Title: PSI - Research Skills 3A

Date: Aug 26, 2009 09:00 AM

URL: http://pirsa.org/09080039

Abstract:

Dark Matter

Dark Matter

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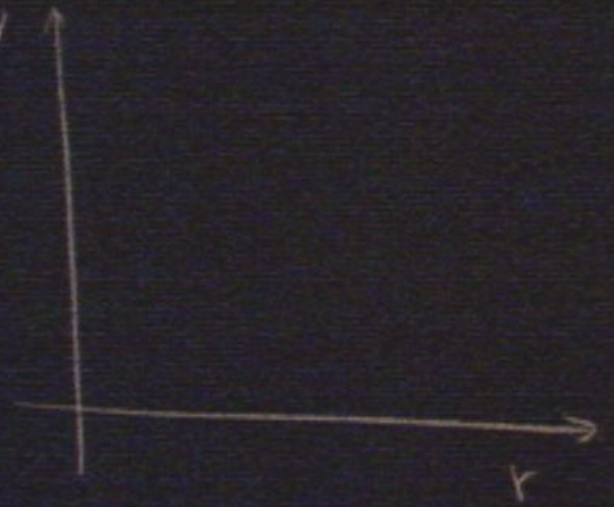
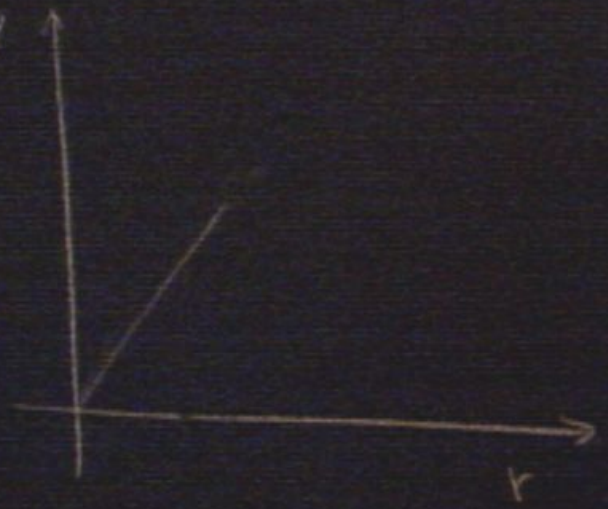
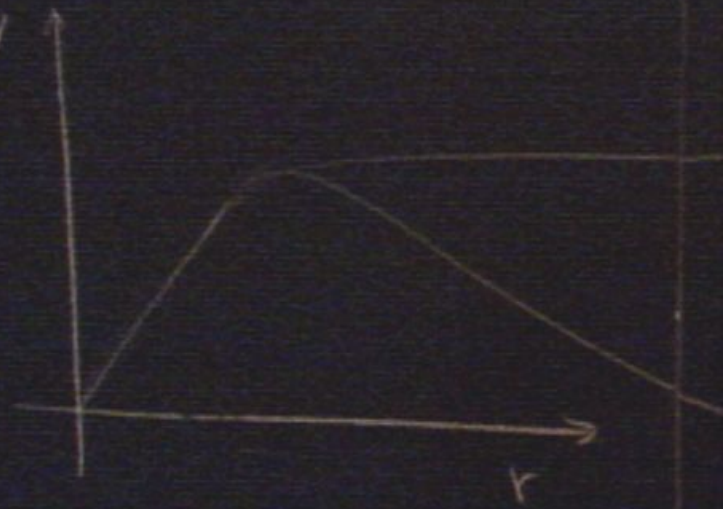
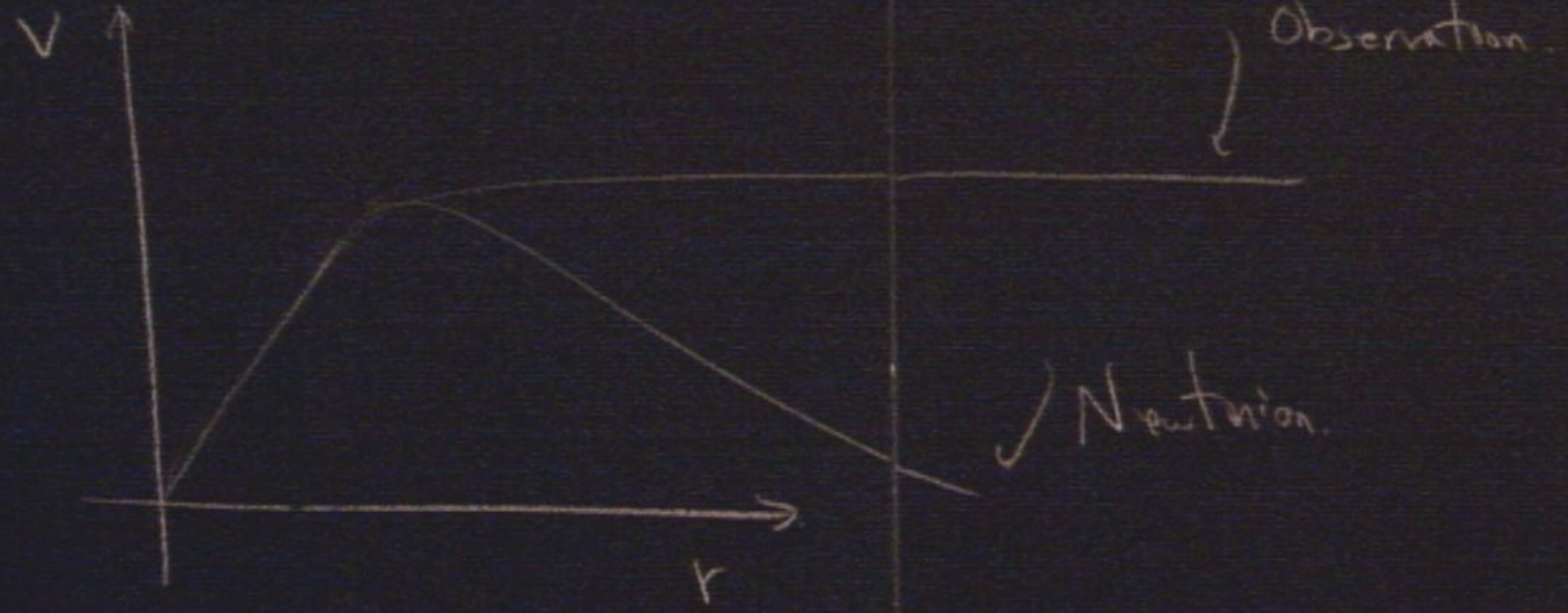


Dark Matter



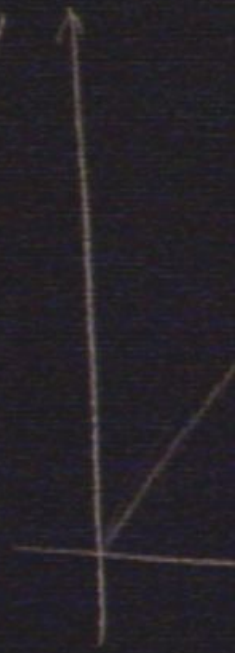
Dark Matter



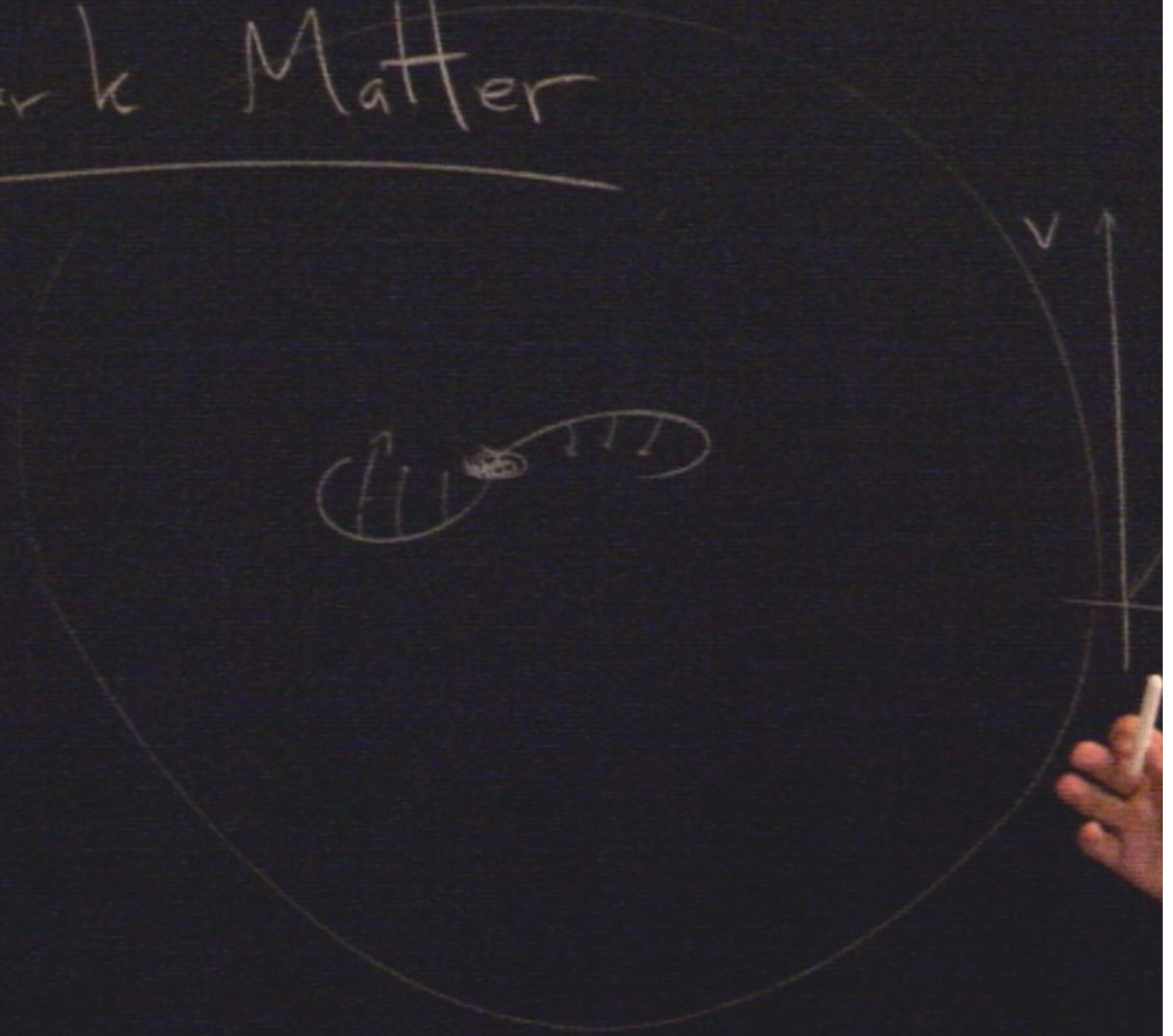

V
r
Observation.
Newtonian.


V
r
Observation.
Newtonian.

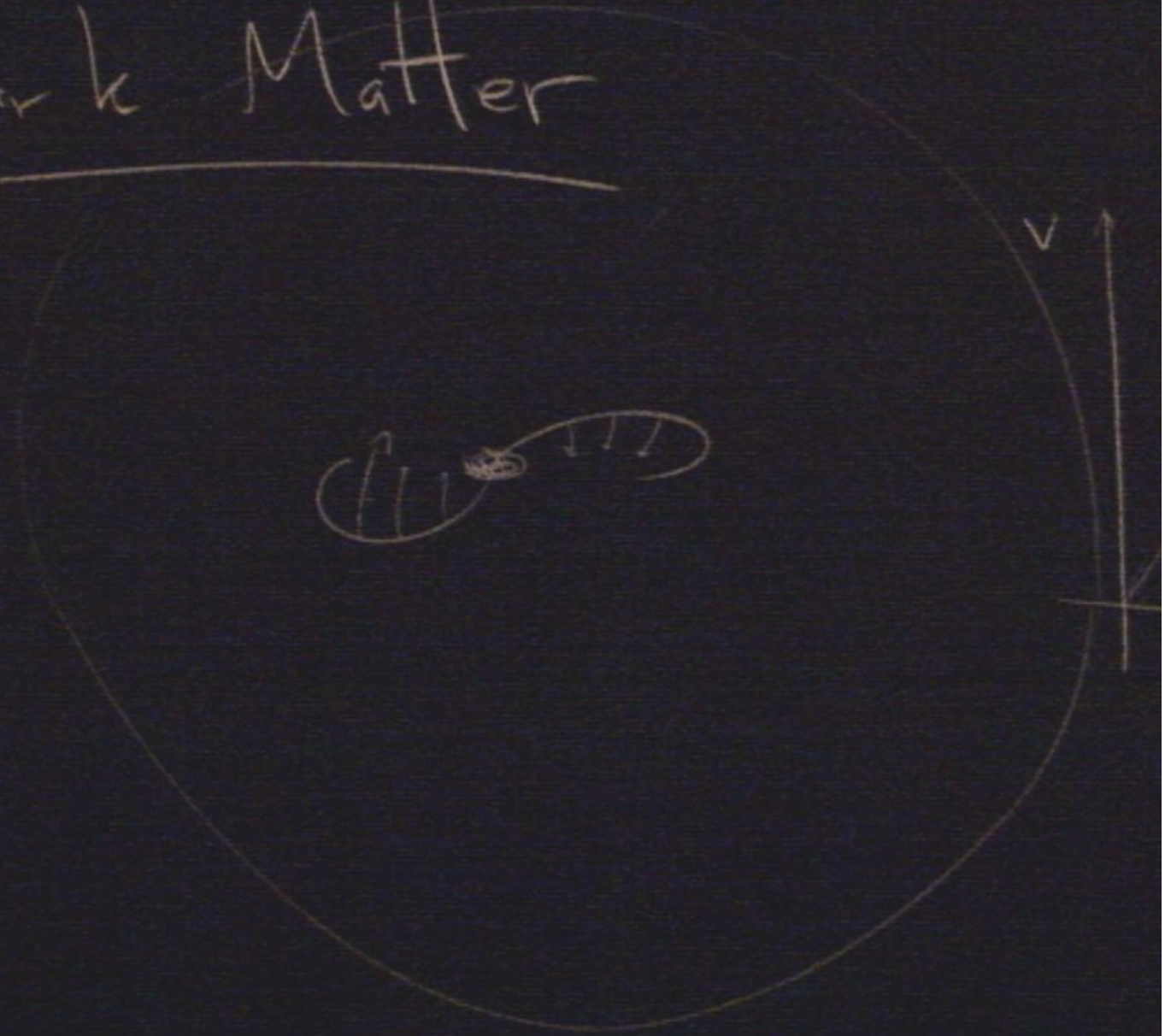
Dark Matter



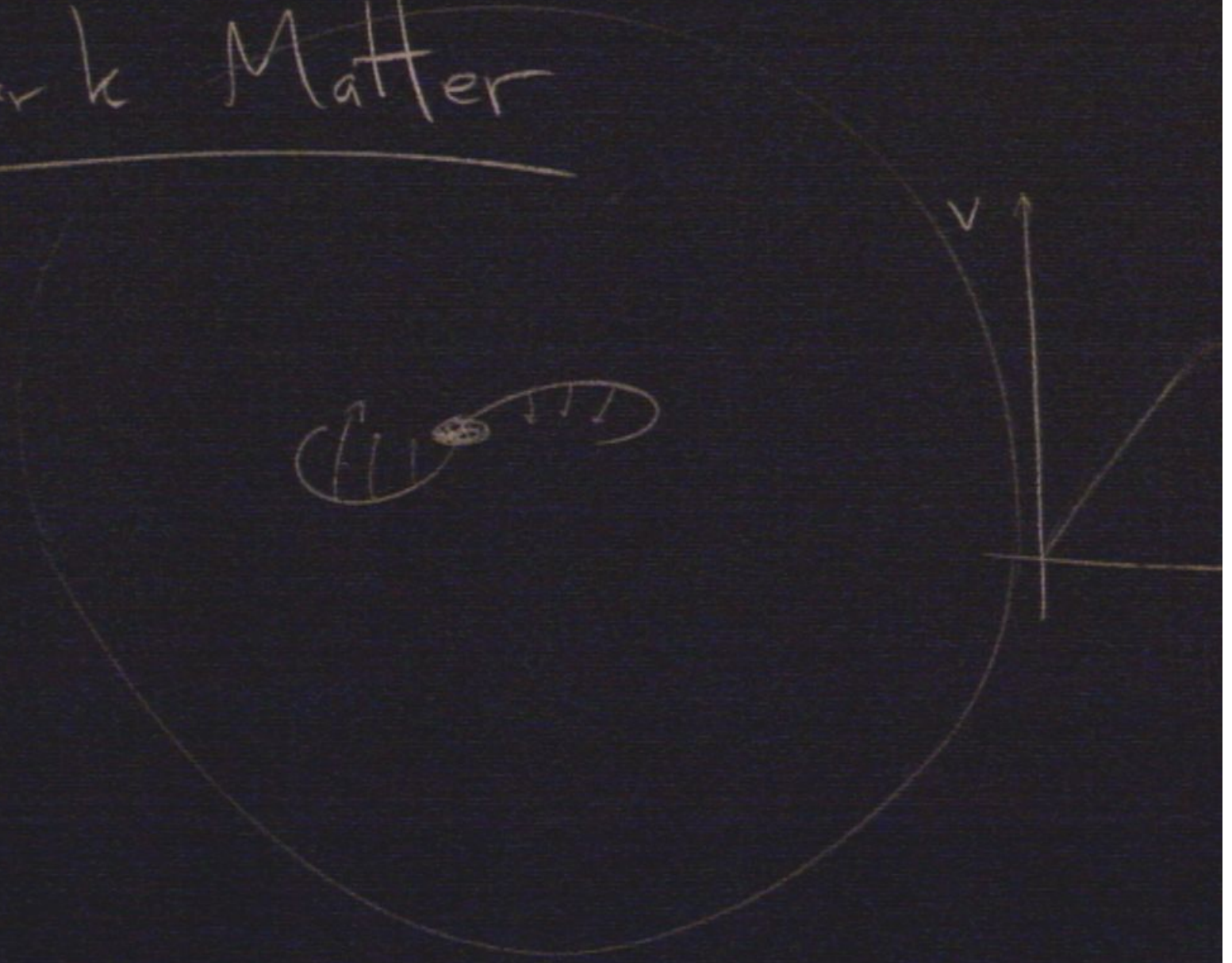
Dark Matter

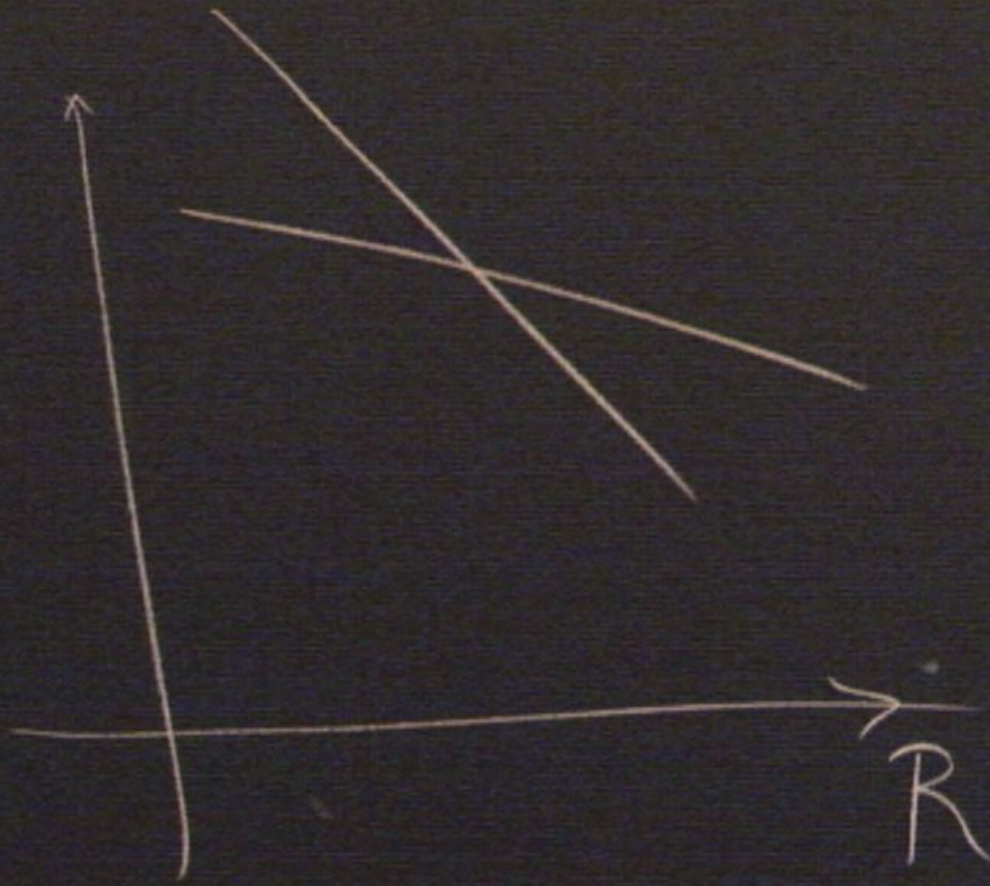


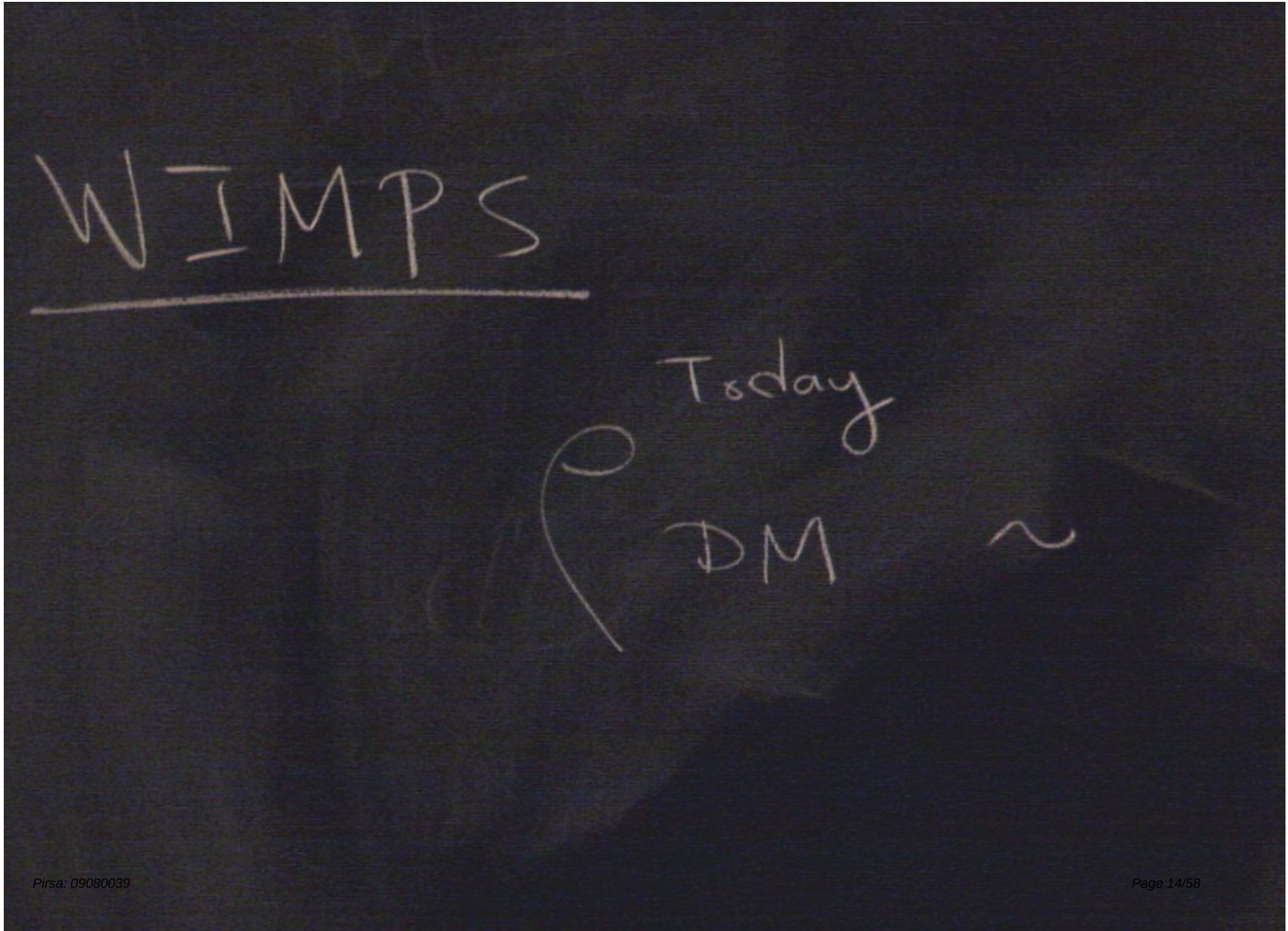
Dark Matter

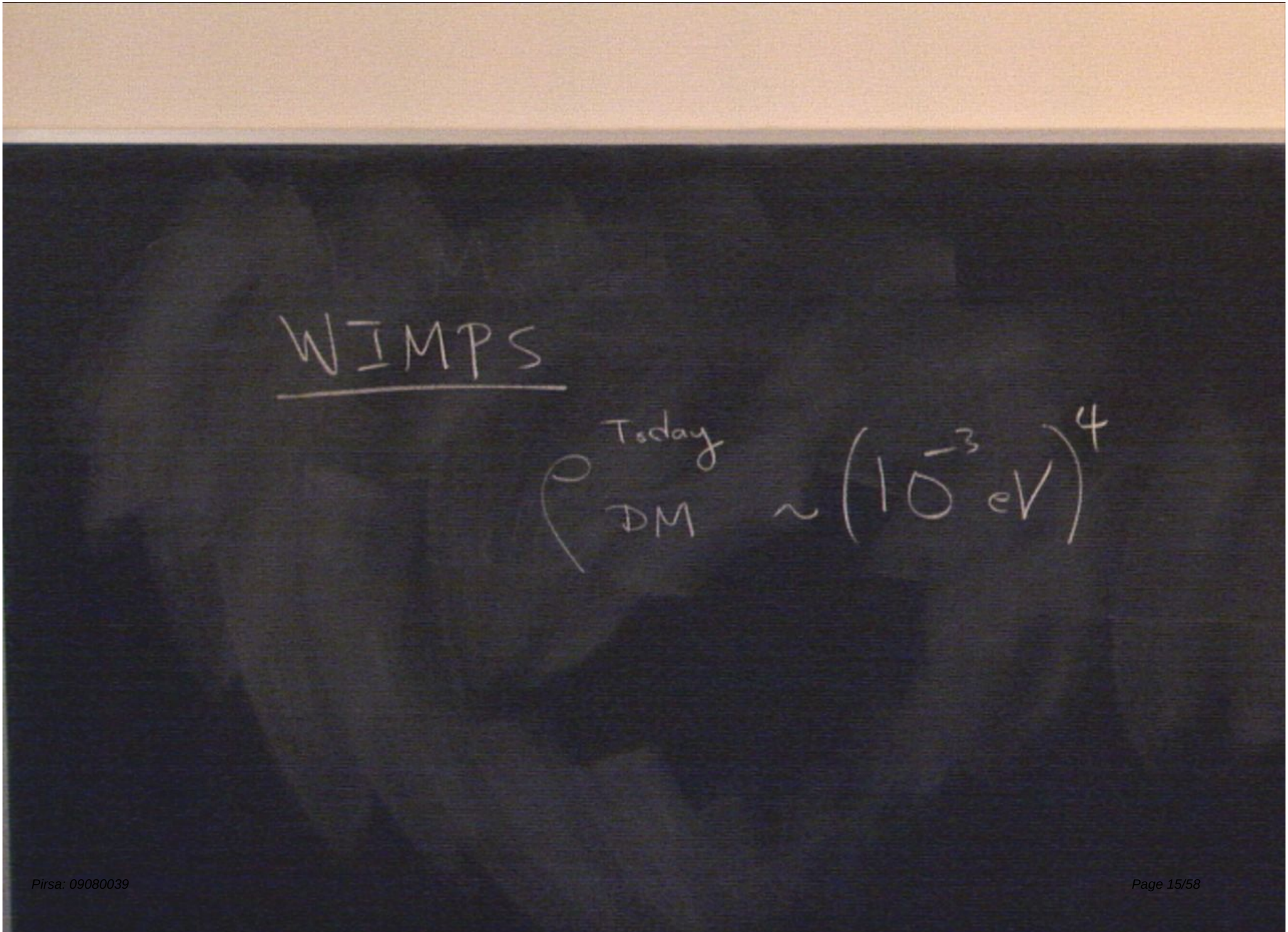


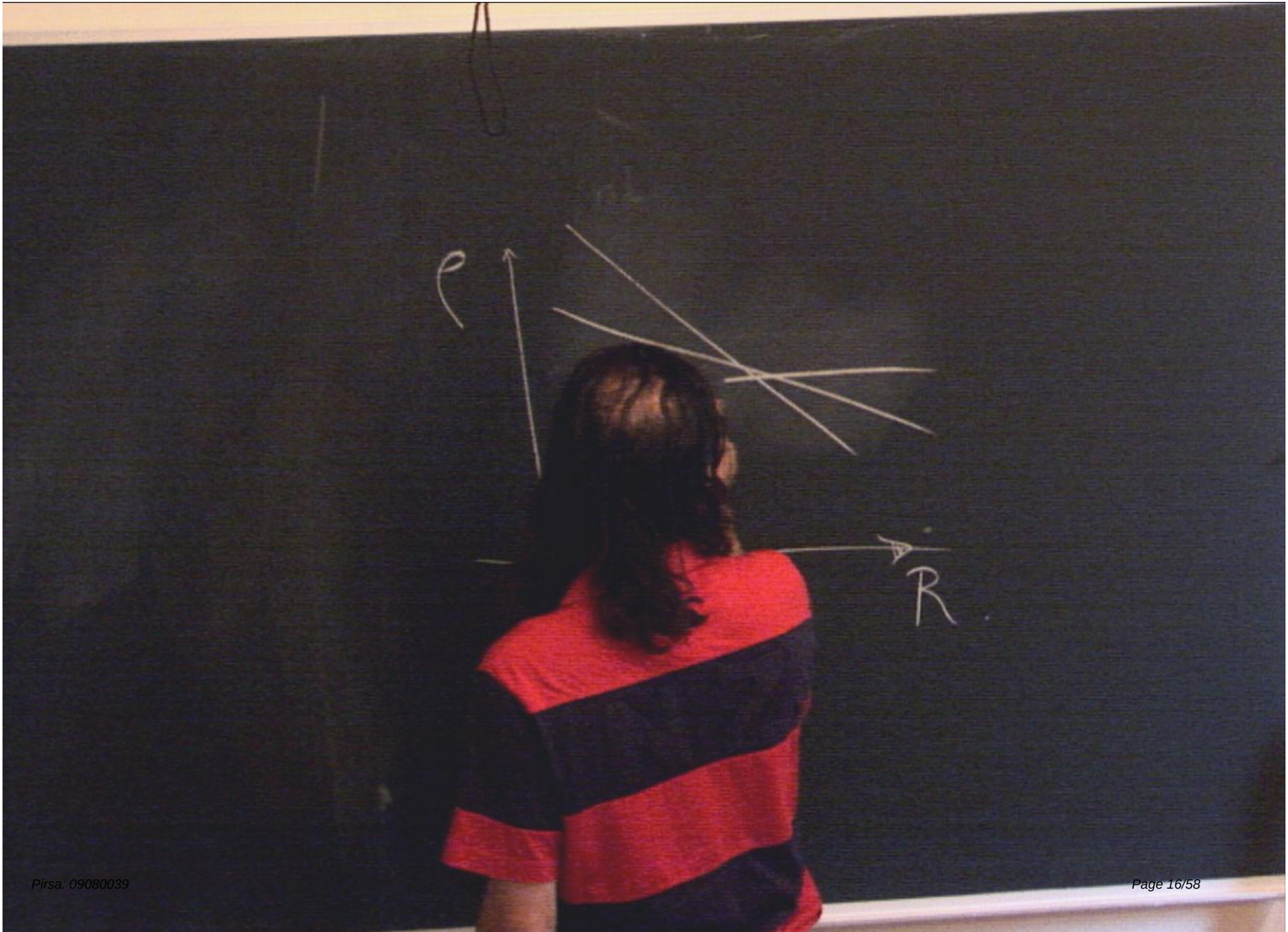
Dark Matter

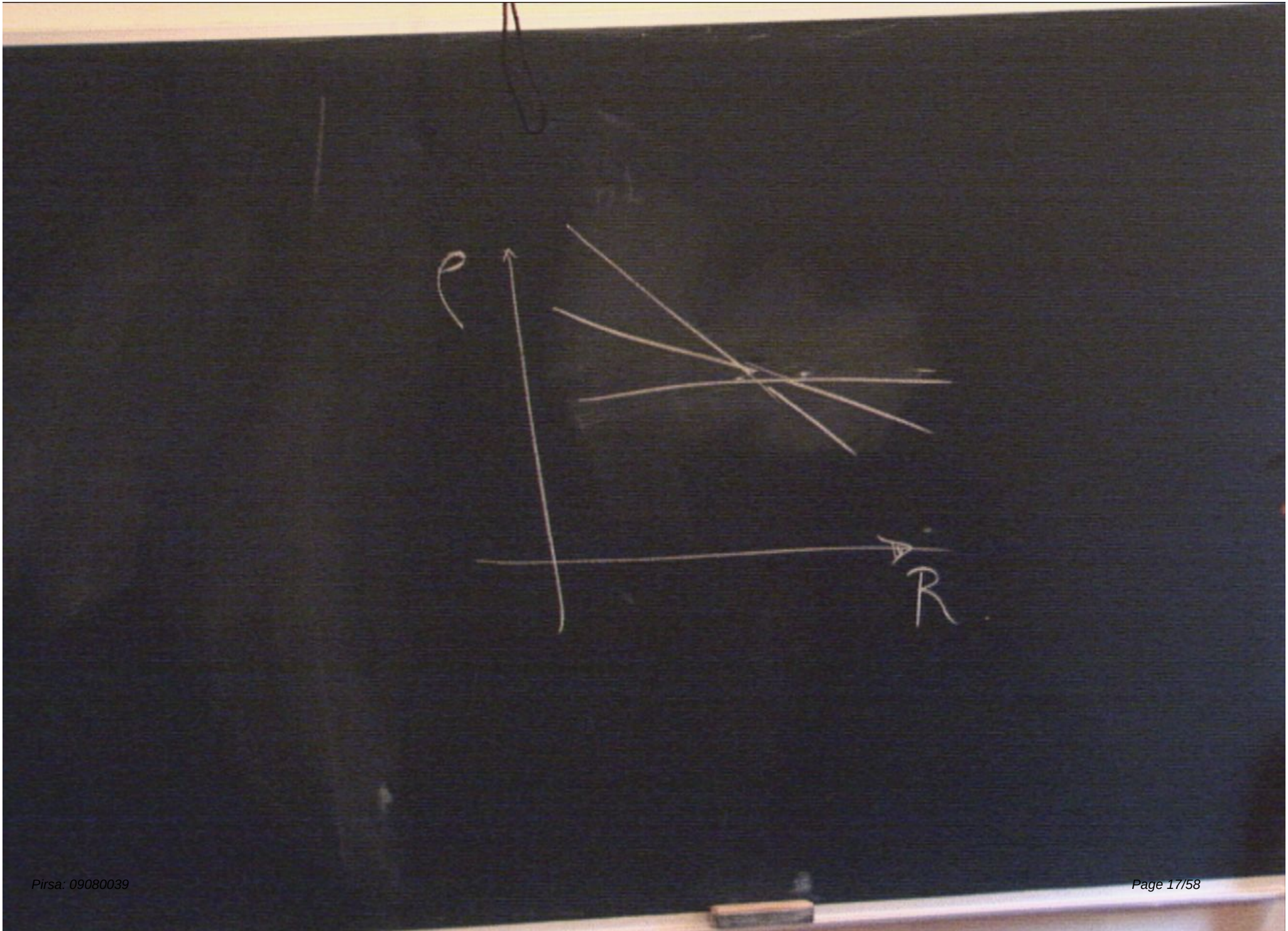


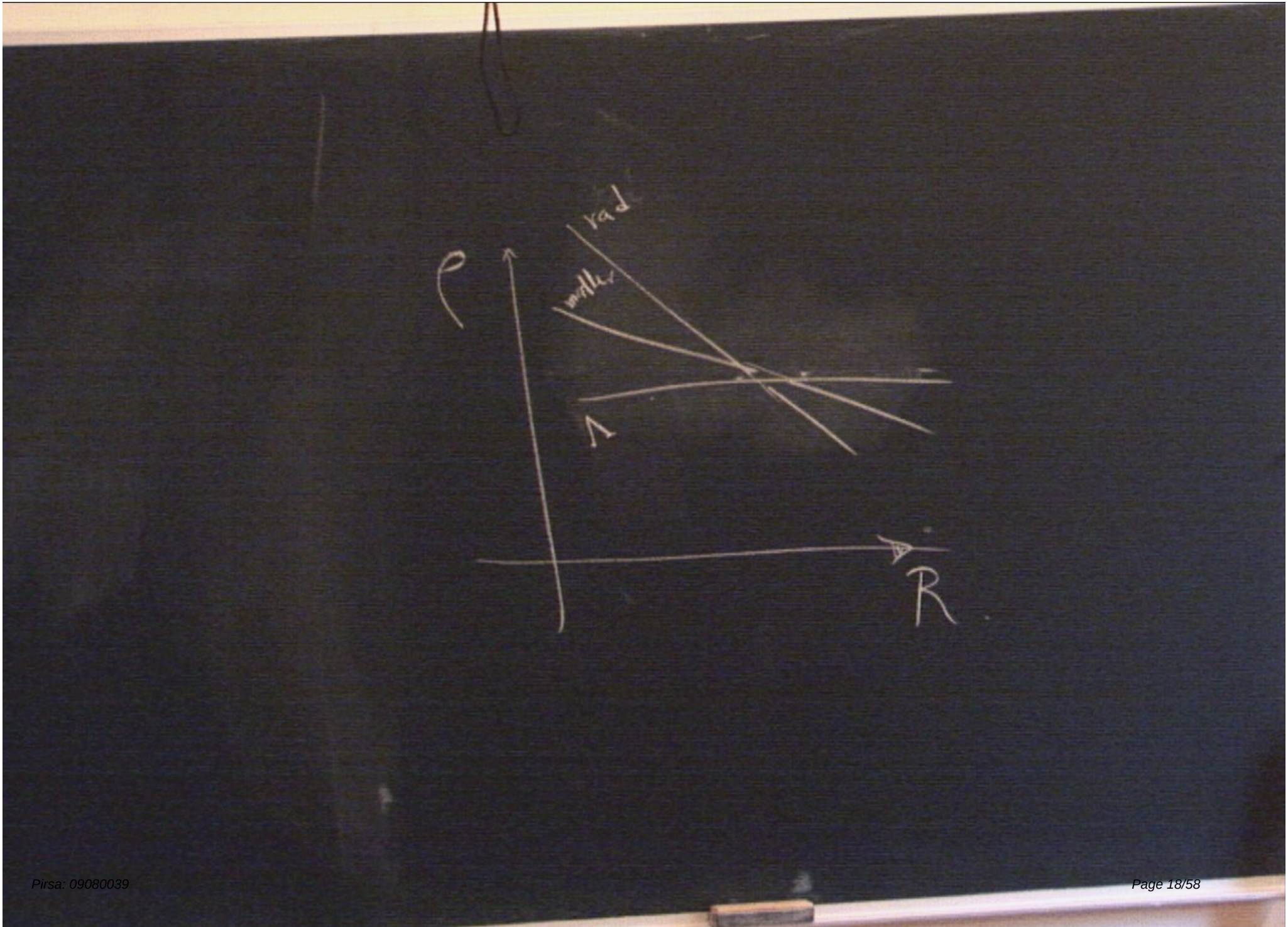

R

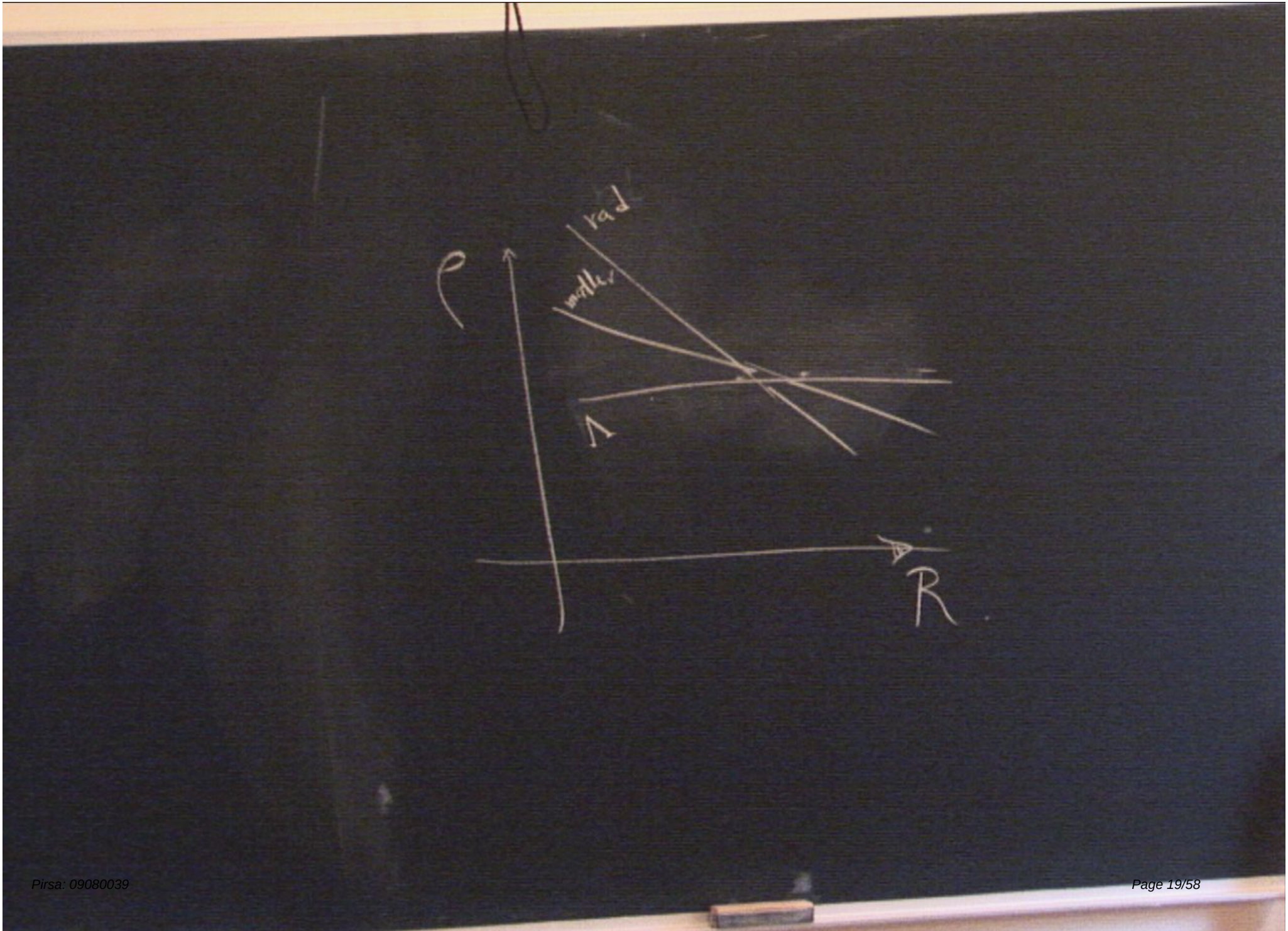

WIMPS
Today
DM ~

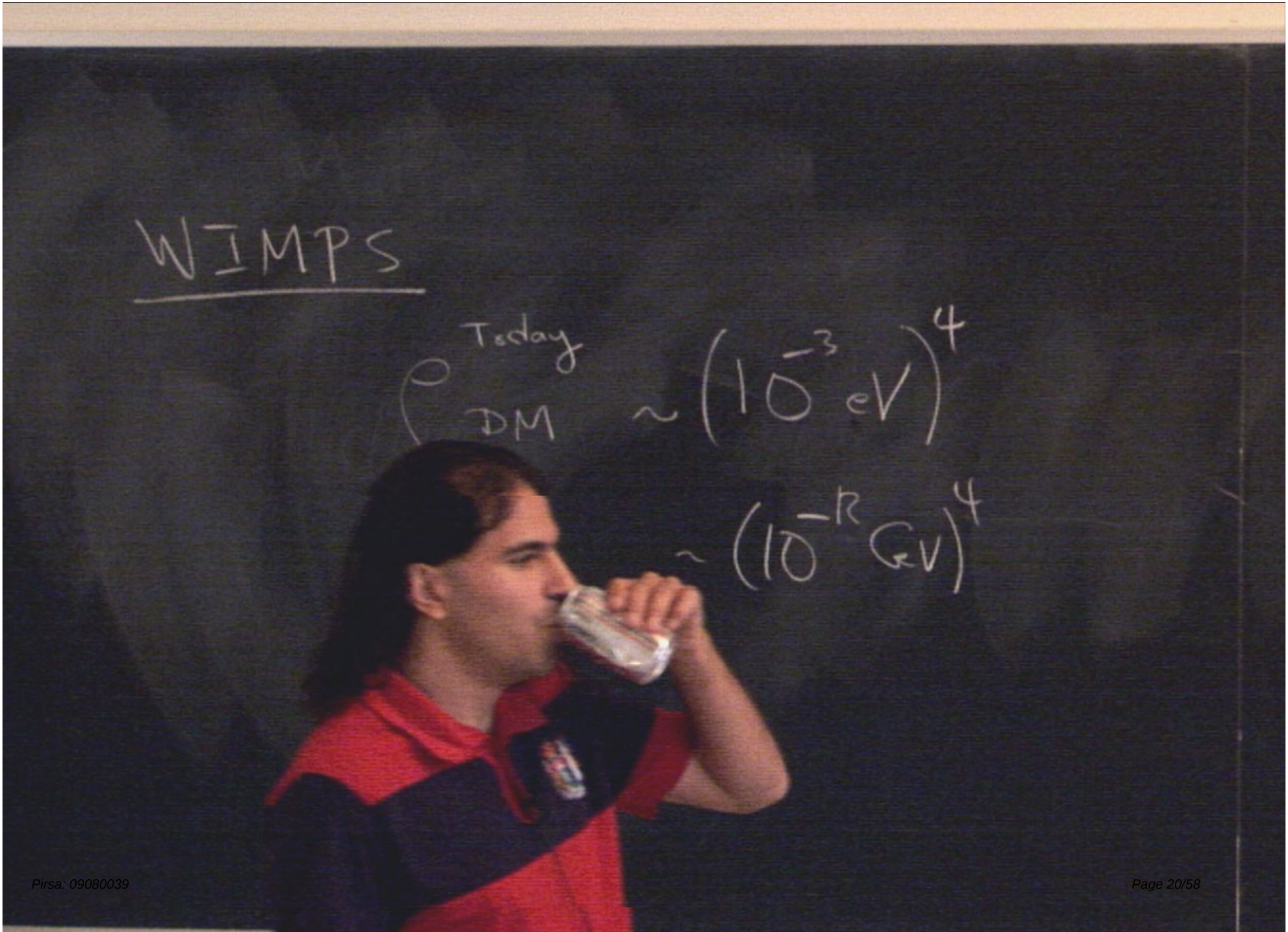

WIMPS
$\rho_{DM}^{Today} \sim (10^{-3}\,eV)^4$


R


P
R


rad
matter
Λ
R

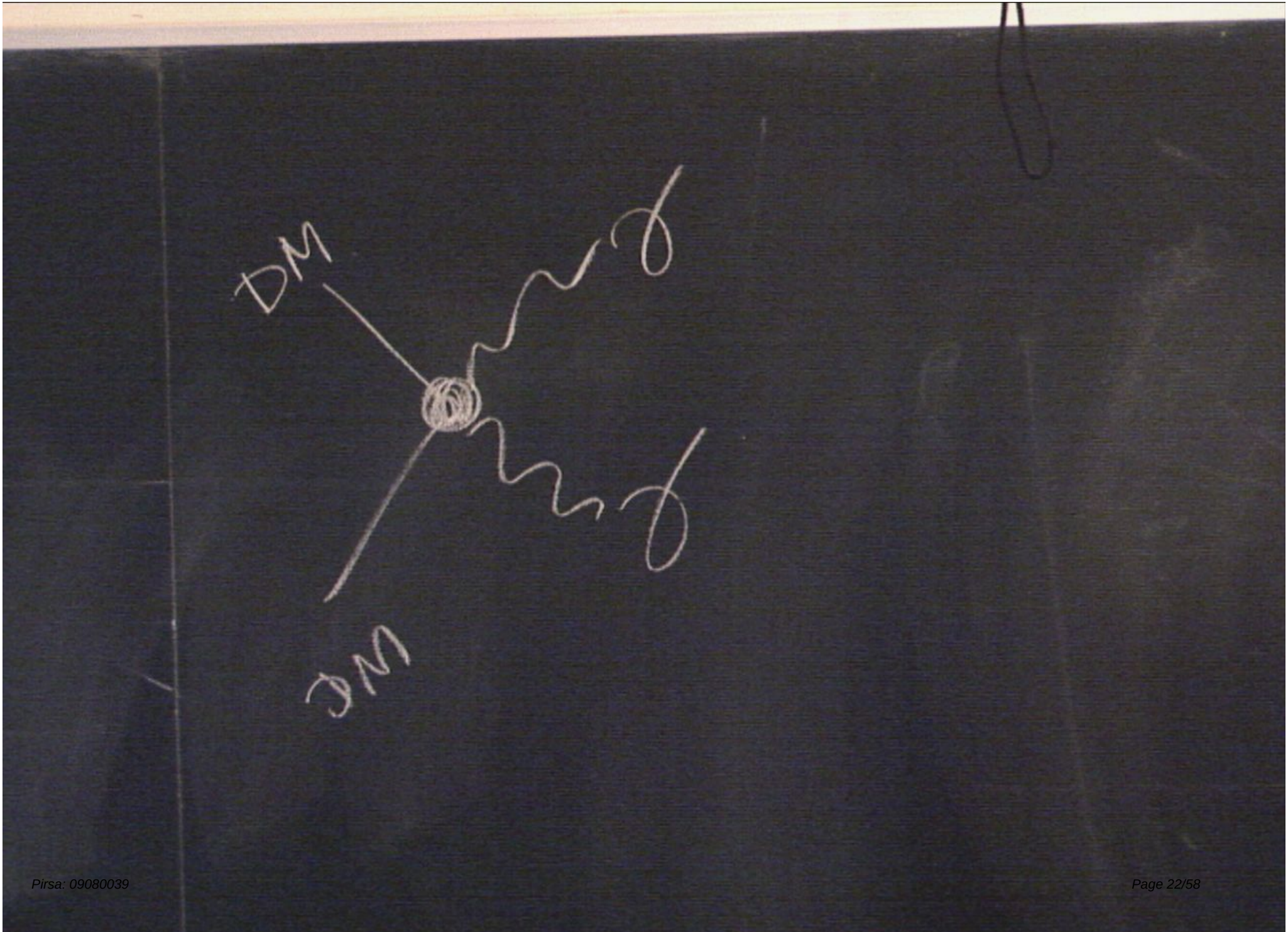

rad
matter
Λ
A
R


WIMPS
$\rho_{DM}^{Today} \sim (10^{-3}\ eV)^4$
$\sim (10^{-R}\ GeV)^4$

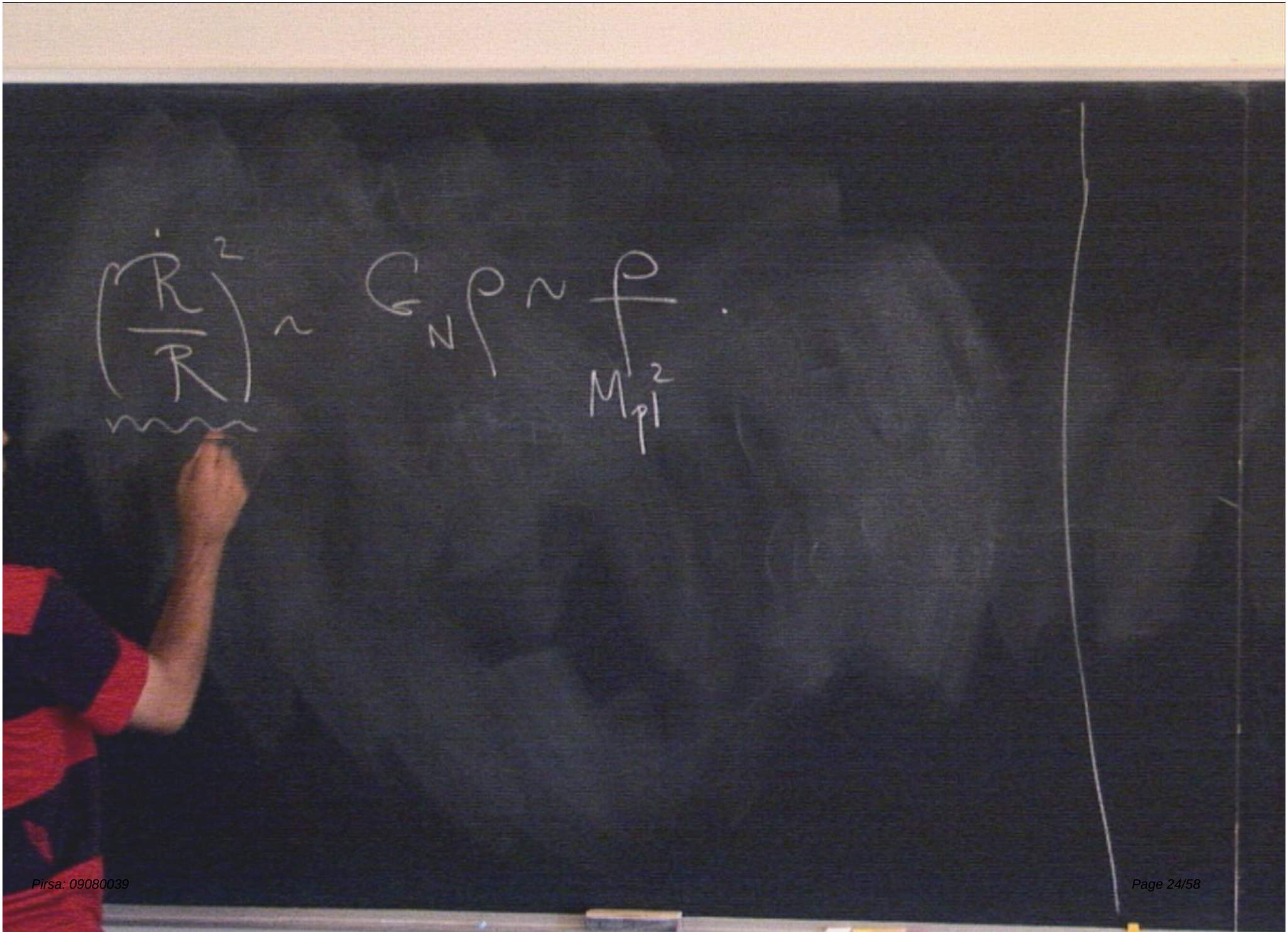
WIMPS

$$\rho_{DM}^{Today} \sim (10^{-3}\ eV)^4$$

$$\sim (10^{-R}\ GeV)^4$$


DM
γ
γ
DM


DM
γ
γ
DM
T >> m_DM
σ ~ 1/m_DM²

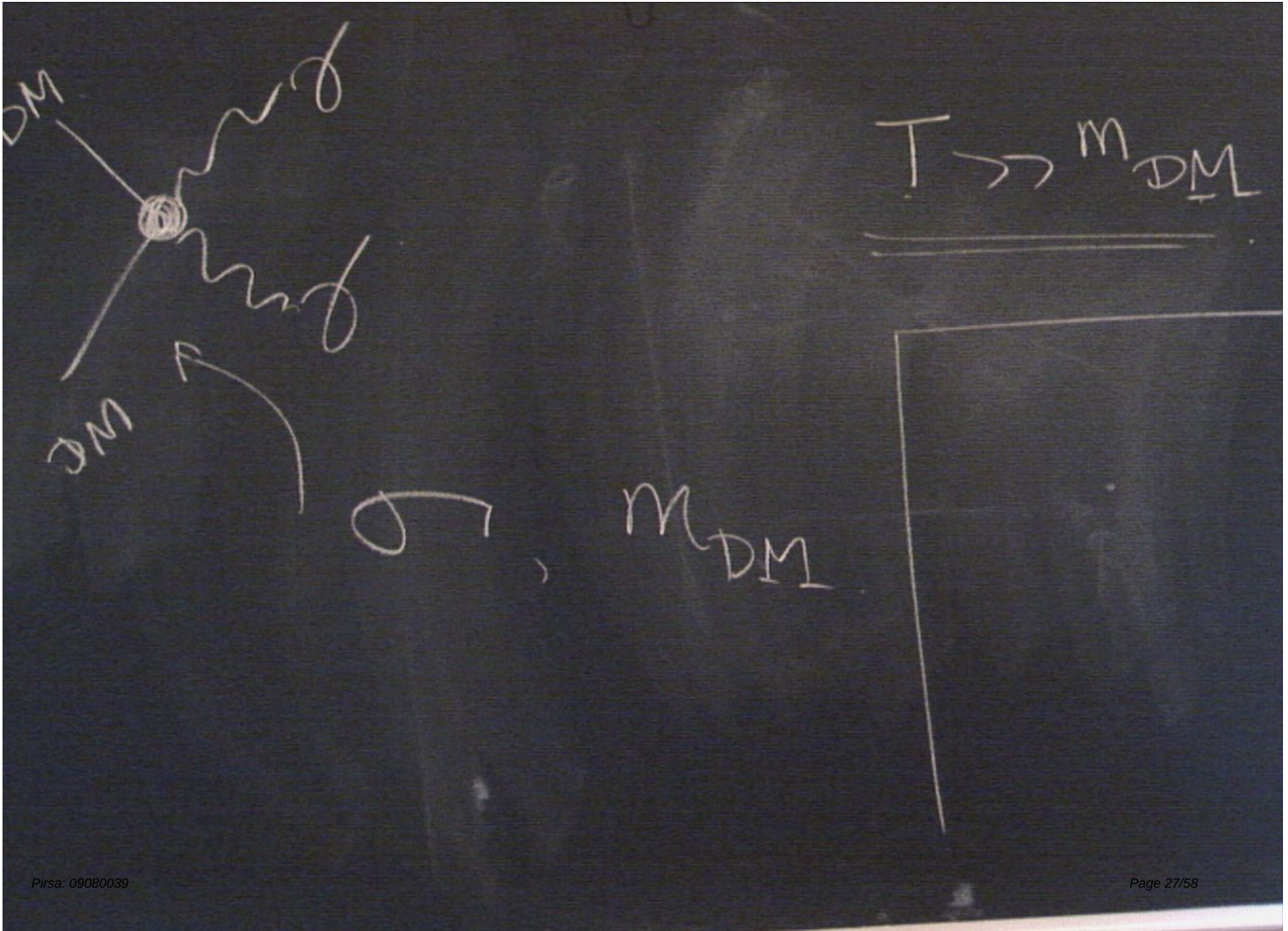

$\left(\frac{\dot{R}}{R}\right)^2 \sim G_N \rho \sim \frac{\rho}{M_{pl}^2}$.

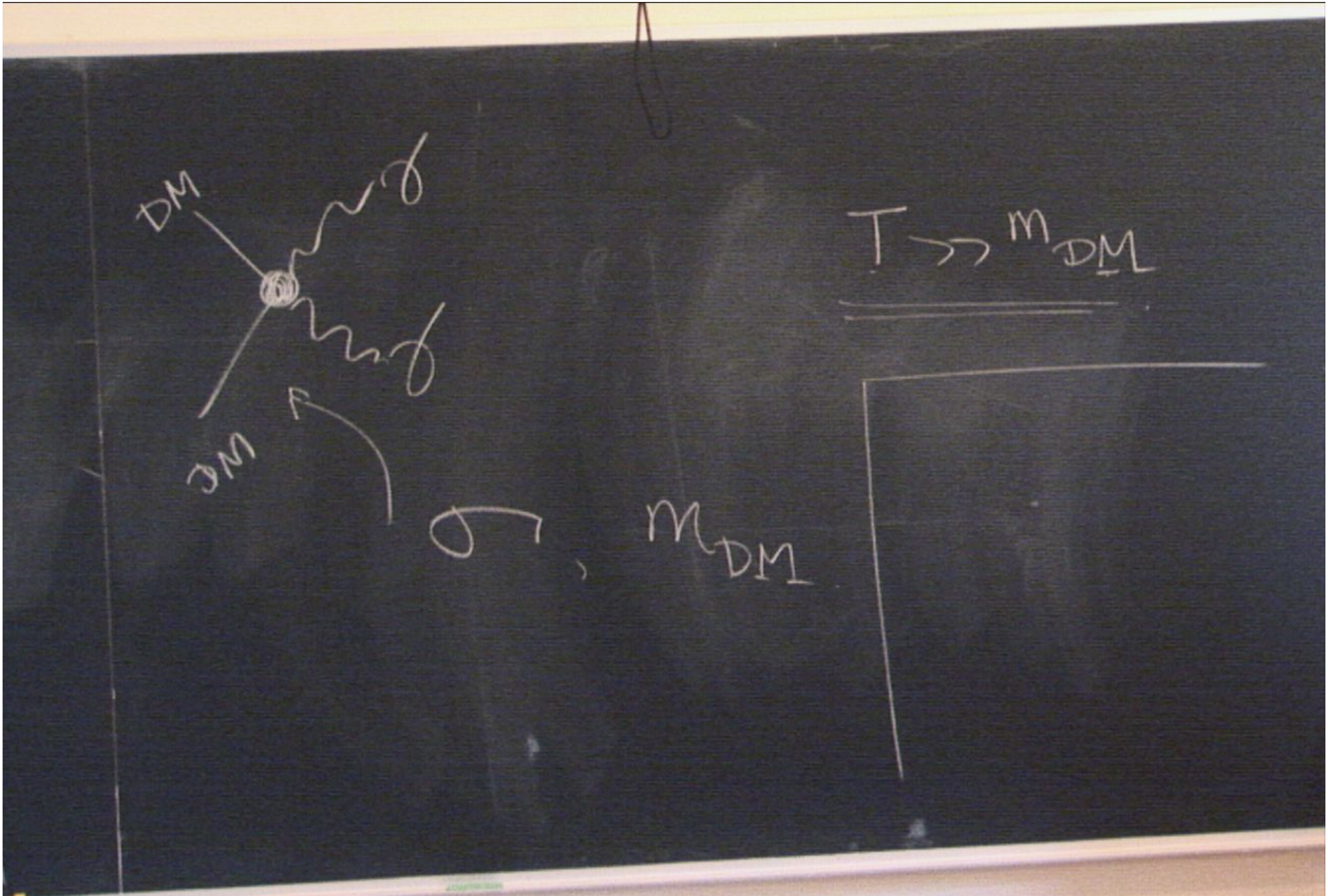
$$\left(\frac{\dot{R}}{R}\right)^2 \sim G_N \rho \sim \frac{\rho}{M_{Pl}^2} .$$

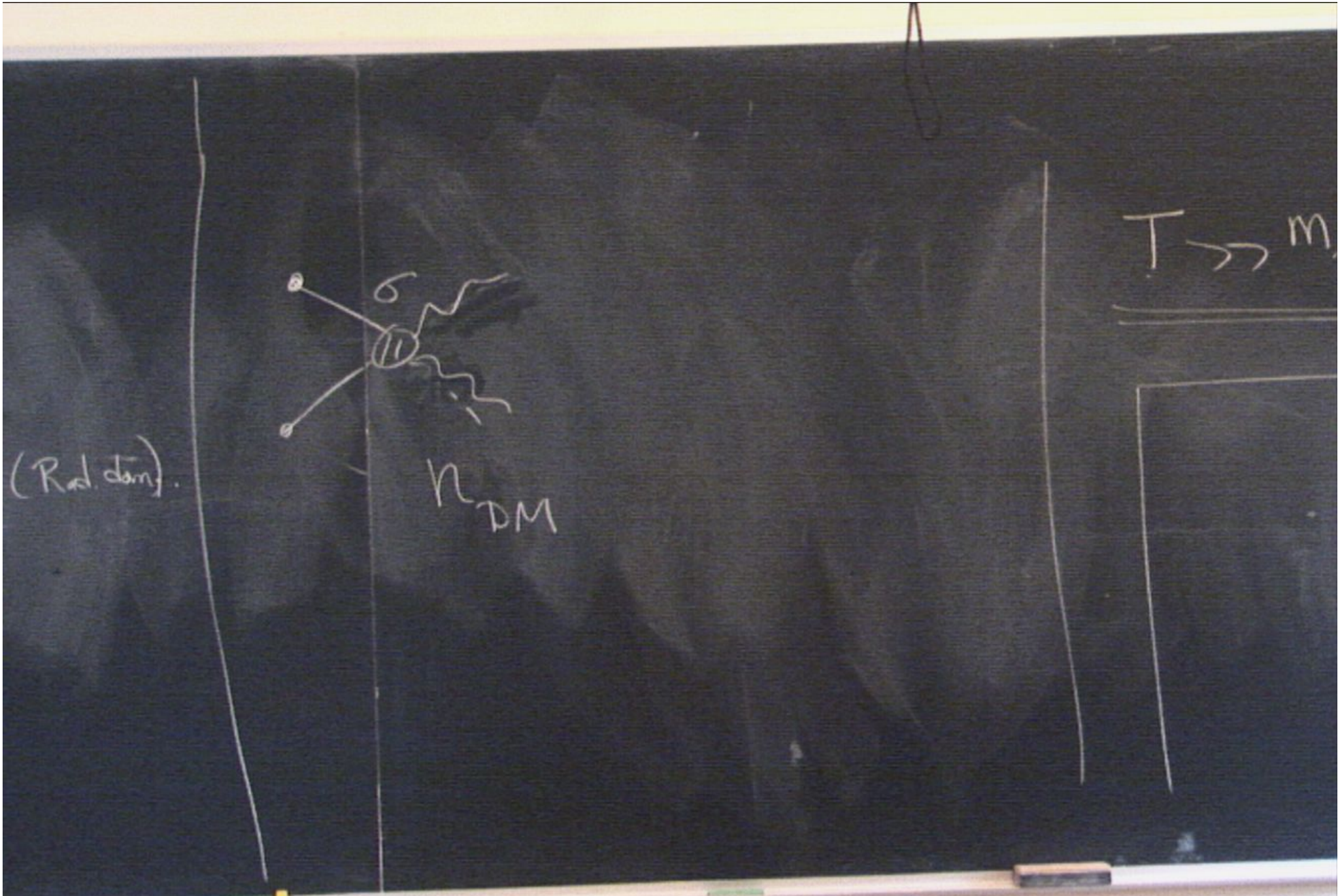
$$H^2 \sim \frac{\rho}{M_{Pl}^2}$$

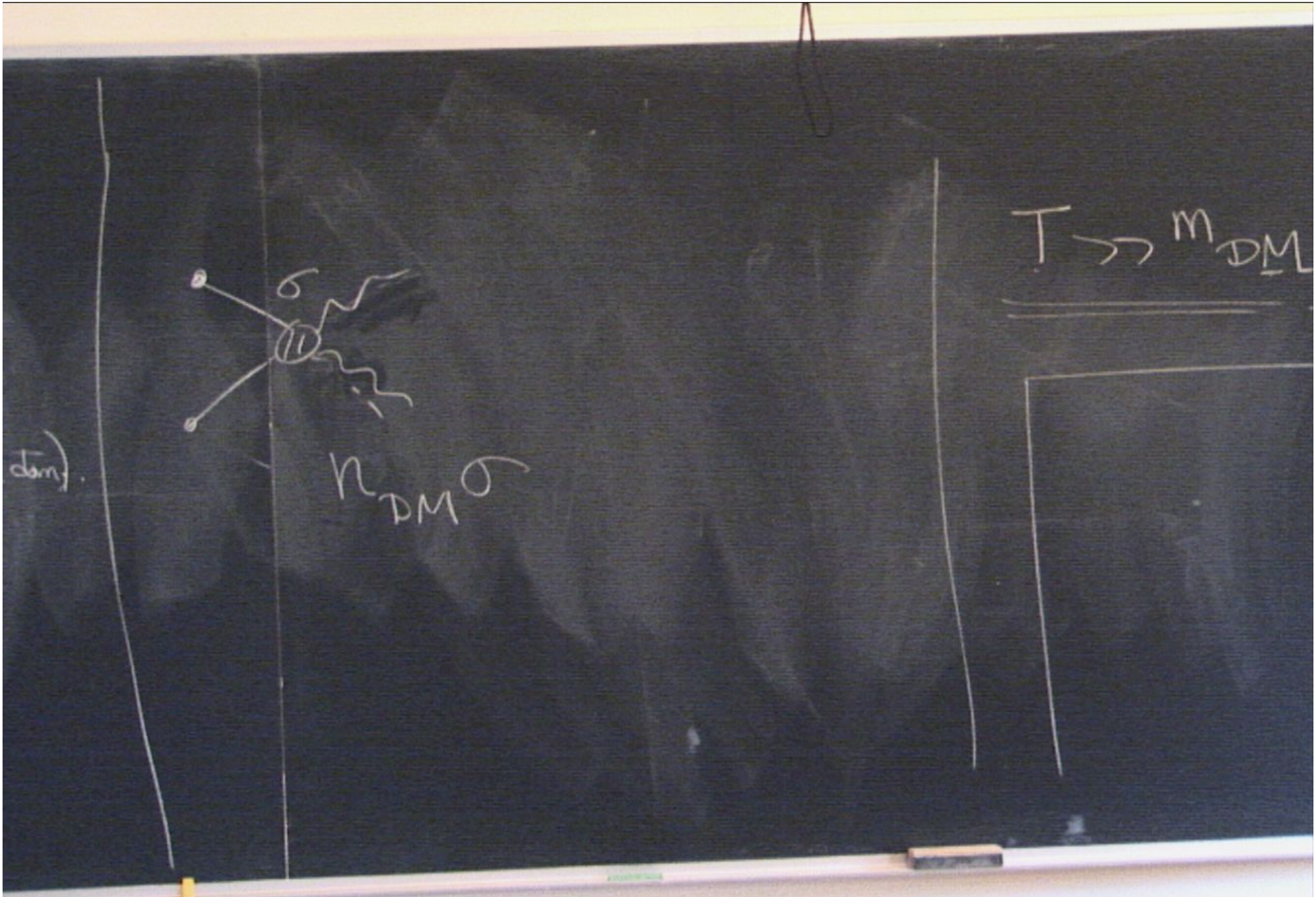
$$\left(\frac{\dot{R}}{R}\right)^2 \sim G_N \rho \sim \frac{\rho}{M_{pl}^2} .$$

$$H^2 \sim \frac{\rho}{M_{pl}^2} \sim \frac{T^4}{M_{pl}^2} \quad \text{(Rad. dom.)} .$$


DM
DM
$T \gg m_{DM}$
σ, m_{DM}


DM
γ
γ
DM
T >> m_DM
σ ~ m_DM

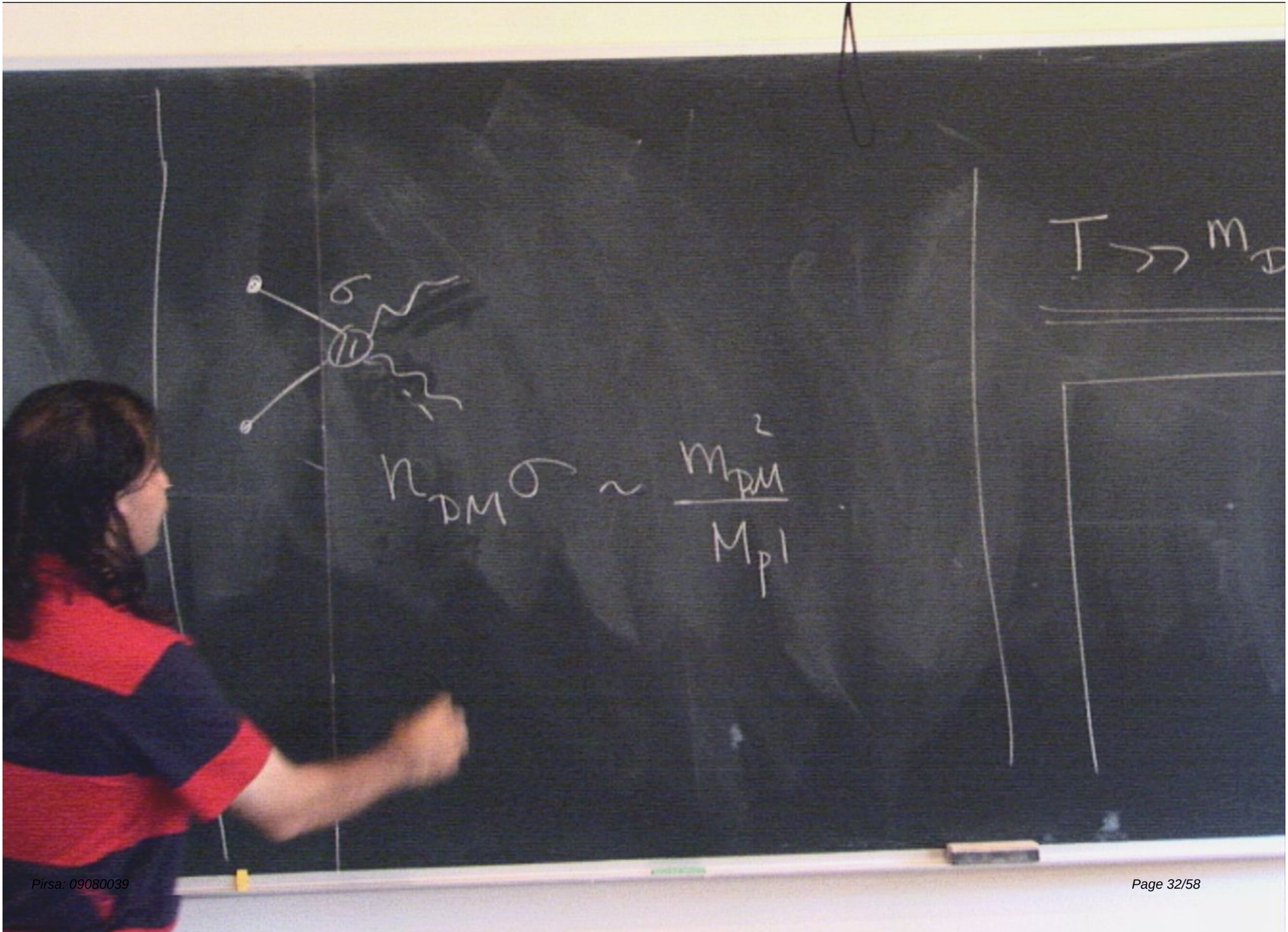

T >> m
(Rad. dom).
σ
n_{DM}

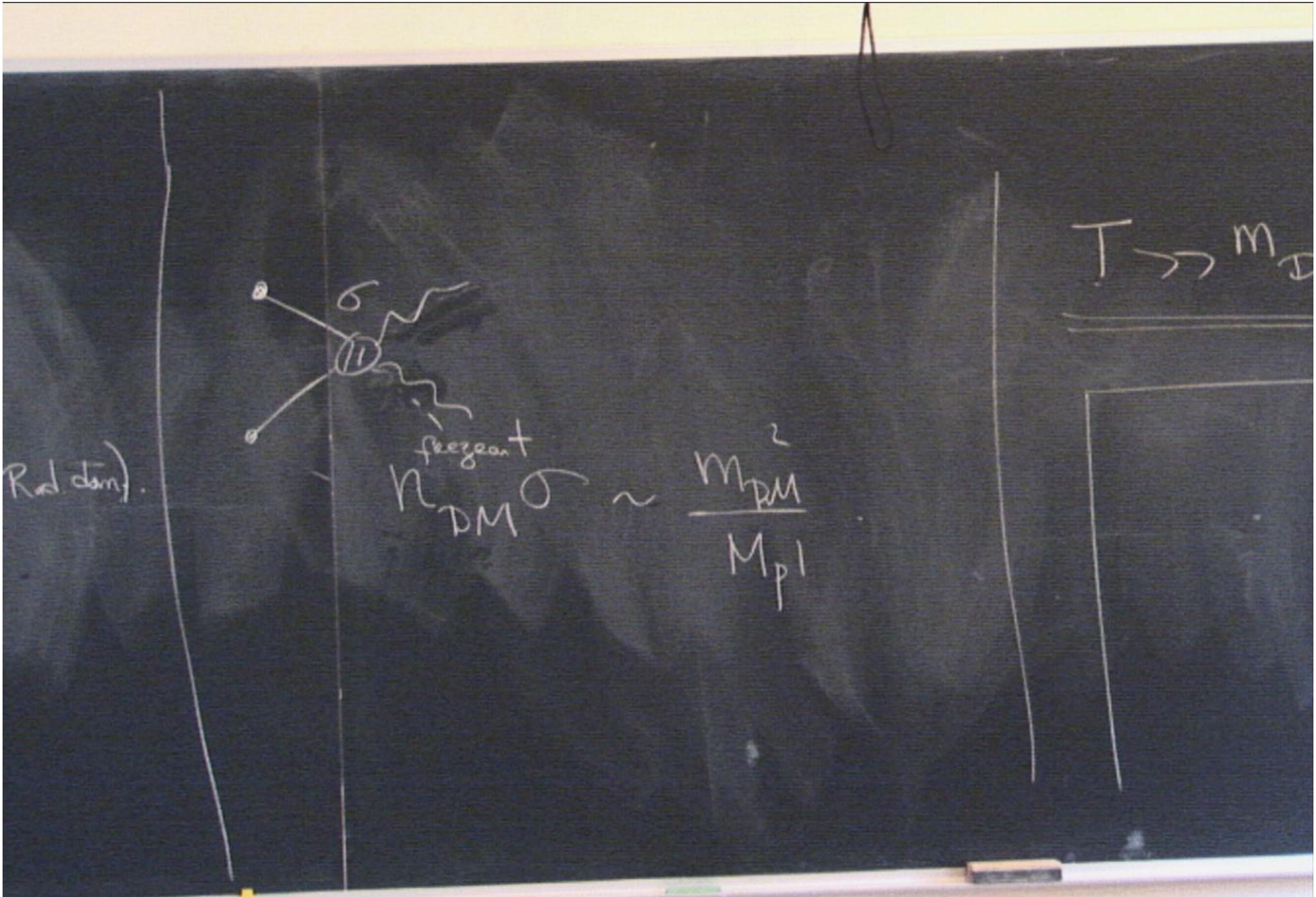

σ
$n_{DM}\sigma$
$T \gg m_{DM}$

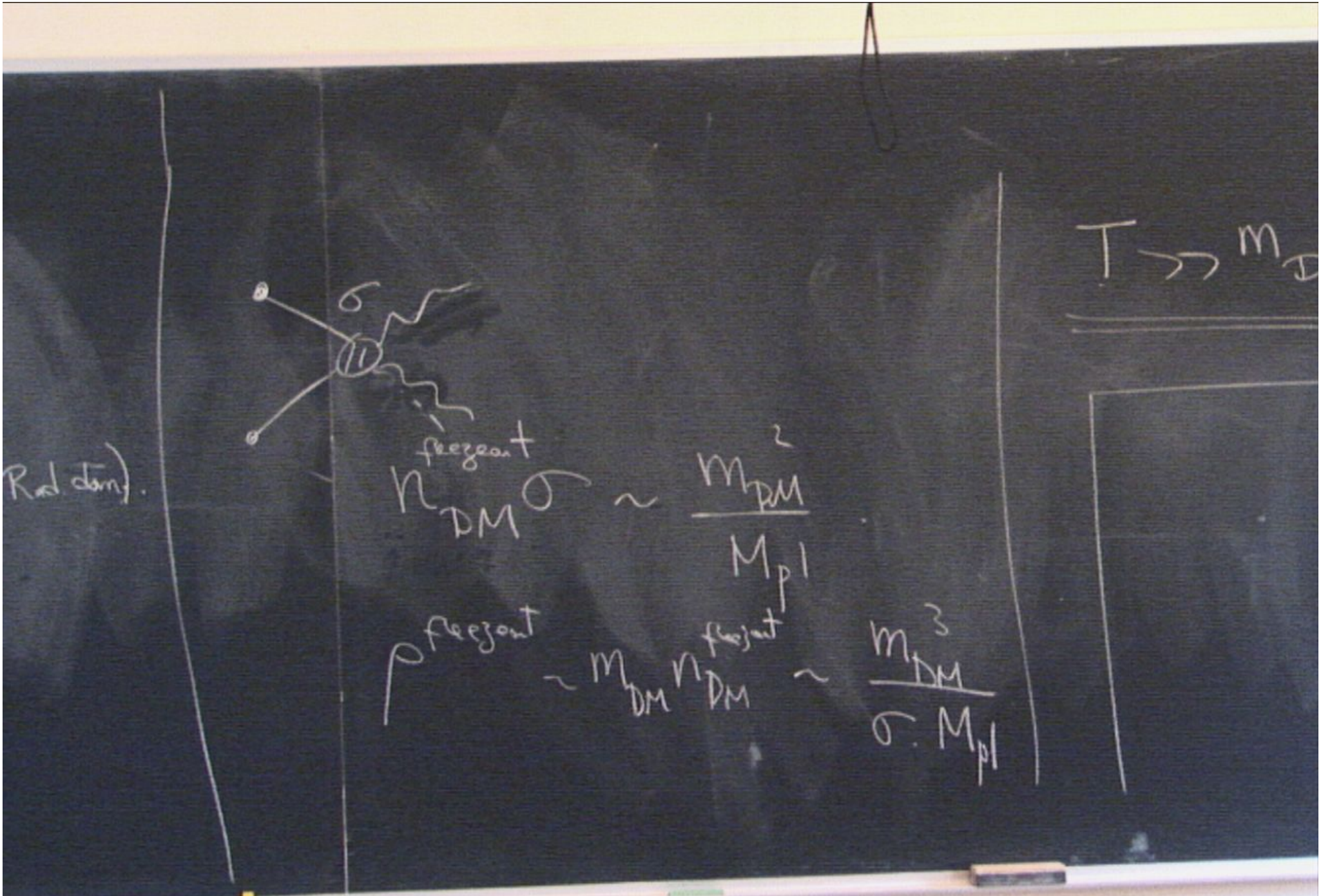
$$\left(\frac{\dot{R}}{R}\right)^2 \sim G_N \rho \sim \frac{\rho}{M_{Pl}^2} .$$

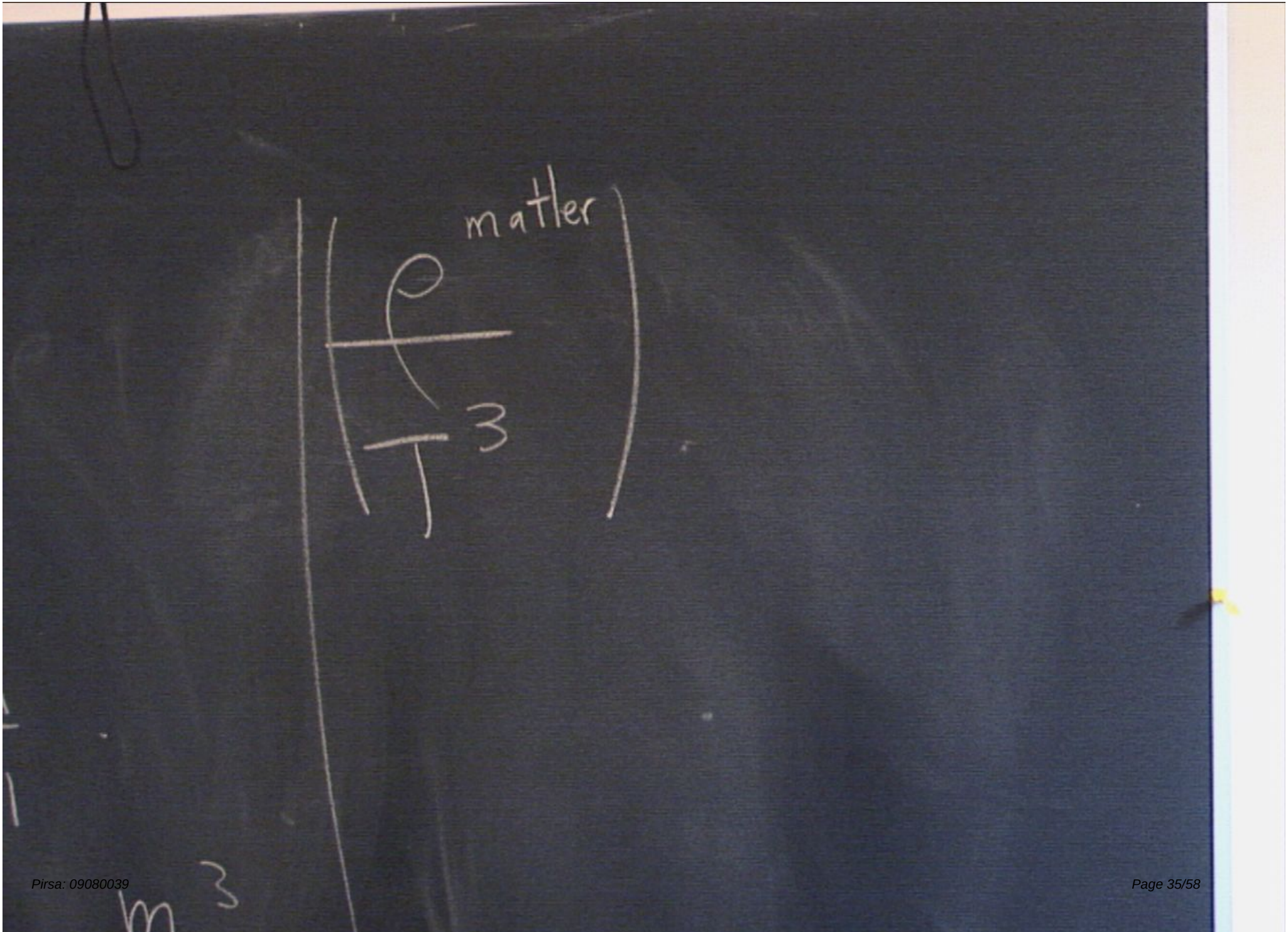
$$H^2 \sim \frac{\rho}{M_{Pl}^2} \sim \frac{T^4}{M_{Pl}^2} \quad (\text{Rad. dom.}) .$$

$$H \sim \frac{T^2}{M_{Pl}}$$


σ
$n_{DM}\sigma \sim \frac{m_{DM}^2}{M_{Pl}}$
$T \gg m_D$


σ
freezout
$n_{DM}\sigma \sim \frac{m_{DM}^2}{M_{Pl}}$
(Rad. dom).
$T \gg m_D$


σ
freezout
$n_{DM}\sigma \sim \frac{m_{DM}^2}{M_{pl}}$
$\rho^{freezout} \sim m_{DM} n_{DM}^{freezout} \sim \frac{m_{DM}^3}{\sigma \cdot M_{pl}}$
T >> m
Rad. dom.

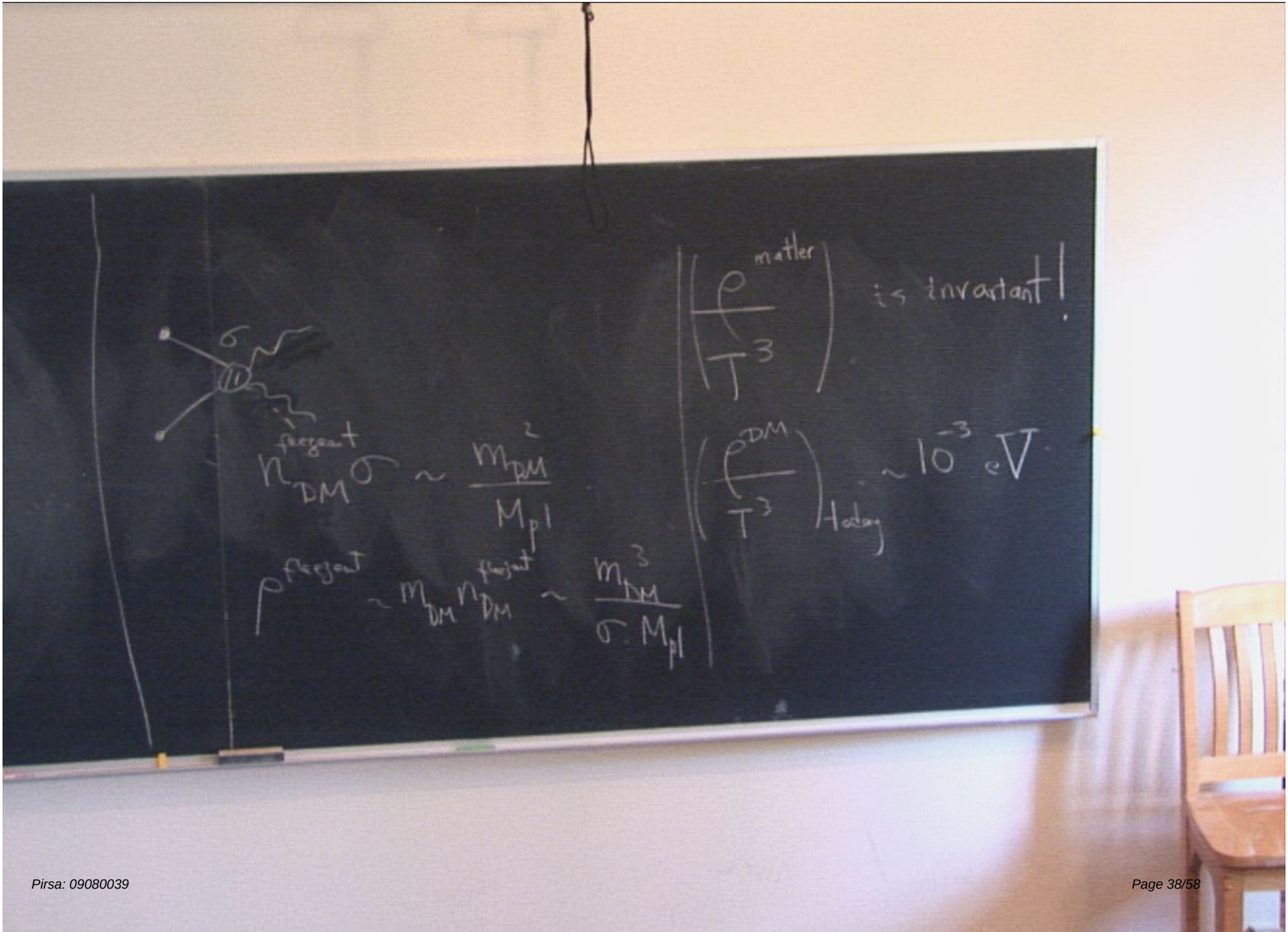

matter
3

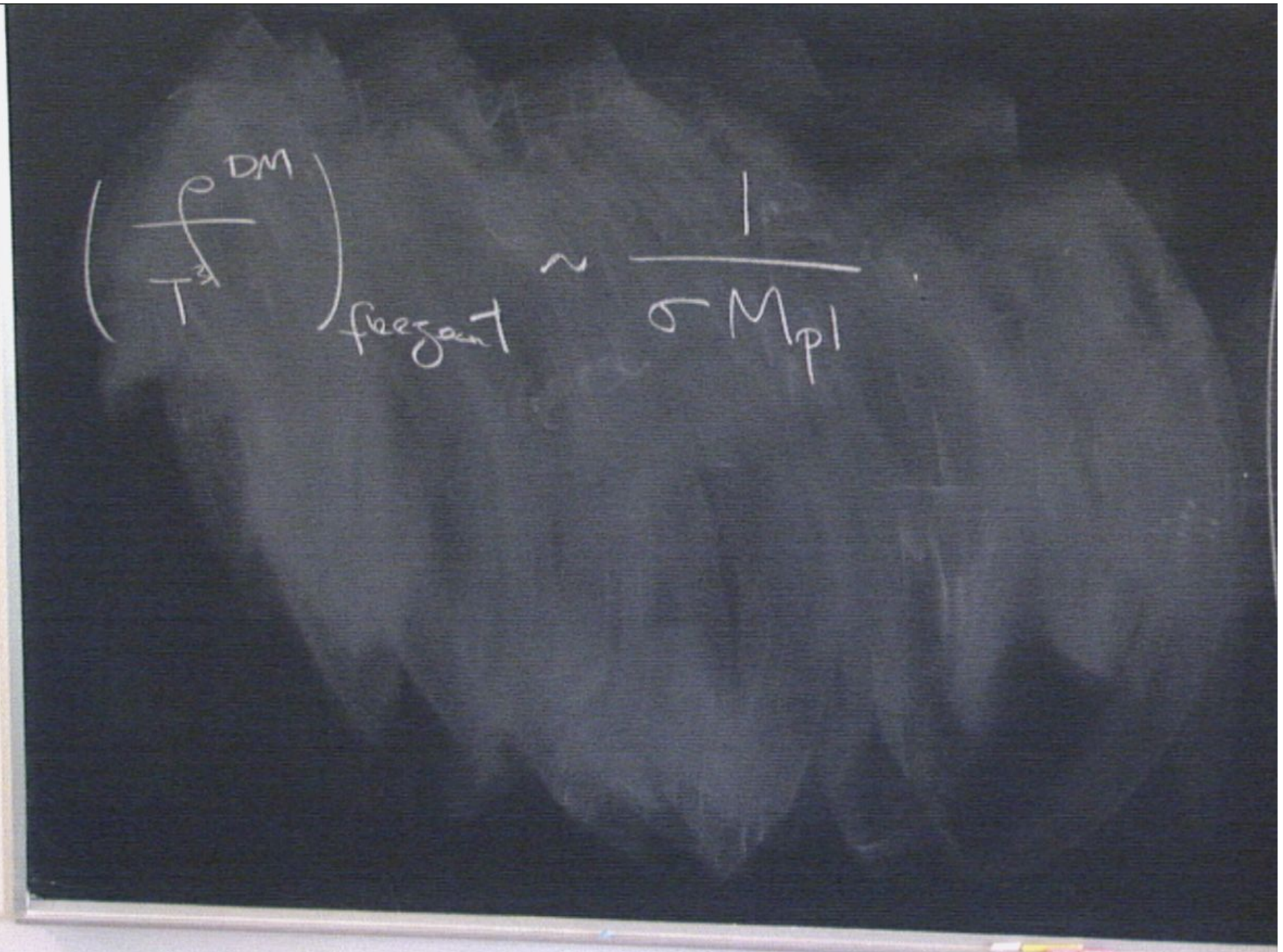
$$\left(\frac{\rho^{\text{matter}}}{T^3}\right)$$ is invariant!

$$\left(\frac{\rho^{matter}}{T^3}\right) \text{ is invariant!}$$

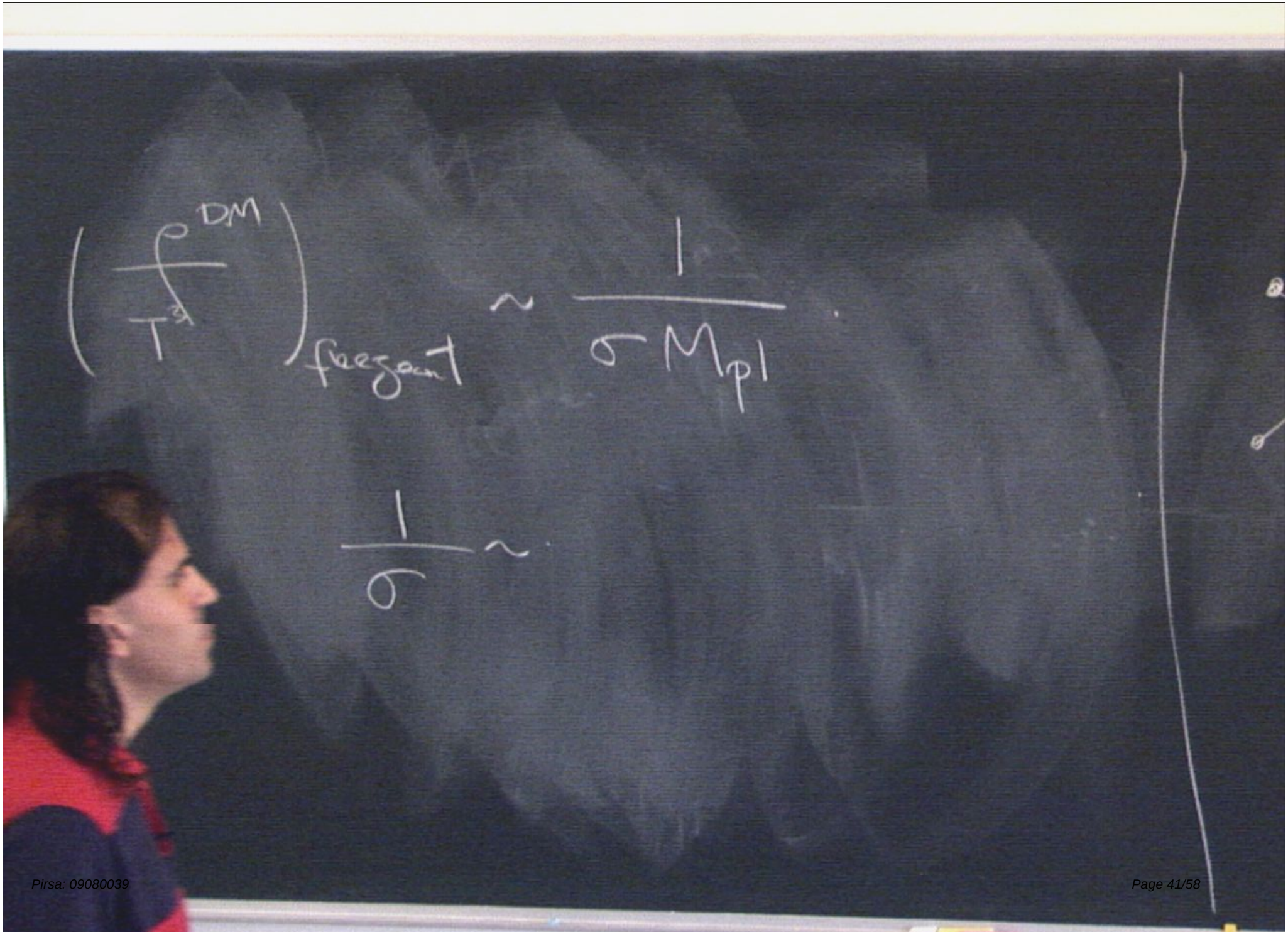
$$\left(\frac{\rho^{DM}}{T^3}\right)_{today} \sim 10^{-3}\ eV$$

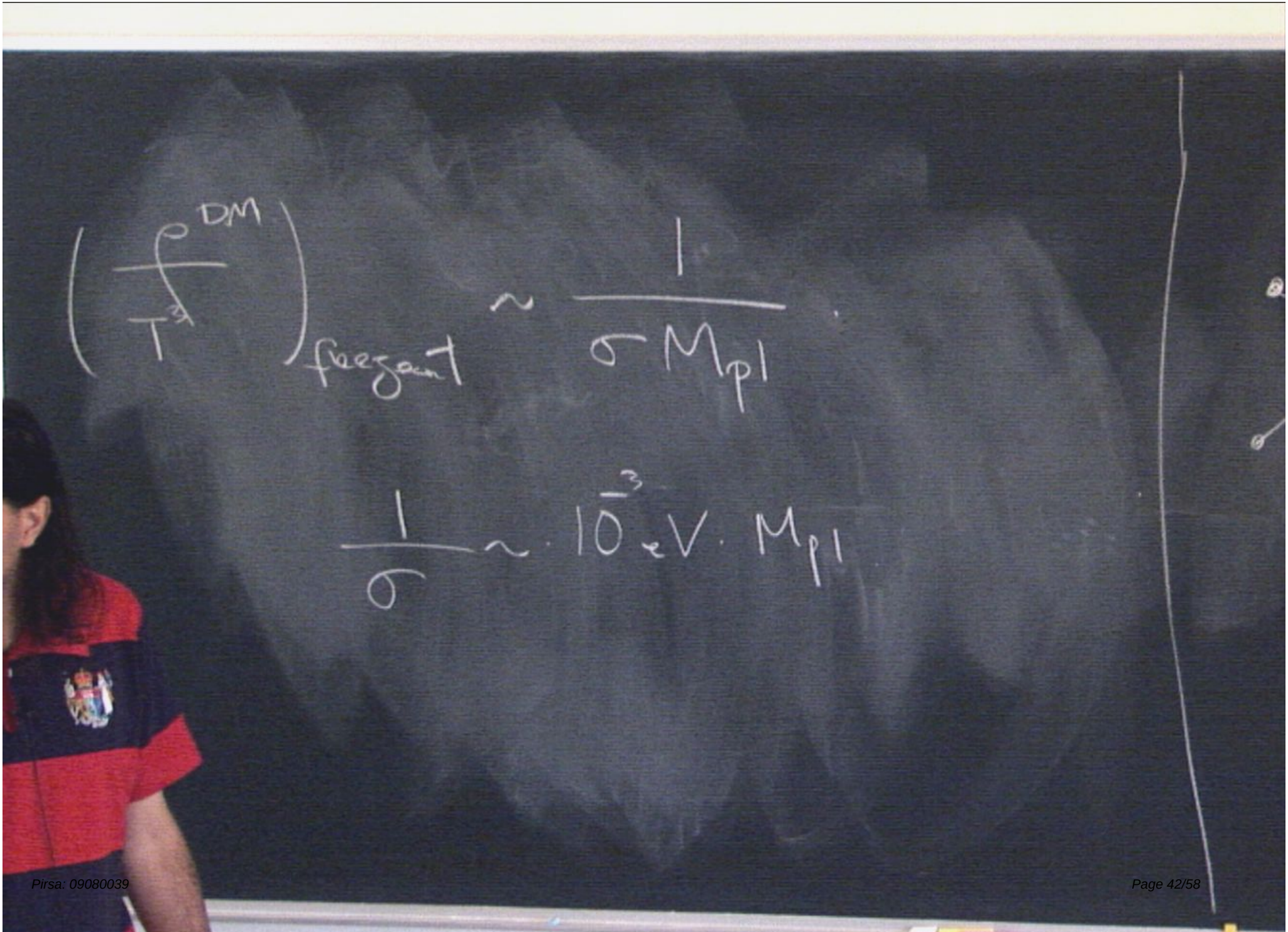
m^3

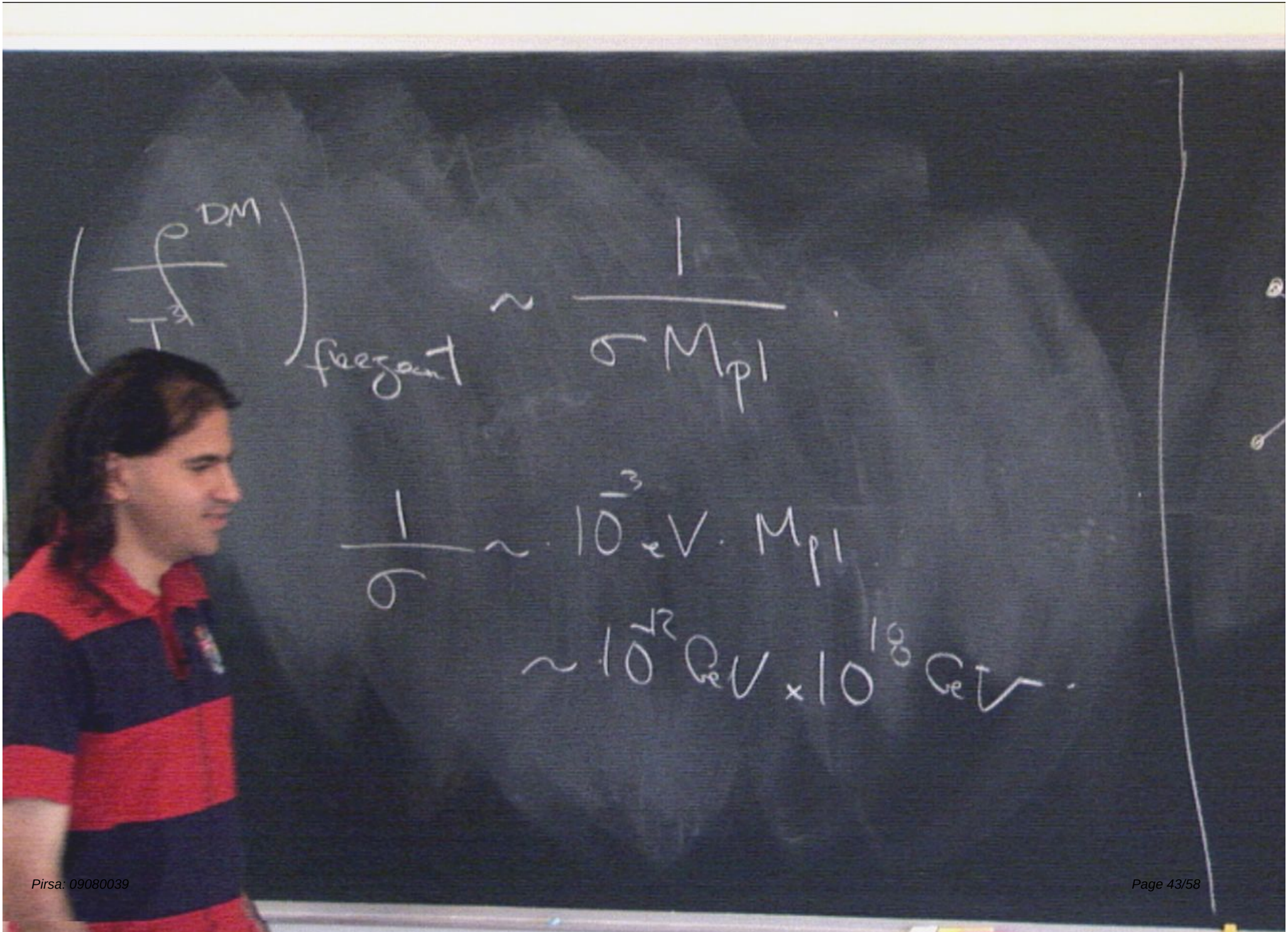

$\left(\frac{\rho^{matter}}{T^3}\right)$ is invariant!
σ
freezout
$n_{DM}\sigma \sim \frac{m_{DM}^2}{M_{pl}}$
$\left(\frac{\rho^{DM}}{T^3}\right)_{today} \sim 10^{-3}$ eV
$\rho^{freezout} \sim m_{DM} n_{DM}^{freezout} \sim \frac{m_{DM}^3}{\sigma M_{pl}}$

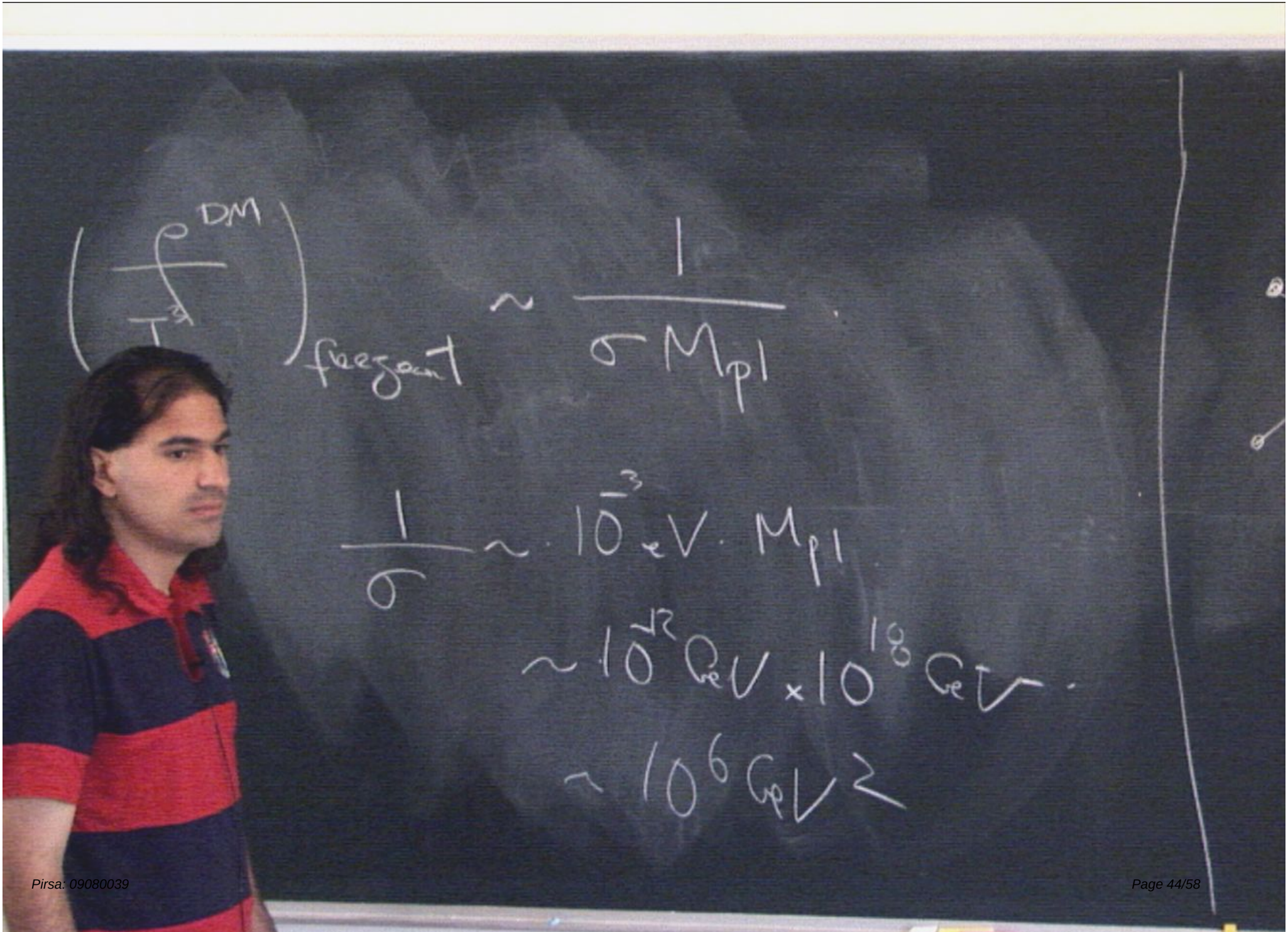

$\left(\frac{\rho^{DM}}{T^3}\right)_{freezout} \sim \frac{1}{\sigma M_{pl}}$

$$\left(\frac{\rho^{DM}}{T^3}\right)_{freezout} \sim \frac{1}{\sigma M_{Pl}}$$


$\left(\frac{\rho^{DM}}{T^3}\right)_{freezout} \sim \frac{1}{\sigma M_{pl}}$
$\frac{1}{\sigma} \sim$


$\left(\frac{\rho^{DM}}{T^3}\right)_{freezout} \sim \frac{1}{\sigma M_{Pl}}$
$\frac{1}{\sigma} \sim 10^{-3} eV \cdot M_{Pl}$


$\left(\frac{\rho^{DM}}{T^3}\right)_{freezout} \sim \frac{1}{\sigma M_{Pl}}$.
$\frac{1}{\sigma} \sim 10^{-3} eV \cdot M_{Pl}$
$\sim 10^{-12} GeV \times 10^{18} GeV$.


$\left(\frac{\rho^{DM}}{T^3}\right)_{freezout} \sim \frac{1}{\sigma M_{Pl}}$
$\frac{1}{\sigma} \sim 10^{-3}\,eV \cdot M_{Pl}$
$\sim 10^{12}\,GeV \times 10^{18}\,GeV$
$\sim 10^{6}\,GeV^2$

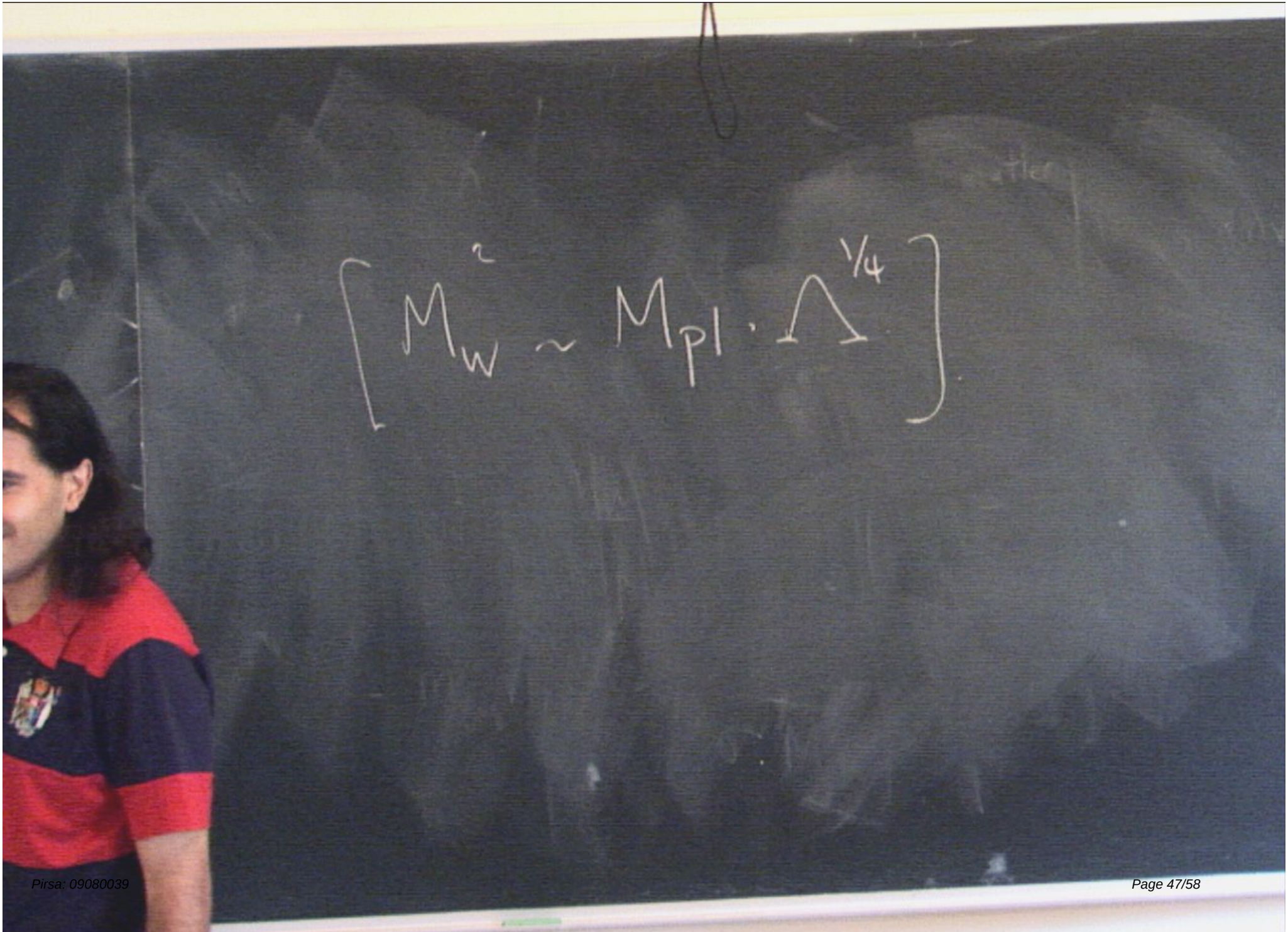
$$\left(\frac{\rho^{DM}}{T^3}\right)_{freezout} \sim \frac{1}{\sigma M_{Pl}}$$

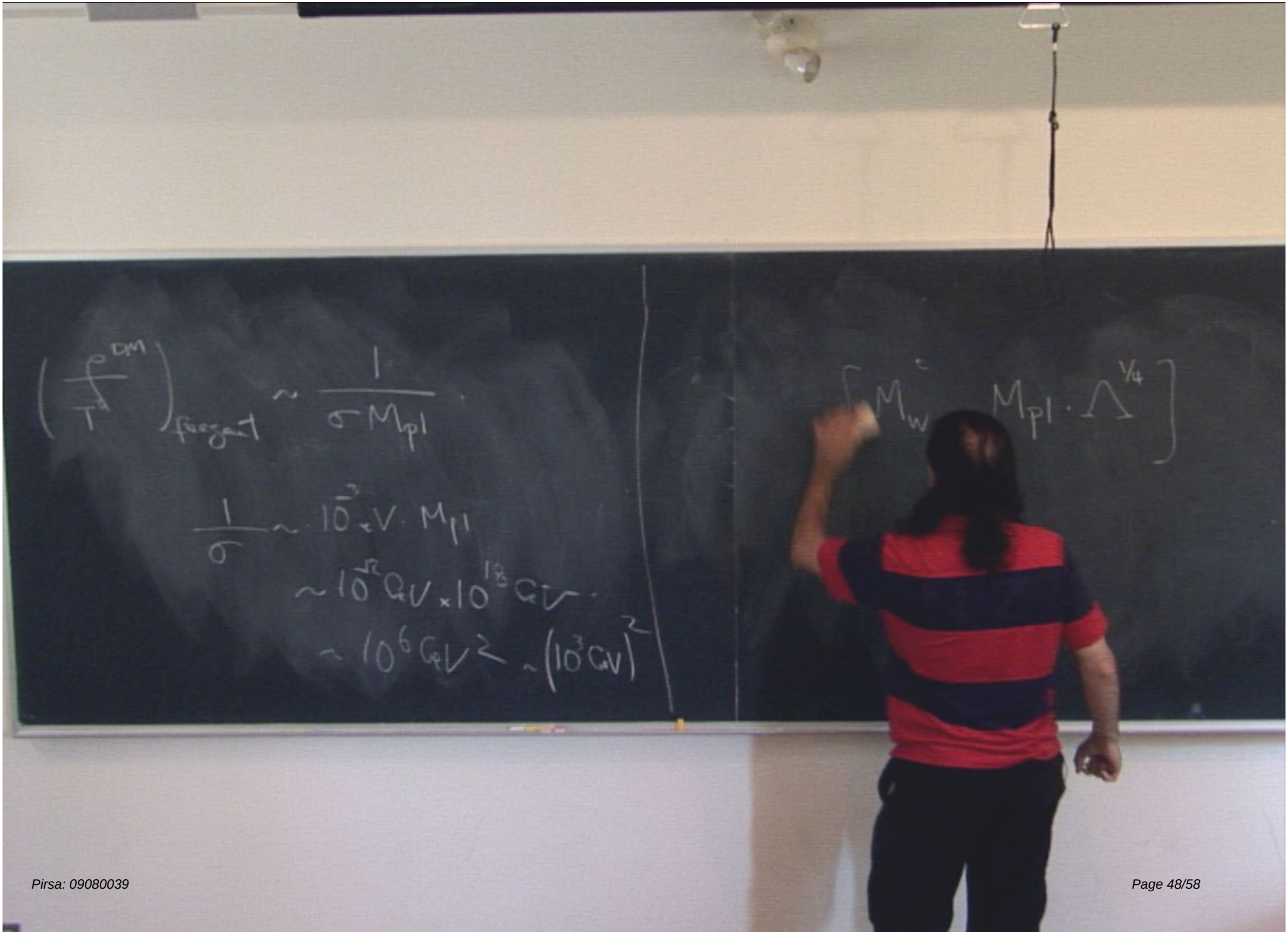
$$\frac{1}{\sigma} \sim 10^{-3}\,eV \cdot M_{Pl}$$

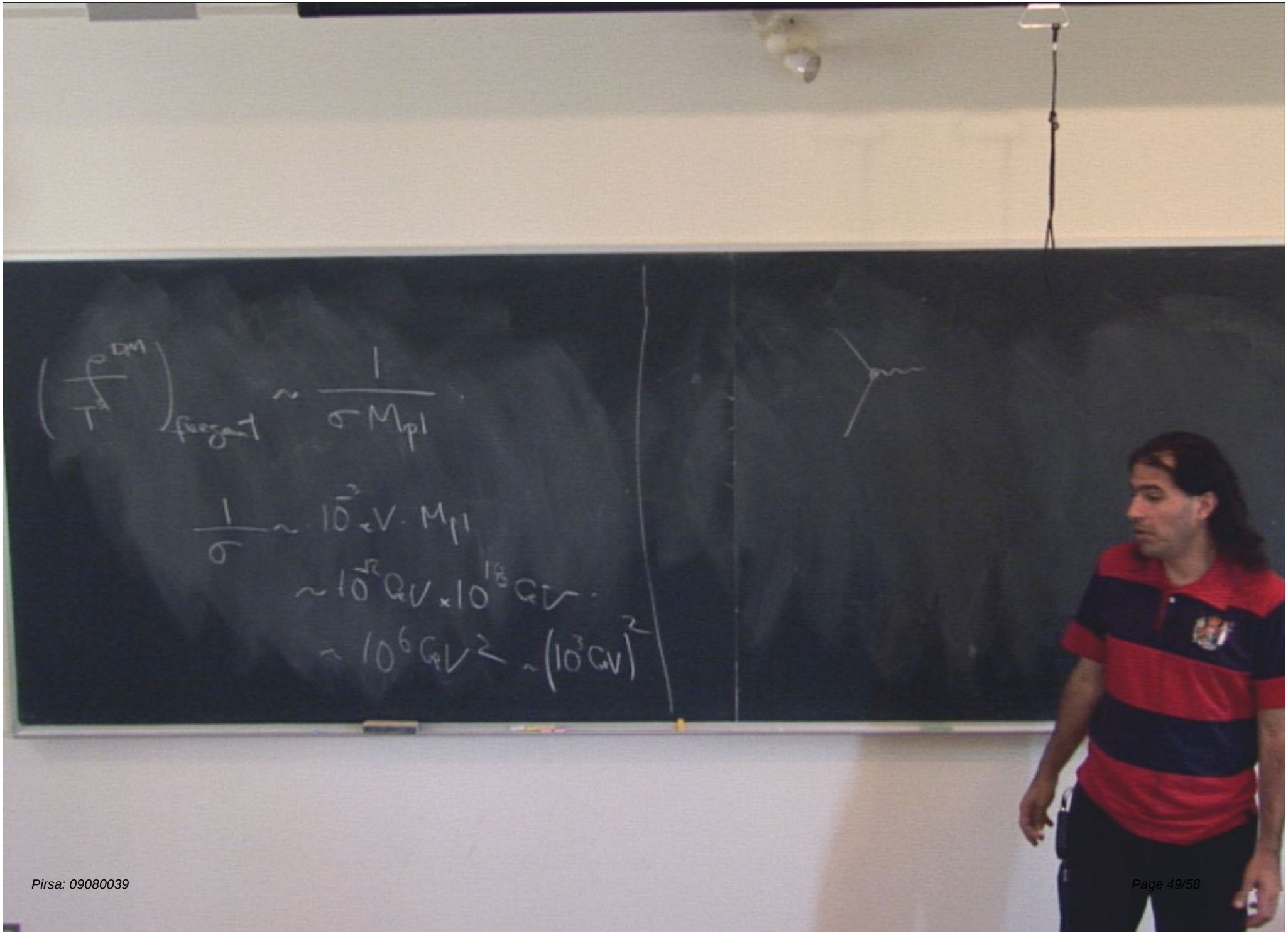
$$\sim 10^{12}\,GeV \times 10^{18}\,GeV$$

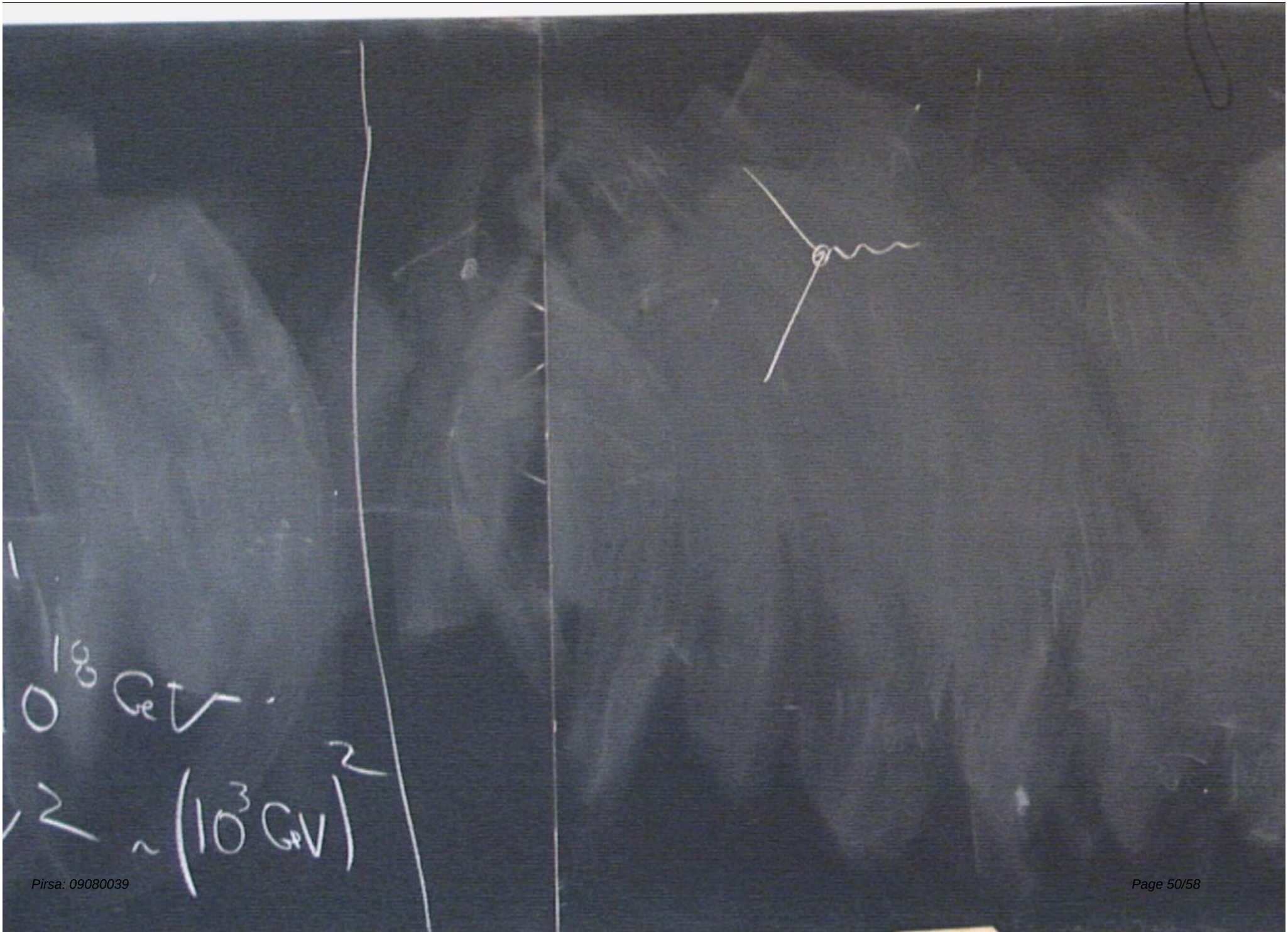
$$\sim 10^{6}\,GeV^2 \sim (10^3\,GeV)^2$$

$$M_W^2 \sim M_{Pl} \cdot \Lambda^{1/4}$$


$[M_W^2 \sim M_{Pl} \cdot \Lambda^{1/4}]$


$\left(\frac{\rho^{DM}}{T^3}\right)_{freeze-out} \sim \frac{1}{\sigma M_{Pl}}$
$\frac{1}{\sigma} \sim 10^{-3} \cdot v \cdot M_{Pl}$
$\sim 10^{-3} GeV \times 10^{19} GeV$
$\sim 10^6 GeV^2 \sim (10^3 GeV)^2$
$M_W \sim M_{Pl} \cdot \Lambda^{1/4}$


$\left(\frac{\rho^{DM}}{T^3}\right)_{freeze-t} \sim \frac{1}{\sigma M_{Pl}}$
$\frac{1}{\sigma} \sim 10^{-3} \cdot V \cdot M_{Pl}$
$\sim 10^{-2} GeV \times 10^{19} GeV$
$\sim 10^6 GeV^2 \sim (10^3 GeV)^2$

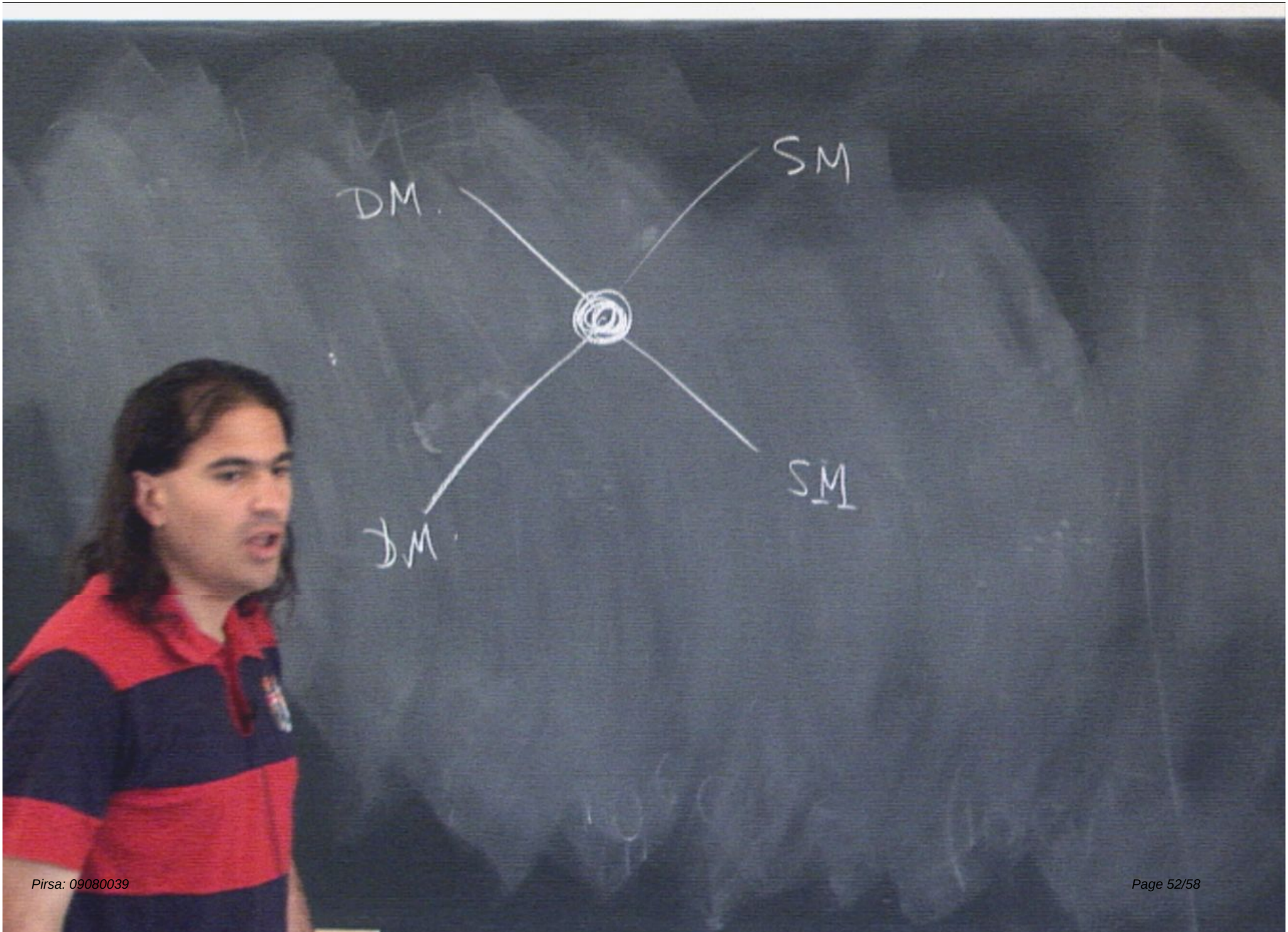

10^{18} GeV.
$\sim (10^3 \text{ GeV})^2$

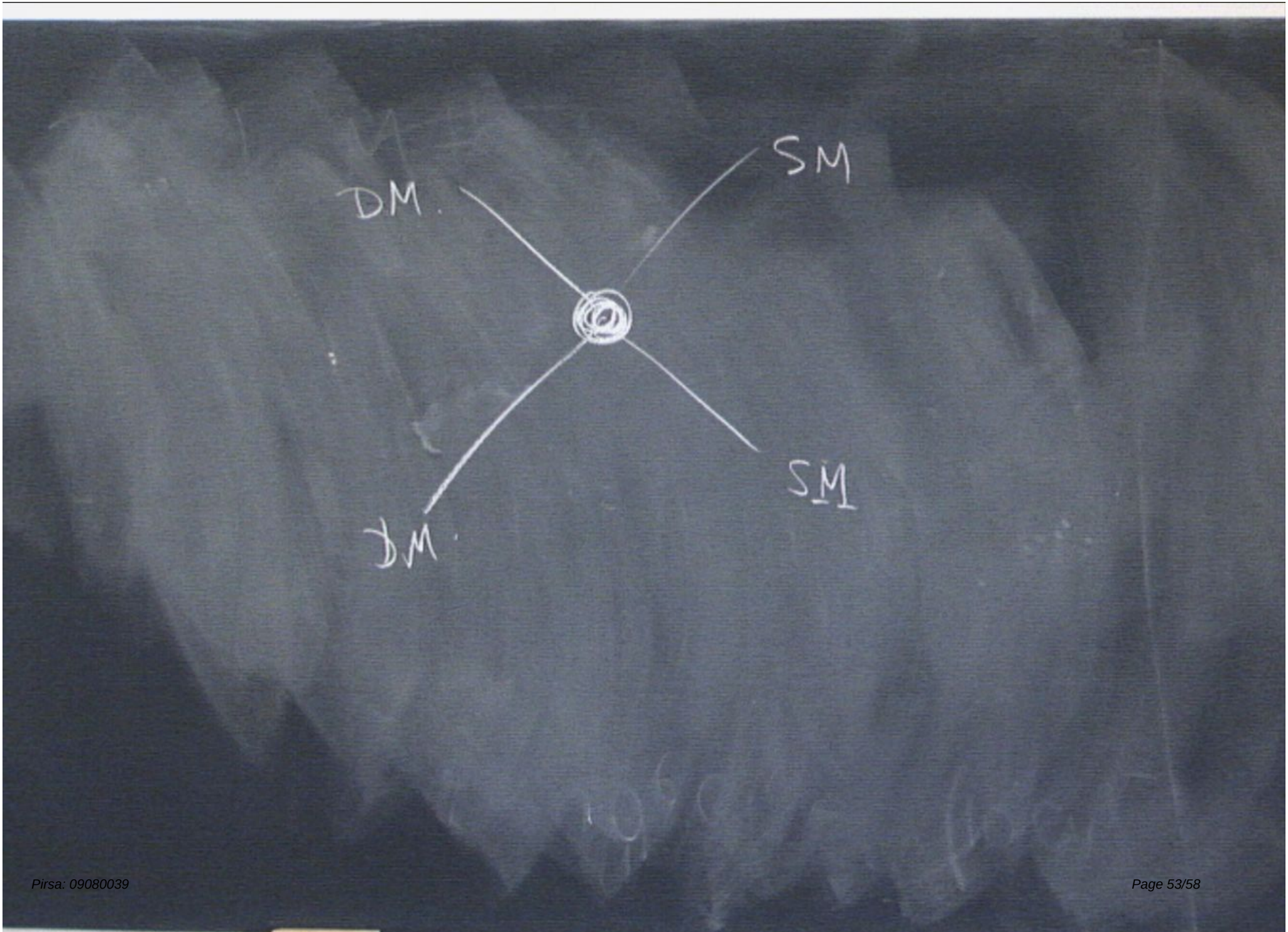
$$\left(\frac{\rho^{DM}}{T^3}\right)_{freezout} \sim \frac{1}{\sigma M_{Pl}}$$

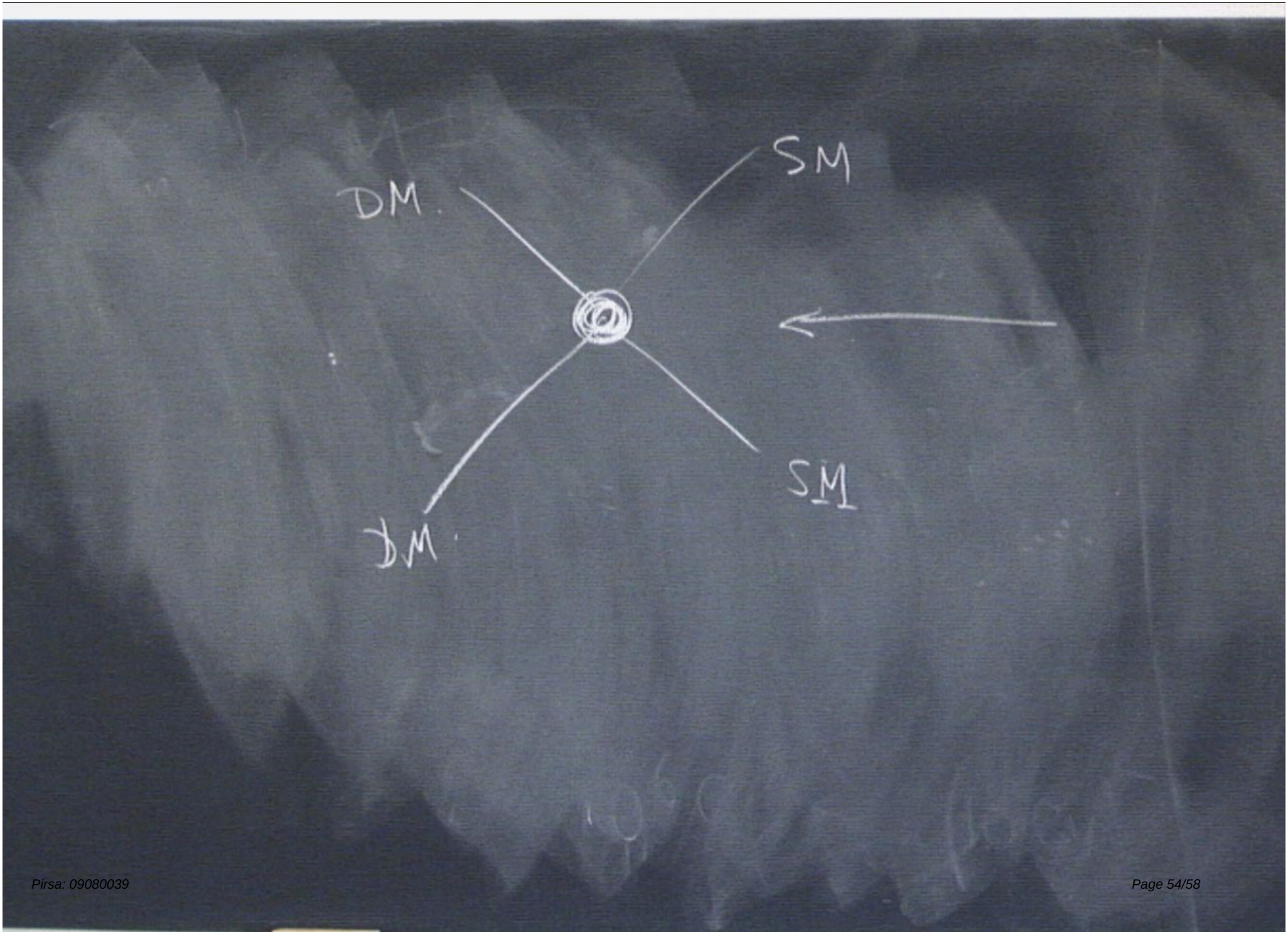
$$\frac{1}{\sigma} \sim 10^{-3}\,eV \cdot M_{Pl}$$

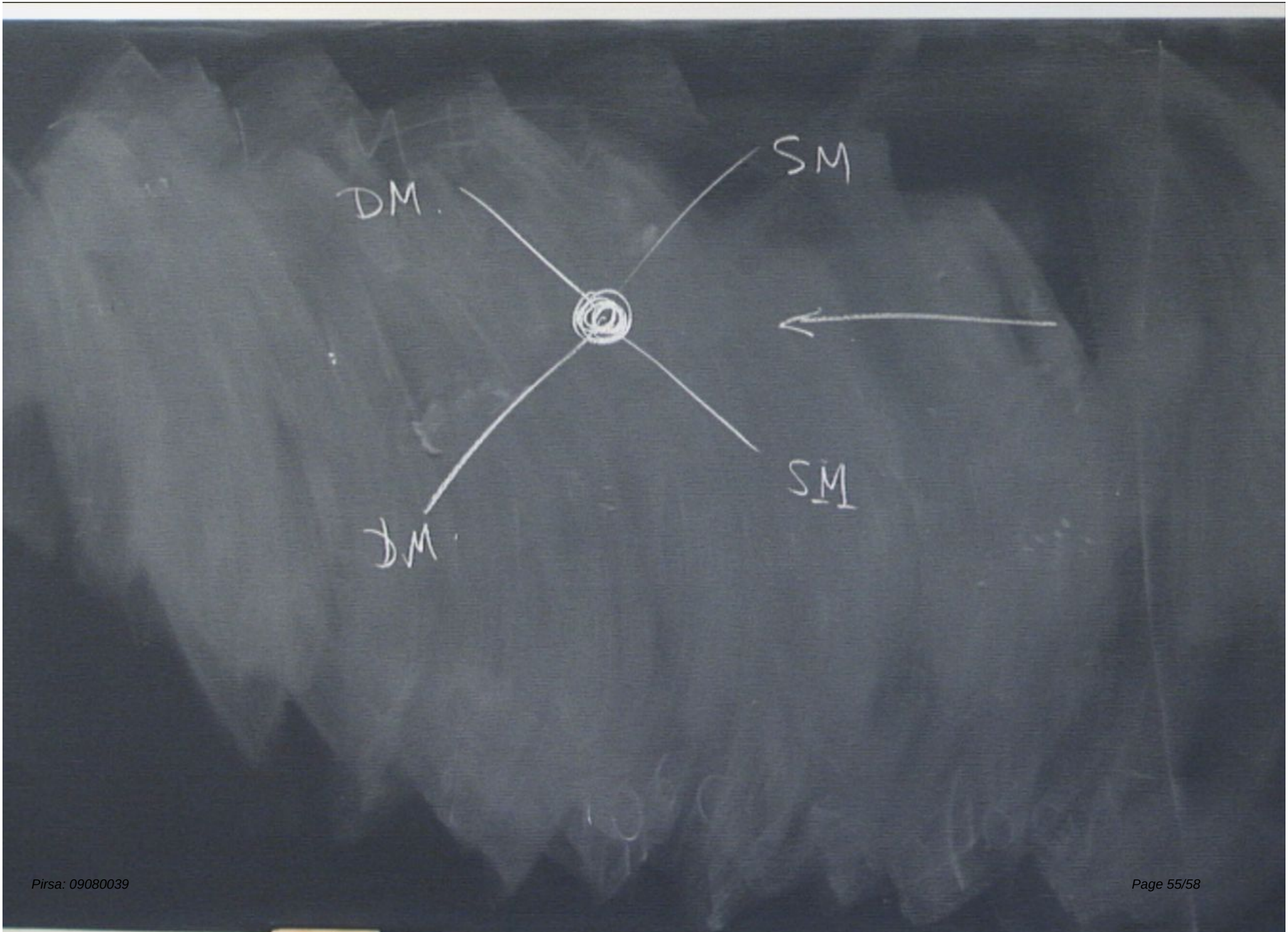
$$\sim 10^{-12}\,GeV \times 10^{18}\,GeV$$

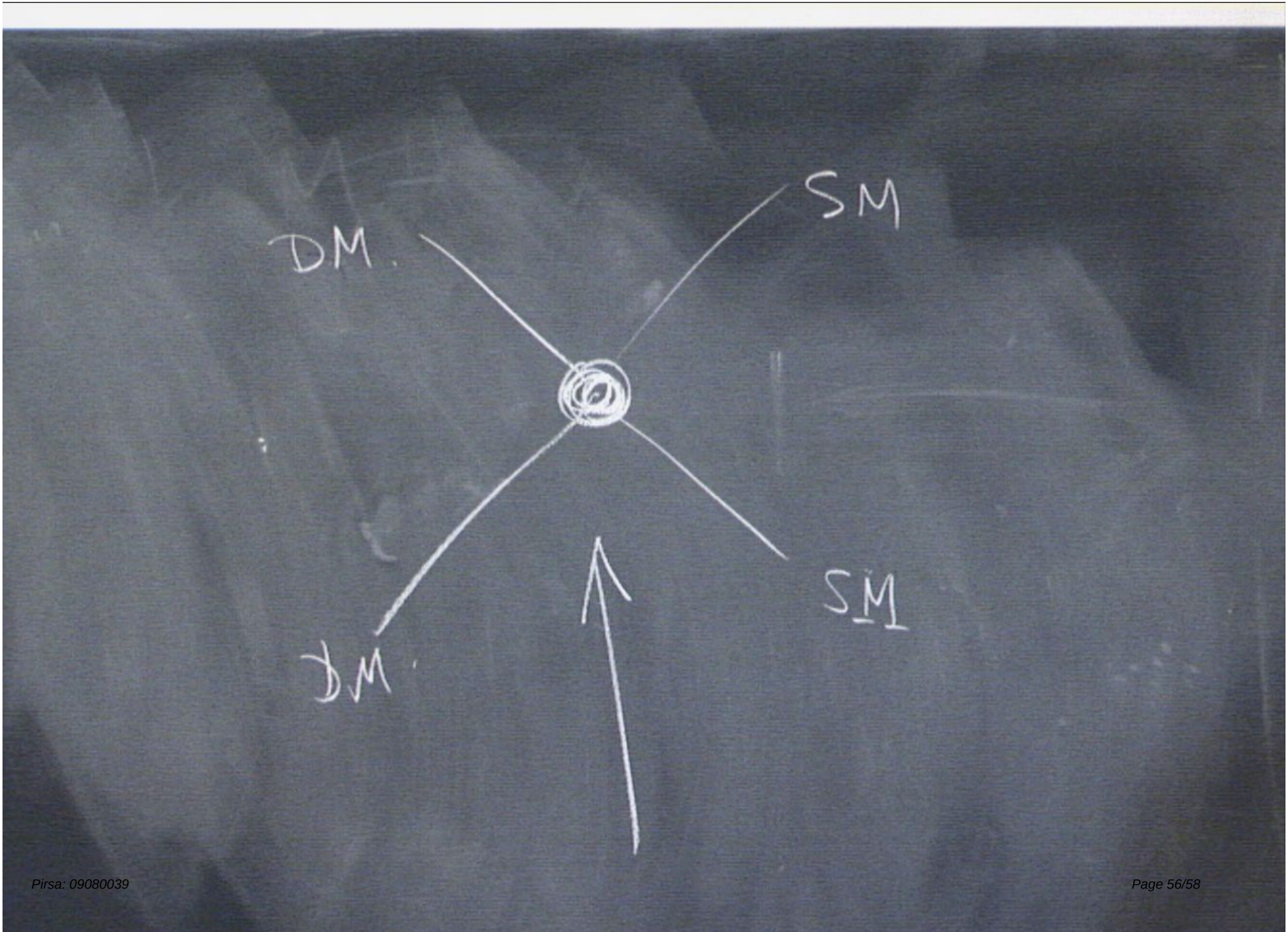
$$\sim 10^{6}\,GeV^2 \sim (10^3\,GeV)^2$$

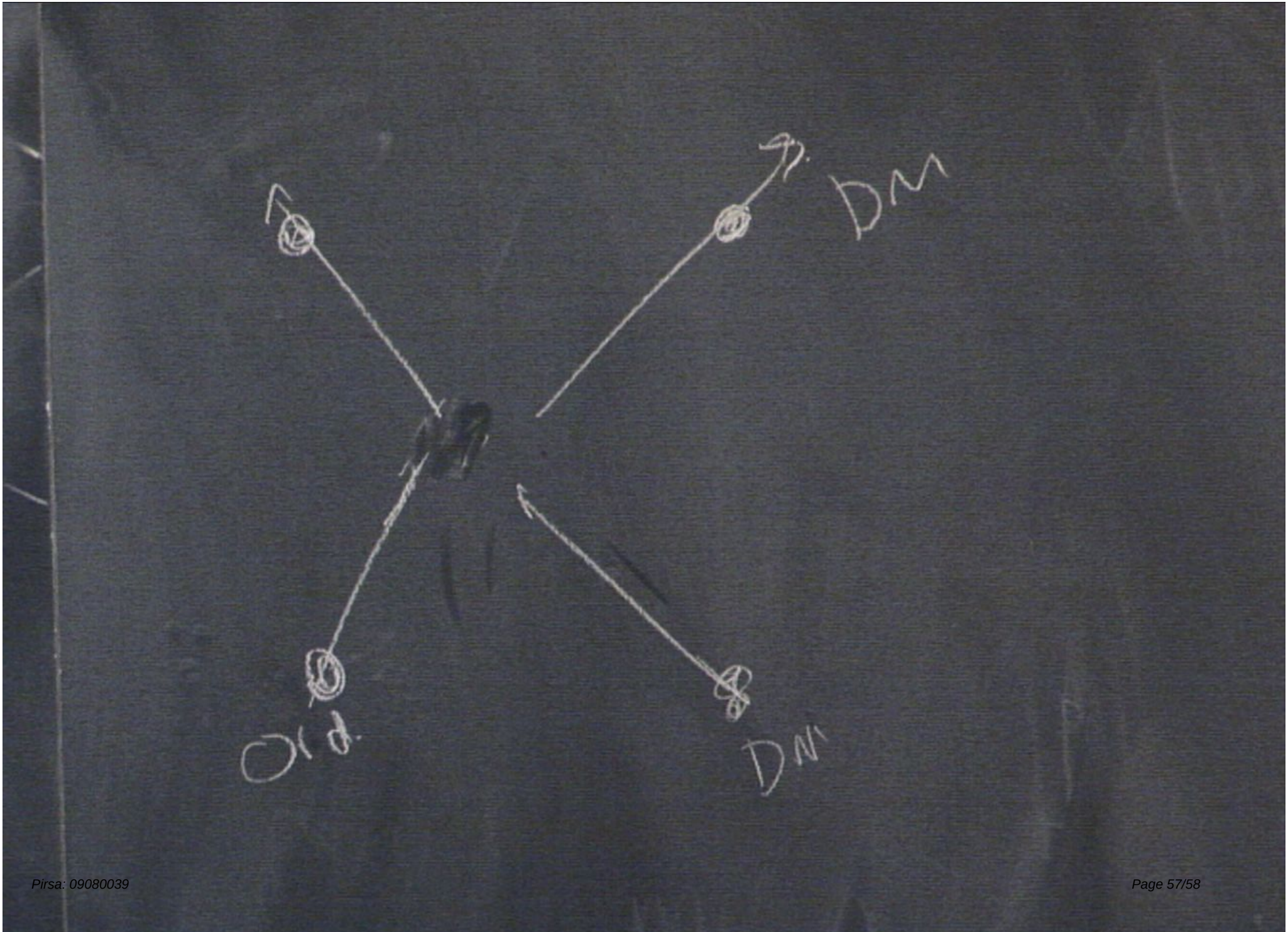

DM.
SM
SM
DM.

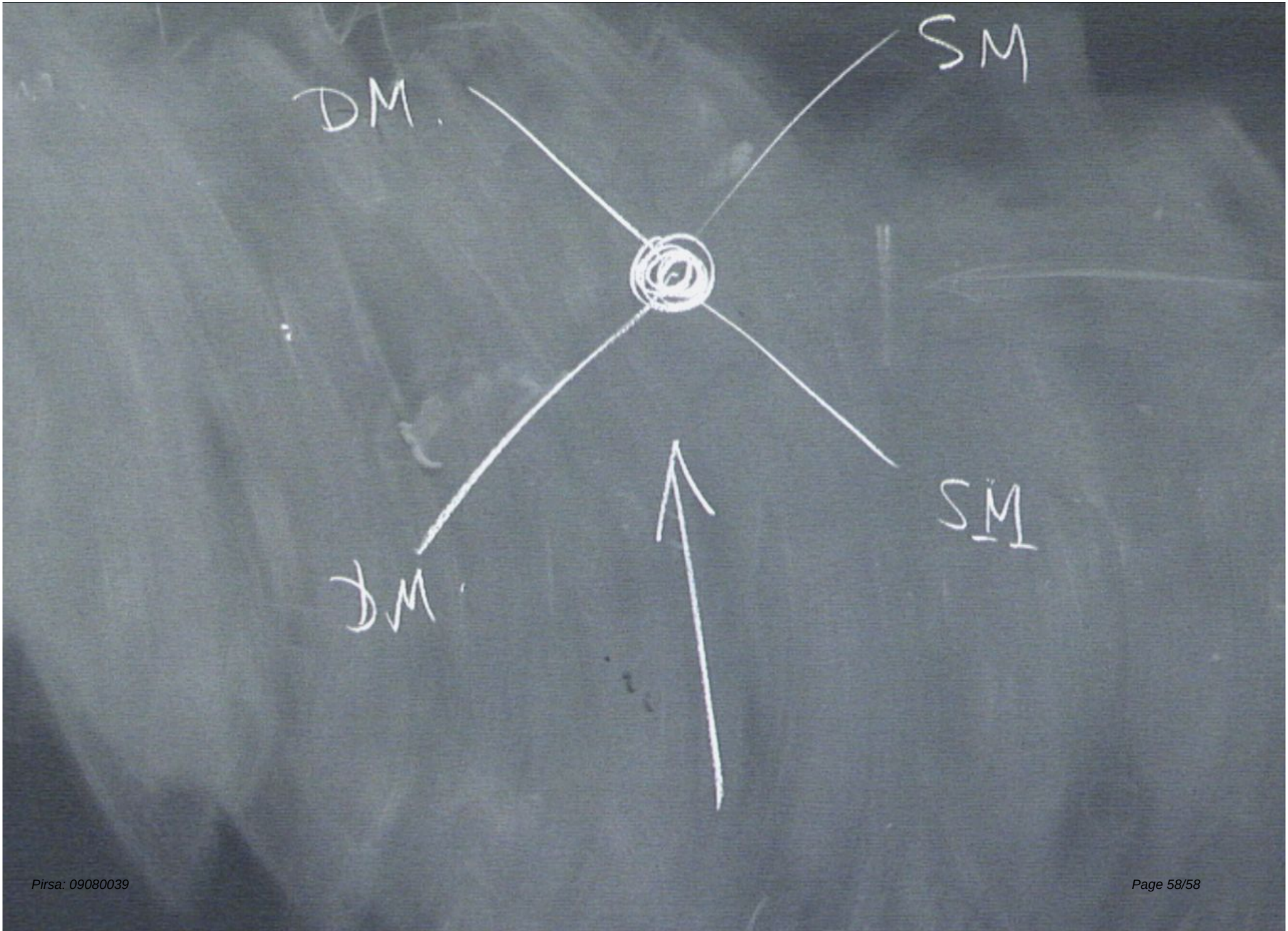

DM
SM
SM
DM


DM
SM
SM
DM


DM
SM
SM
DM


DM
SM
SM
DM


DM
DM'


SM
DM
SM
DM