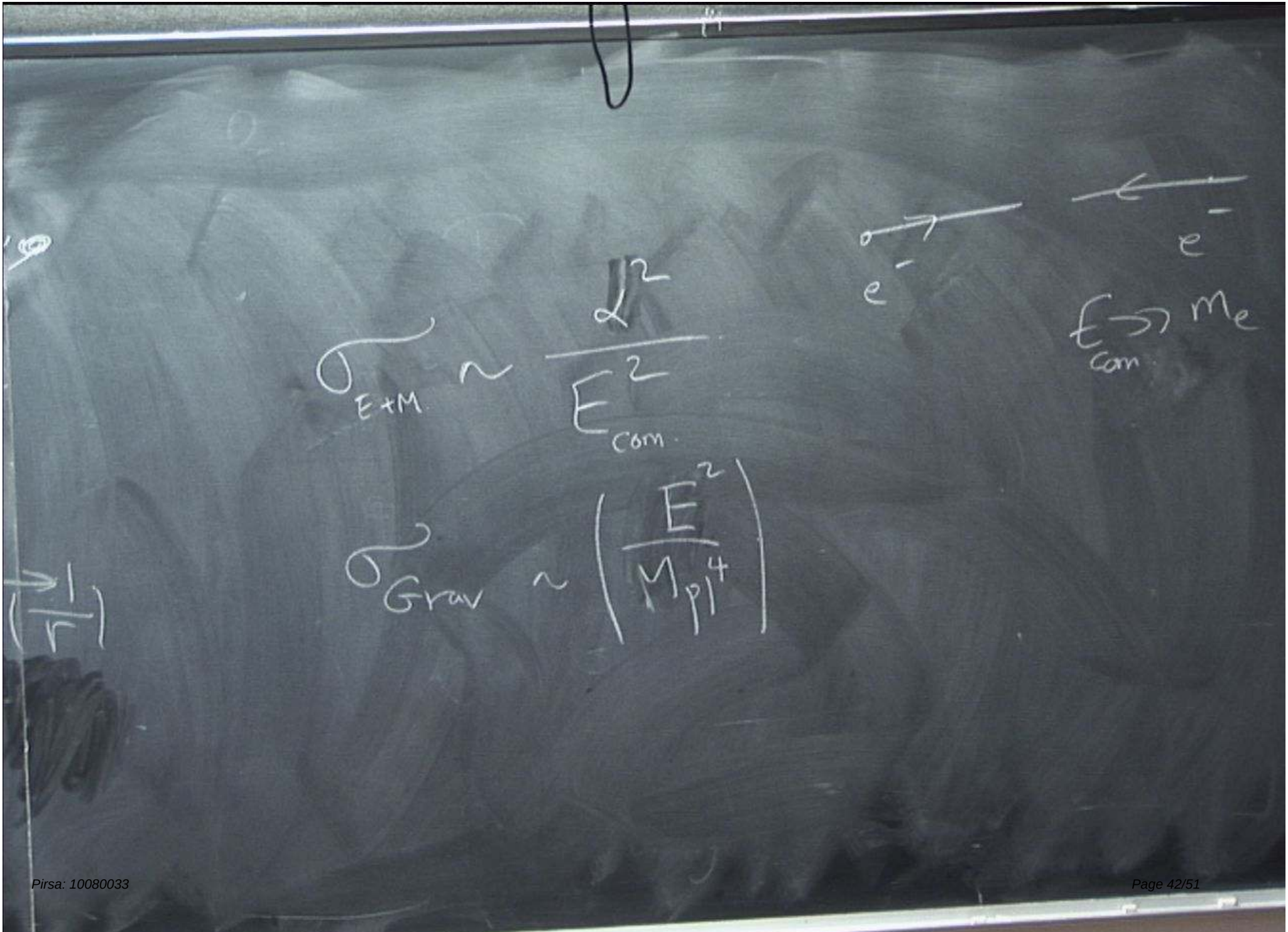

$r \ll \frac{1}{m_e}$
$\Delta E \sim \left(\frac{1}{r}\right)$
$V \sim G_N \left(\frac{1}{r}\right)\left(\frac{1}{r}\right)$
r

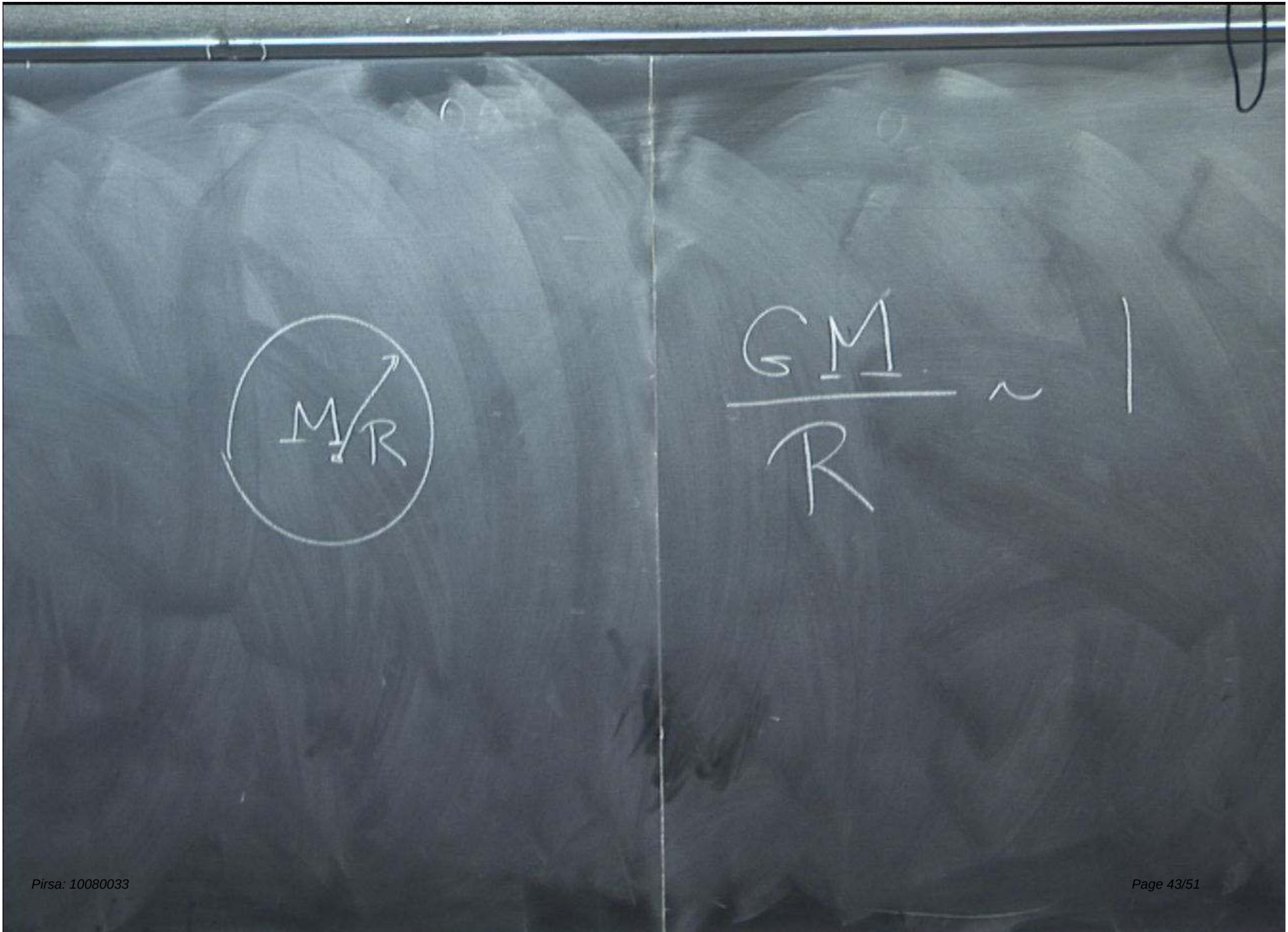

$r \ll \frac{1}{m_e}$
$\Delta E \sim \left(\frac{1}{r}\right)$
r
$V \sim G_N \left(\frac{1}{r}\right)\left(\frac{1}{r}\right)$
r

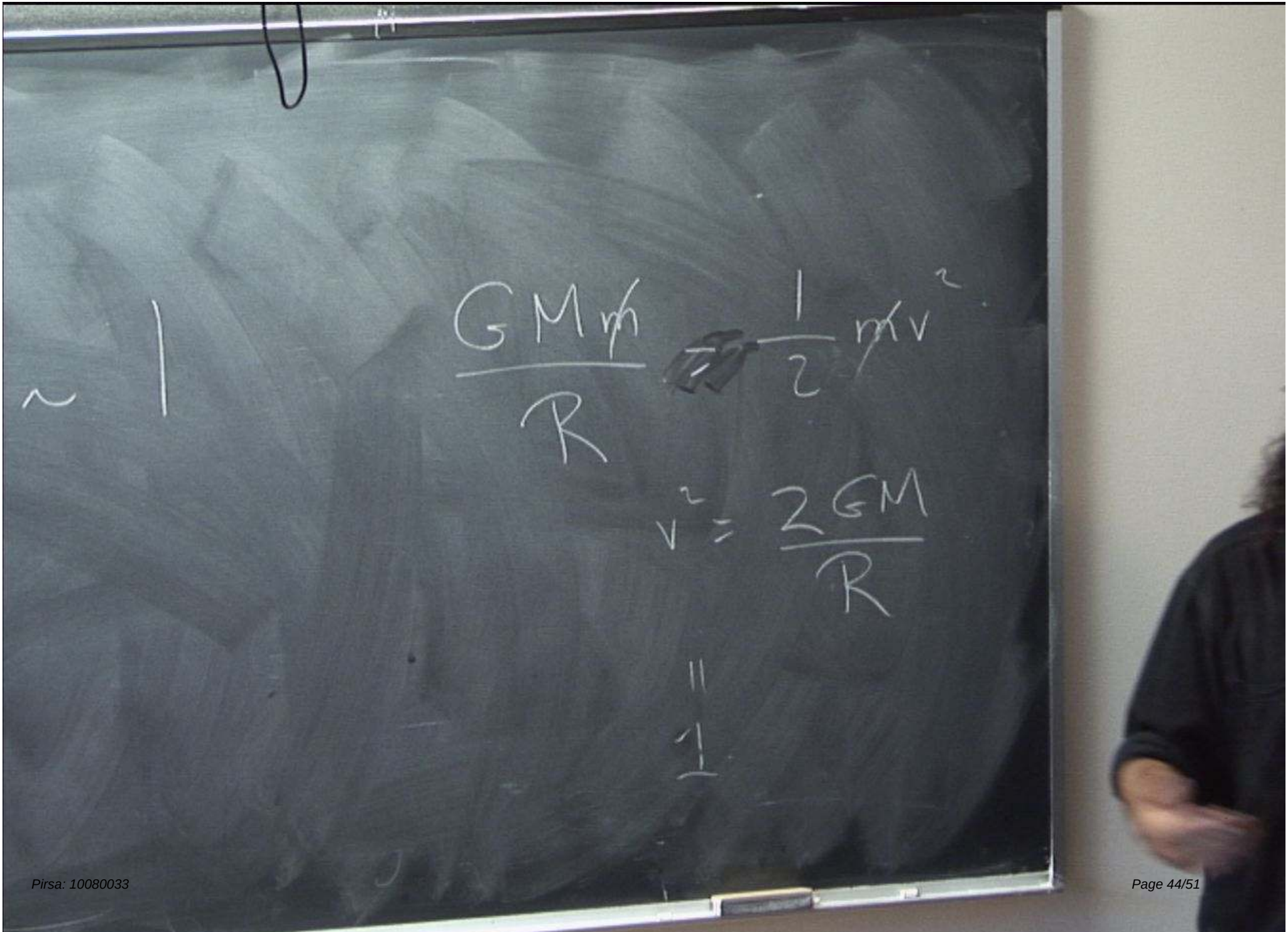

$r \ll \frac{1}{m_e}$
$\Delta E \sim \left(\frac{1}{r}\right)$
r
$V \sim \frac{G_N \left(\frac{1}{r}\right)\left(\frac{1}{r}\right)}{r}$
vs
$\frac{\alpha}{r}$


$\frac{F_{grav}}{F_{el}}$
1
10^{42}
m_e
$\left(\frac{1}{r}\right)$

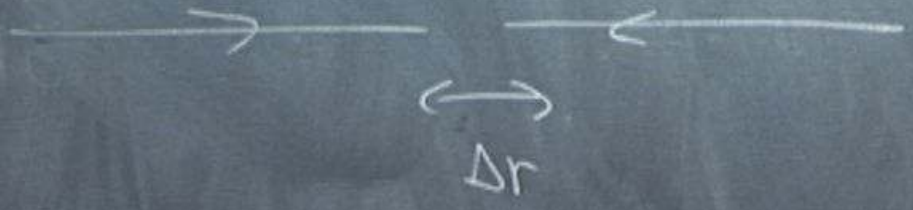

e⁻
e⁻
E → mₑ


$\sigma_{E+M} \sim \frac{\alpha^2}{E_{com.}^2}$
e^-
e^-
$E \to m_e$
com.
$\sigma_{Grav} \sim \left(\frac{E^2}{M_{pl}^4}\right)$
$\left(\frac{1}{r}\right)$


M/R
GM/R ~ 1


~ 1
$\frac{GMm}{R} = \frac{1}{2}mv^2$
$v^2 = \frac{2GM}{R}$
$\frac{1}{1}$

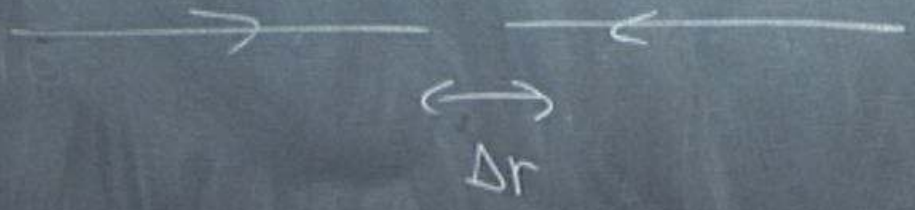
$\Delta E \sim \frac{1}{\Delta r}$



Δr

$G_N \cdot \left(\frac{1}{\Delta r} \right)$

$\Delta E \sim \frac{1}{\Delta r}$



Δr

$G_N \cdot \left(\frac{1}{\Delta r}\right) \sim 1.$

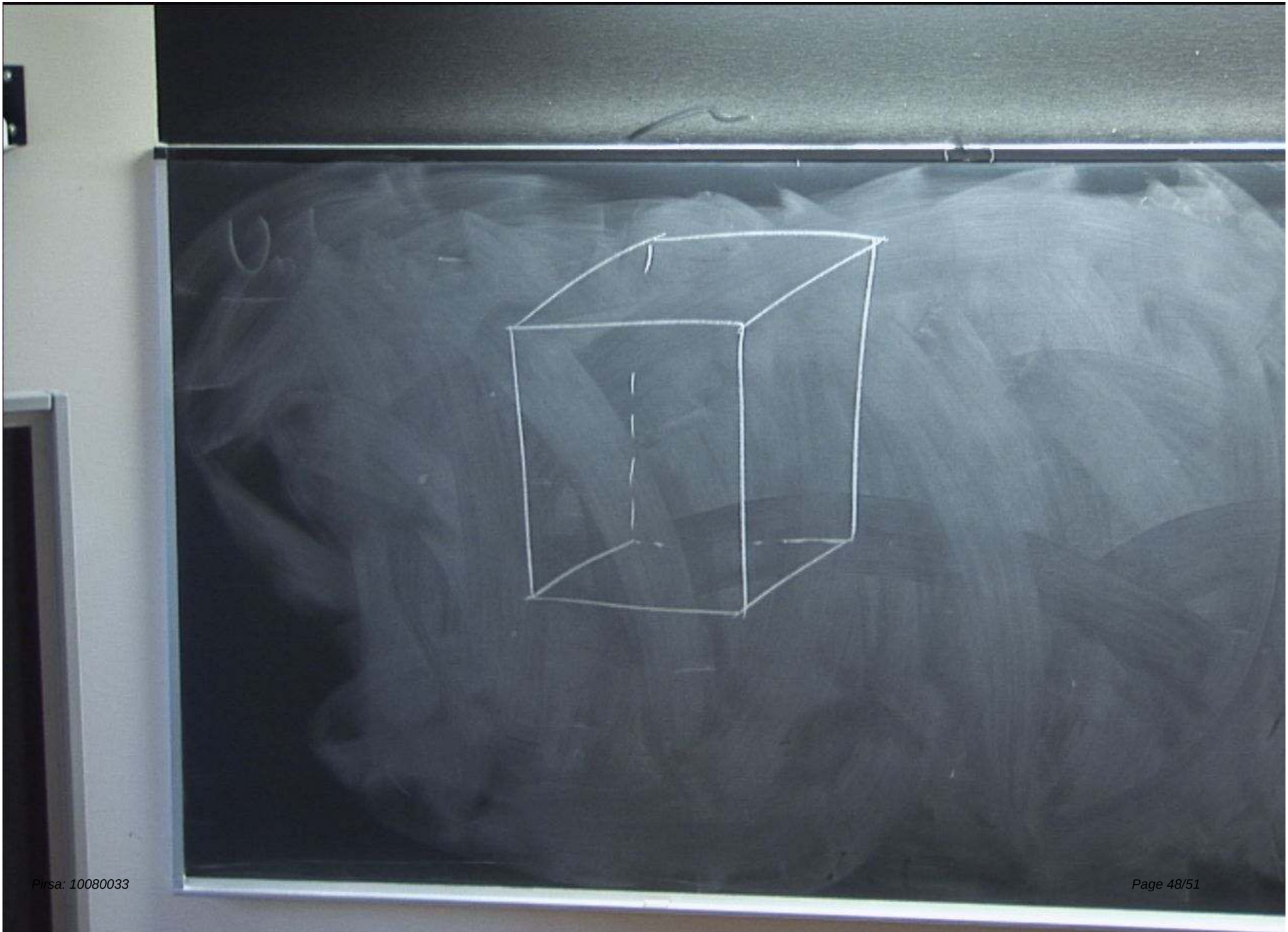
$\Delta r \sim G_N \sim \ell_{Pl}^2$

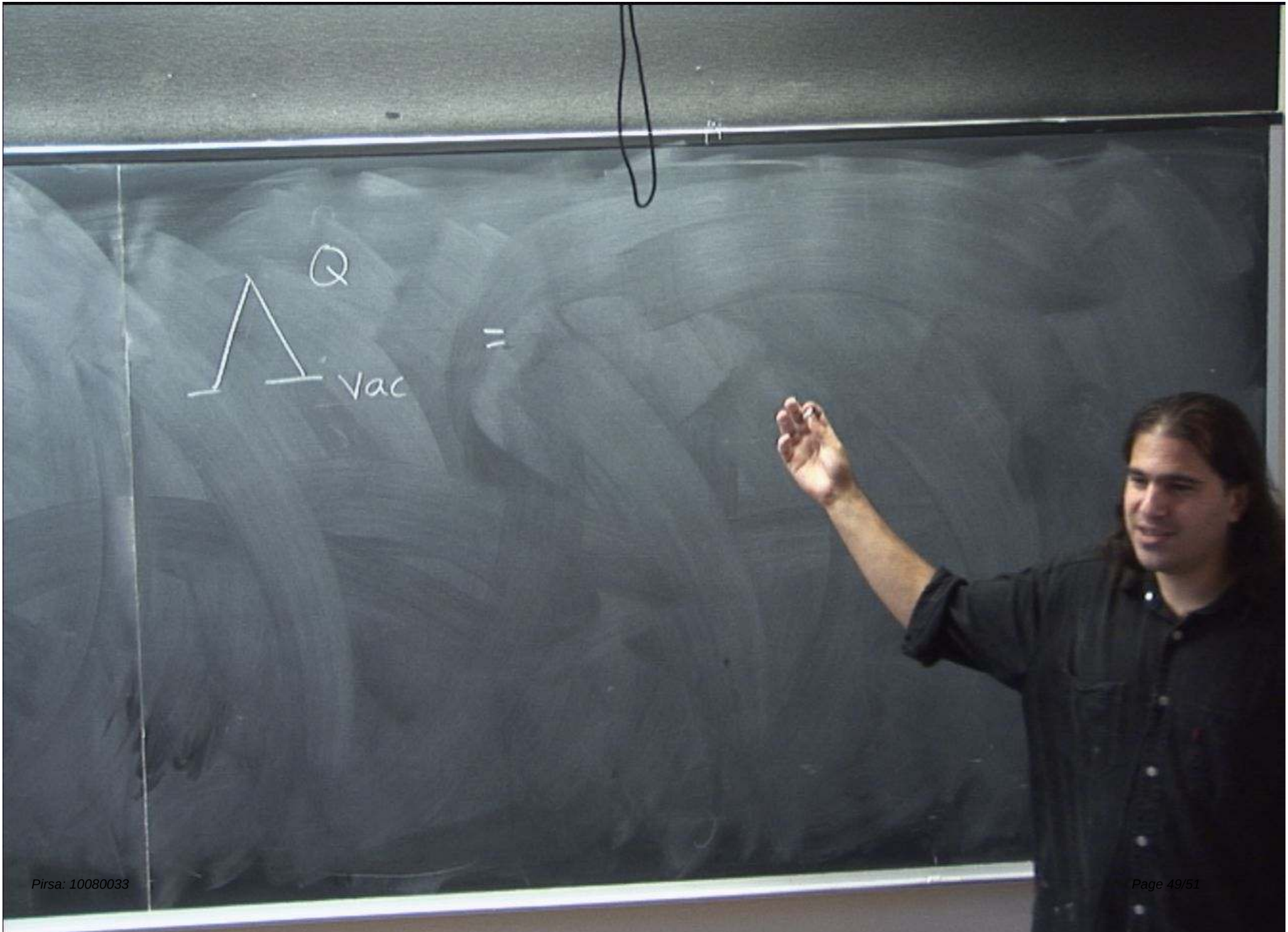
$$\frac{GM}{R} \sim 1$$

$$G_N \cdot \left(\frac{1}{\Delta r}\right) \sim 1.$$

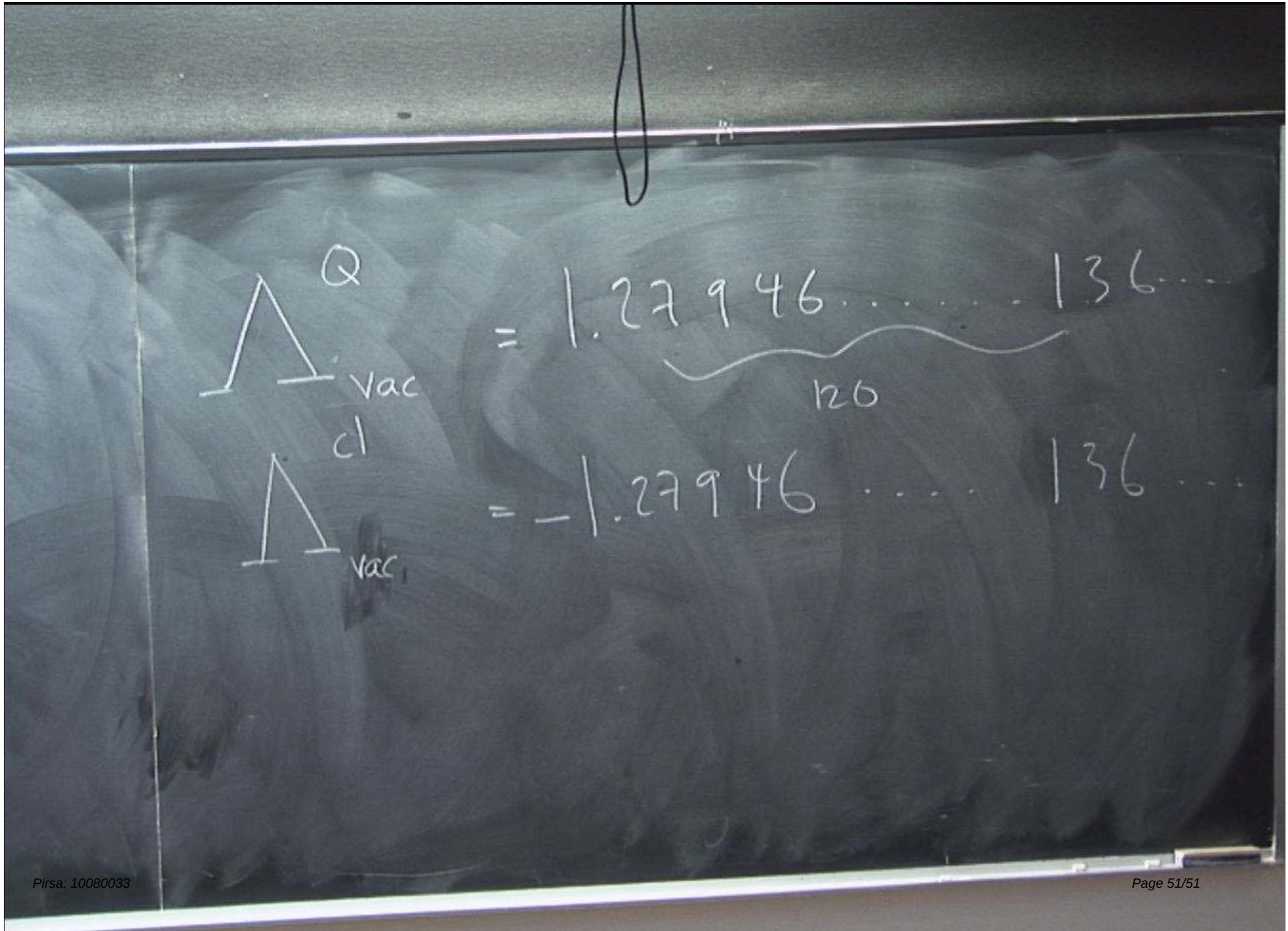
$$\frac{}{\Delta r}$$

$$\Delta r^2 \sim G_N \sim \ell_{Pl}^2$$




Q
vac
=

$$\Lambda^{Q}_{vac} = 1.27946\underbrace{\ldots\ldots}_{120}136\ldots$$


$\Lambda^{Q}_{vac} = 1.27946\ldots\ldots 136\ldots$
120
$\Lambda^{cl}_{vac} = -1.27946\ldots 136\ldots$