Title: Particle Physics Lecture

Speakers: Junwu Huang

Collection: Particle Physics

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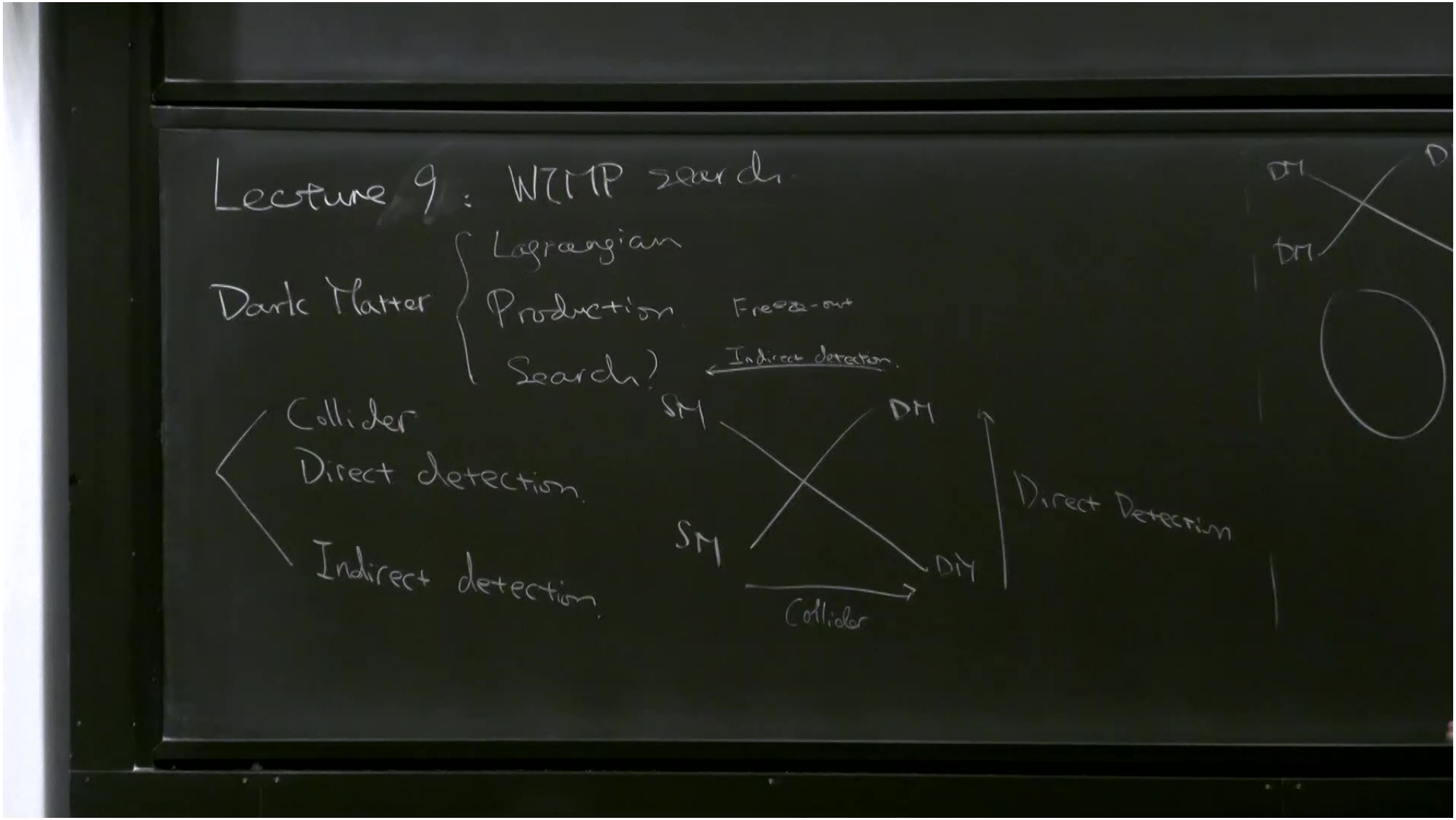
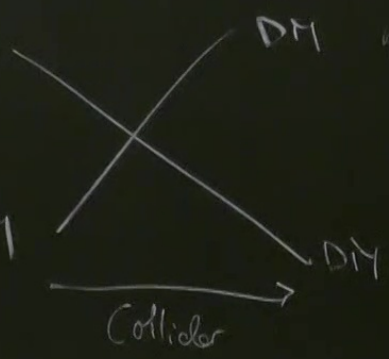
URL: https://pirsa.org/24030023


Lecture 9 : WIMP search
Dark Matter
Lagrangian
Production
Search
Freeze-out
Indirect detection
Collider
Direct detection
Indirect detection
SM
DM
SM
DM
Collider
Direct Detection
DM
DM

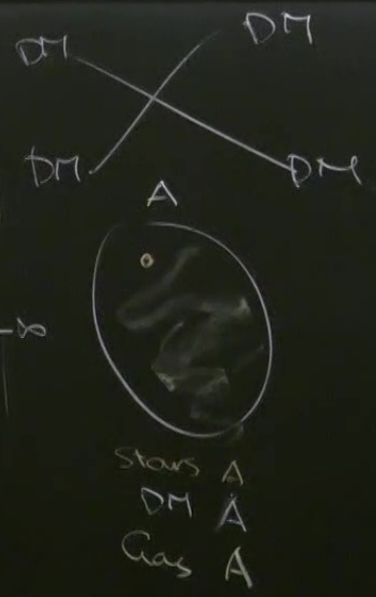
Lecture 9 : WIMP search

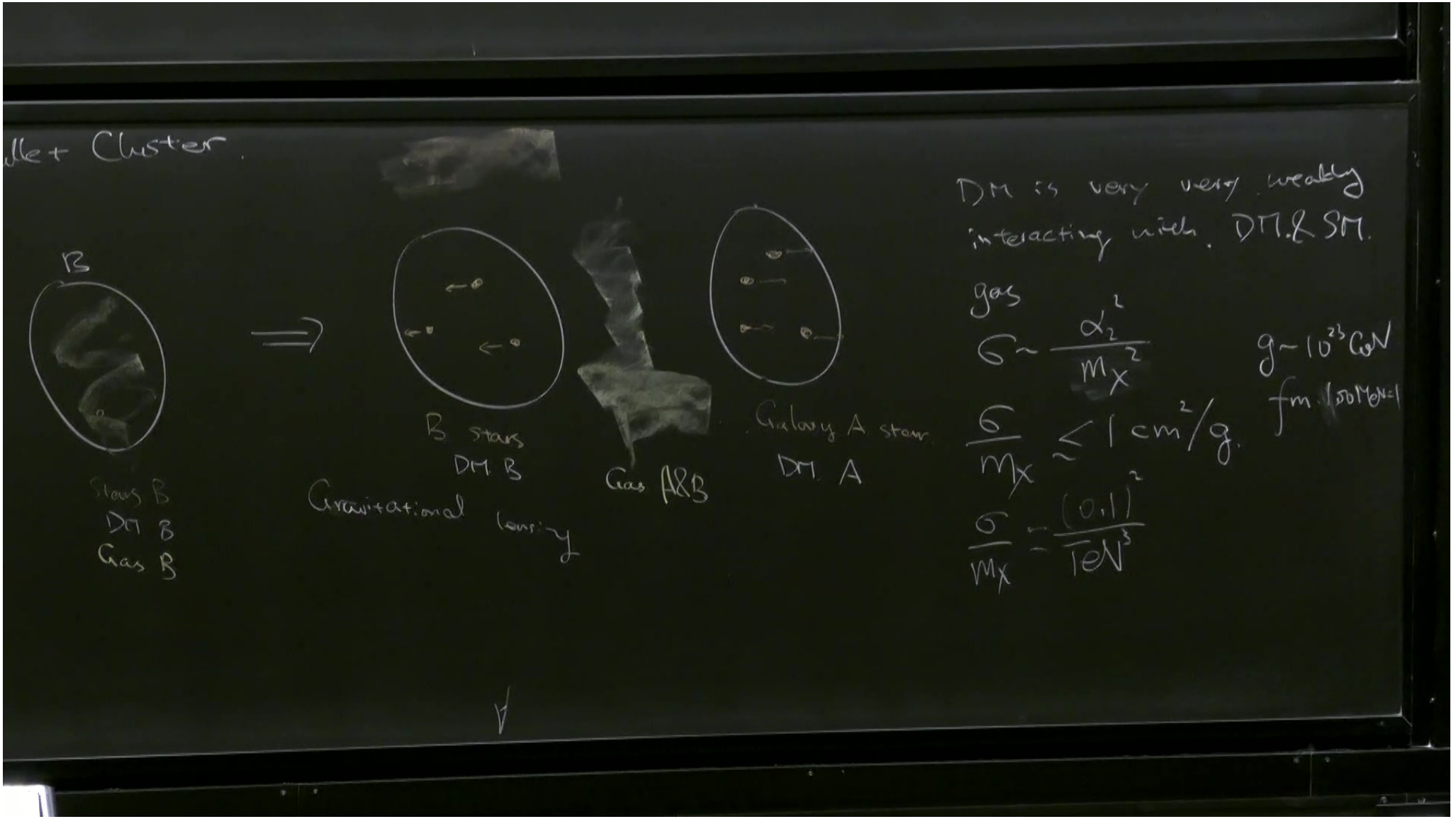
Dark Matter { Lagrangian
Production — Freeze-out
Search? ← Indirect detection.

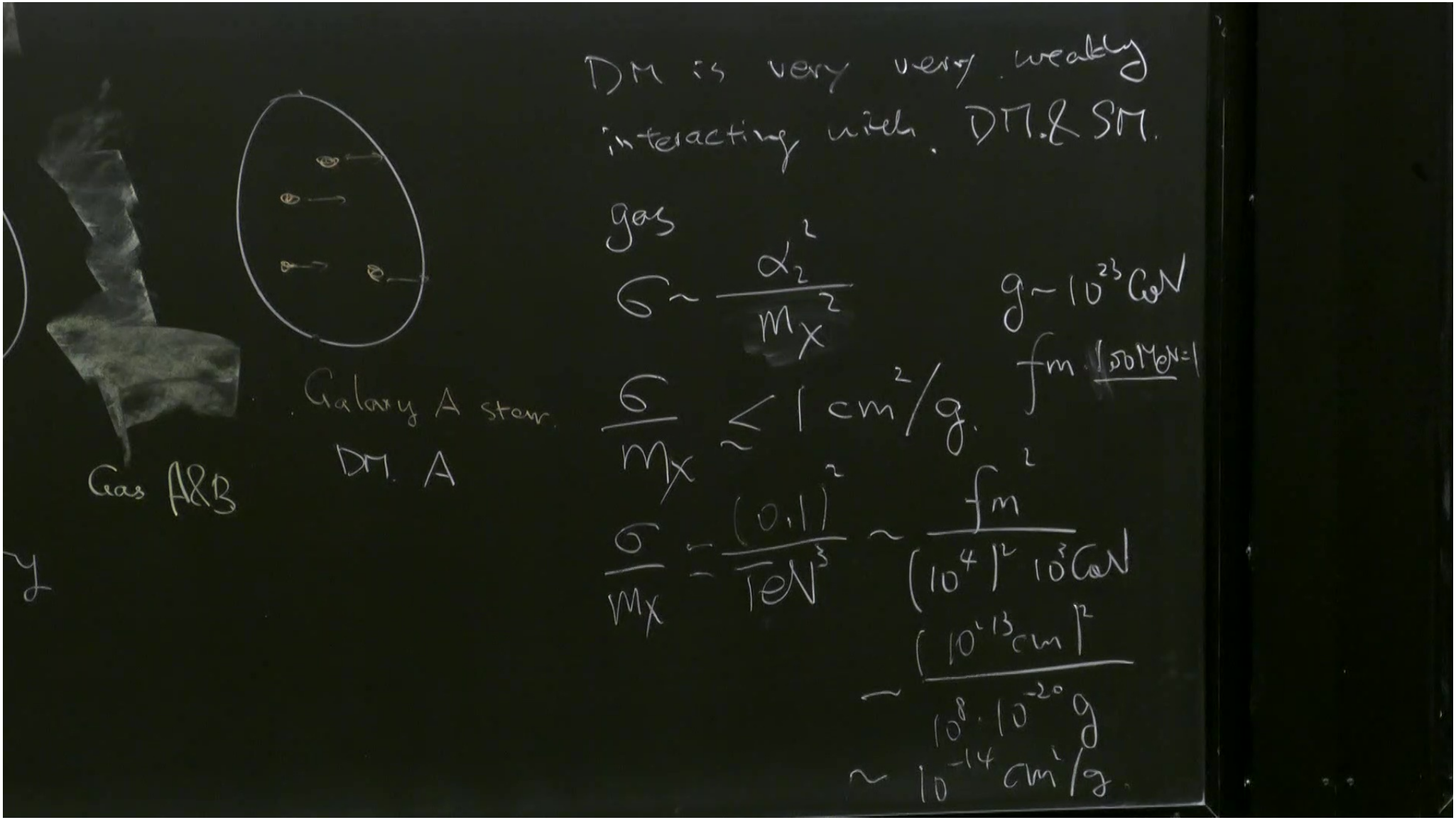
Collider
Direct detection.
Indirect detection.

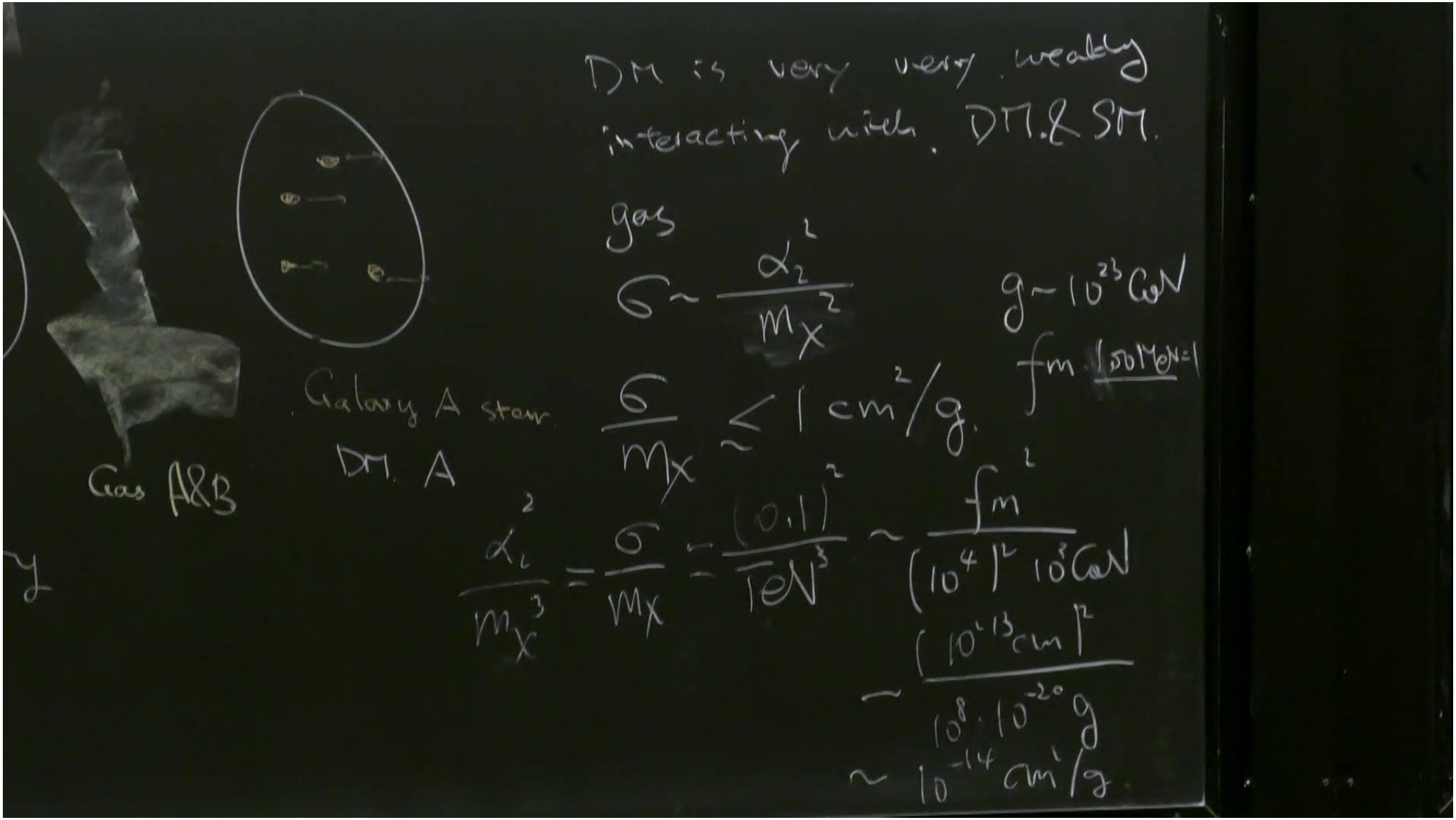


Direct Detection



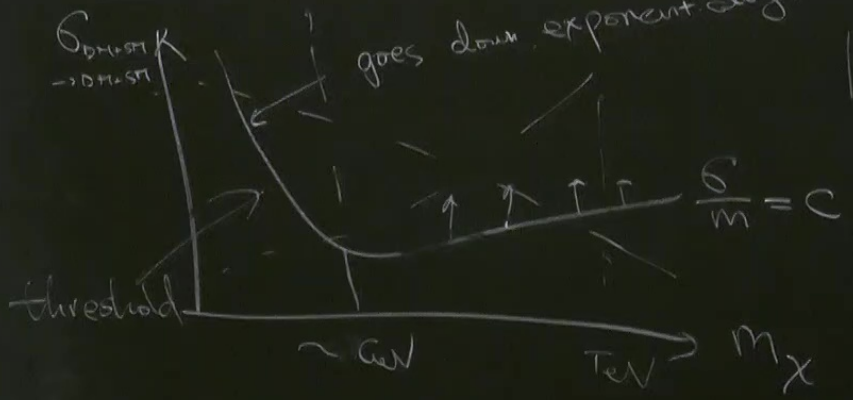

Bullet Cluster
B
Stars B
DM B
Gas B
B stars
DM B
Gas A&B
Galaxy A stars
DM A
Gravitational lensing
DM is very very weakly interacting with DM & SM.
gas
$\sigma \sim \frac{\alpha_2^2}{m_X^2}$
$g \sim 10^{23}$ GeV
fm
$\frac{\sigma}{m_X} \lesssim 1\ cm^2/g.$
$\frac{\sigma}{m_X} \sim \frac{(0.1)^2}{1eV^3}$


DM is very very weakly interacting with DM & SM.
gas
$\sigma \sim \frac{\alpha_2^2}{m_X^2}$
$g \sim 10^{23}$ GeV
$\frac{\sigma}{m_X} \lesssim 1\ cm^2/g.$
fm · 100 MeV = 1
$\frac{\sigma}{m_X} \sim \frac{(0.1)^2}{TeV^3} \sim \frac{fm^2}{(10^4)^2\ 10^3\ GeV}$
$\sim \frac{(10^{-13}\ cm)^2}{10^8 \cdot 10^{-20}\ g}$
$\sim 10^{-14}\ cm^2/g.$
Galaxy A star
DM A
Gas A&B


DM is very very weakly interacting with DM & SM.
gas
$\sigma \sim \frac{\alpha_2^2}{m_X^2}$
$g \sim 10^{23}$ GeV
$\frac{\sigma}{m_X} \lesssim 1\ cm^2/g.$
fm. 1/200 MeV = 1
Galaxy A star
DM A
Gas A&B
$\frac{\alpha_i^2}{m_X^3} = \frac{\sigma}{m_X} = \frac{(0.1)^2}{TeV^3} \sim \frac{fm^2}{(10^4)^2\ 10^3\ GeV}$
$\sim \frac{(10^{-13}\ cm)^2}{10^8 \cdot 10^{-20}\ g}$
$\sim 10^{-14}\ cm^2/g$

Direct Detection:

CDMS & Xenon



Signal:

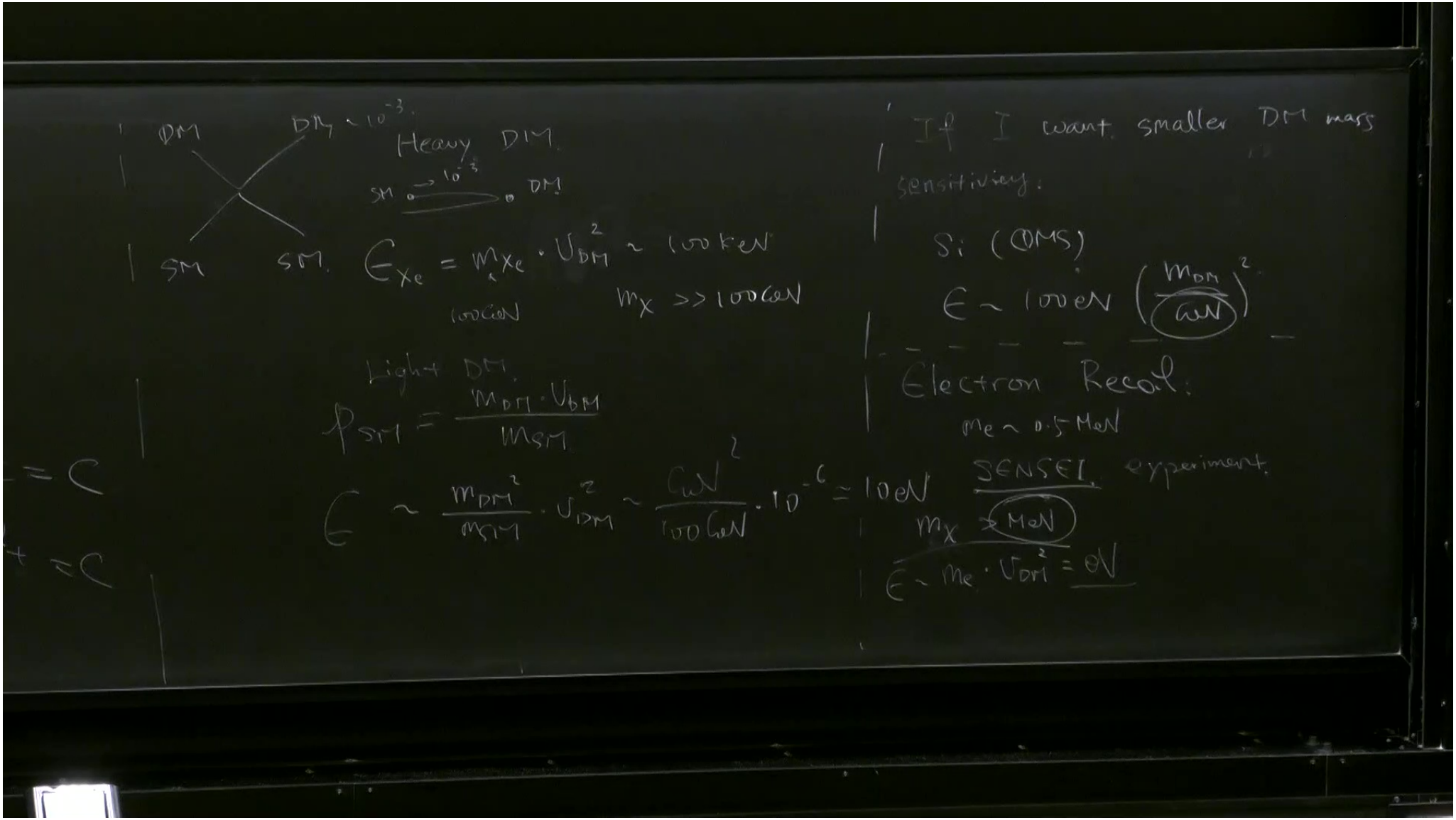
$m_\chi > m_{SM}$ { Xe. ~ 100 GeV ; Si: ~ 10 GeV

Imagine. DM χ, I see it every time it scatters.

$N_{scattering} = \Gamma t = nv \cdot \sigma t = c$

$= \frac{\rho_{DM}}{m_\chi} \cdot v \cdot \sigma t = c$

$\Rightarrow \frac{\sigma}{m_\chi} = c$


DM
DM
SM
SM
Heavy DM.
SM
DM
Light DM.
If I want smaller DM mass
sensitivity:
Si (OMS)
Electron Recoil:
SENSEI
experiment.

Bkg:

Why Xenon?

Signal: Heavy. $m \sim 100$ GeV. $M_X > 100$ GeV. it picks upmost energy

1. What can mimic a signal?

Radioactivity: we stop at Xenon

(Gap)

2. Why not metal?

10keV ~ 10^{-16} K

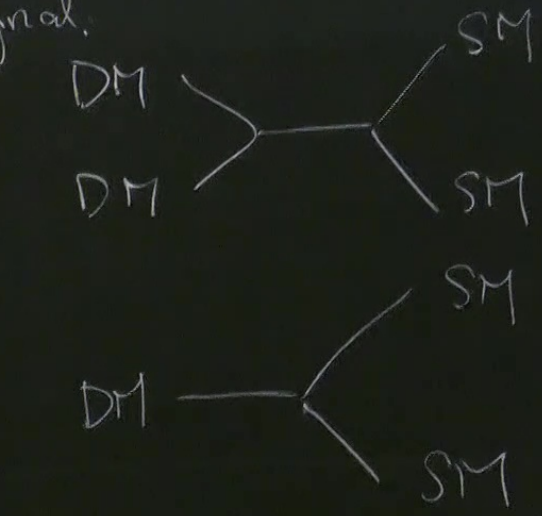
GeV

Thermal Noise

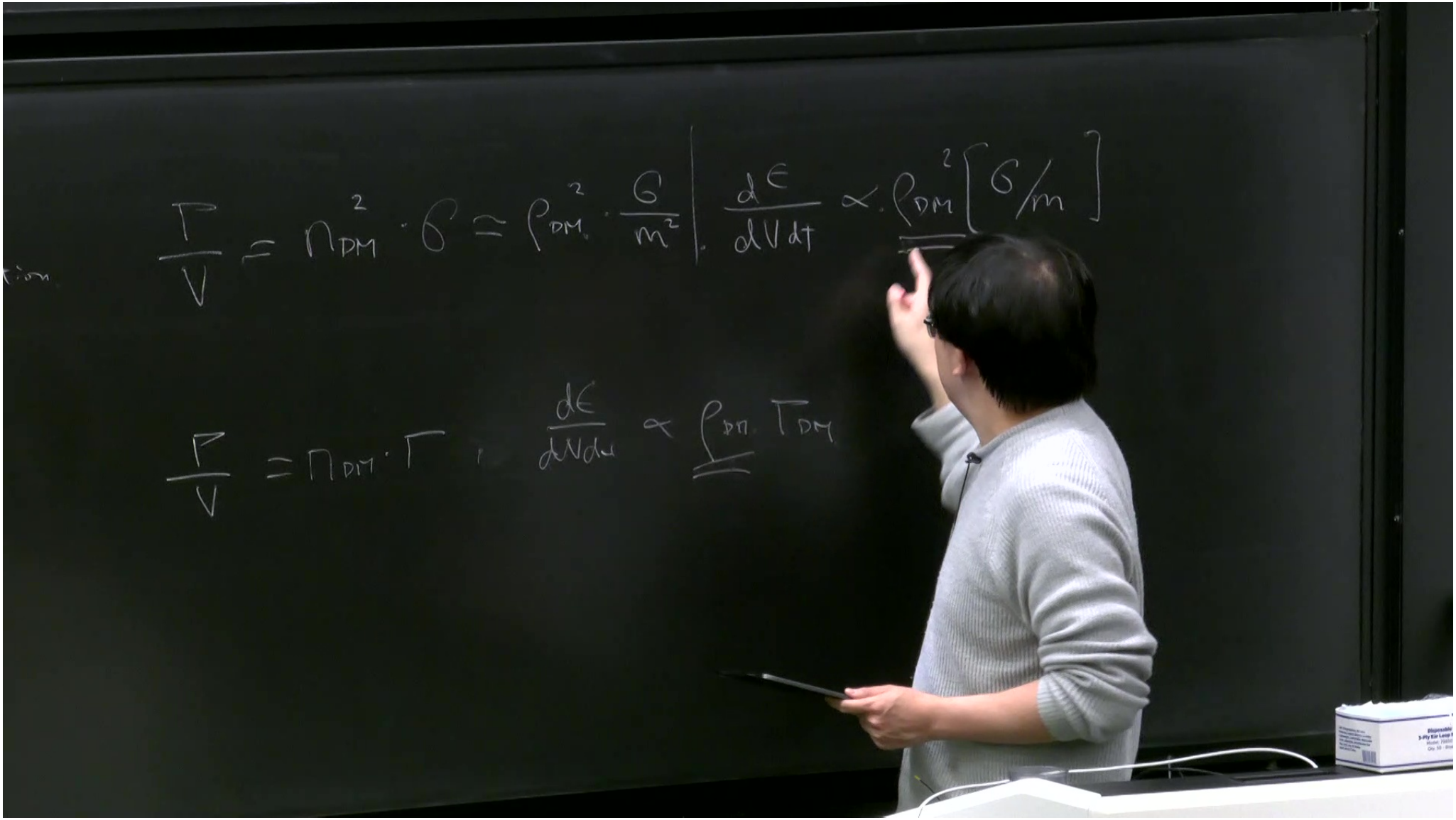
(Pb)

(Pb) Indirect detection.

Signal.



$$\frac{\Gamma}{V} = n_{DM}^2 \cdot \sigma \simeq \rho_{DM}^2 \cdot \frac{\sigma}{m^2}$$


$\frac{\Gamma}{V} = n_{DM}^2 \cdot \sigma \simeq \rho_{DM}^2 \cdot \frac{G}{m^2}$
$\frac{d\epsilon}{dV dt} \propto \rho_{DM}^2 [G/m]$
$\frac{\Gamma}{V} = n_{DM} \cdot \Gamma$
$\frac{d\epsilon}{dV dt} \propto \rho_{DM} \Gamma_{DM}$

When indirect detection.

Lab vs. Galaxy

Bkg:

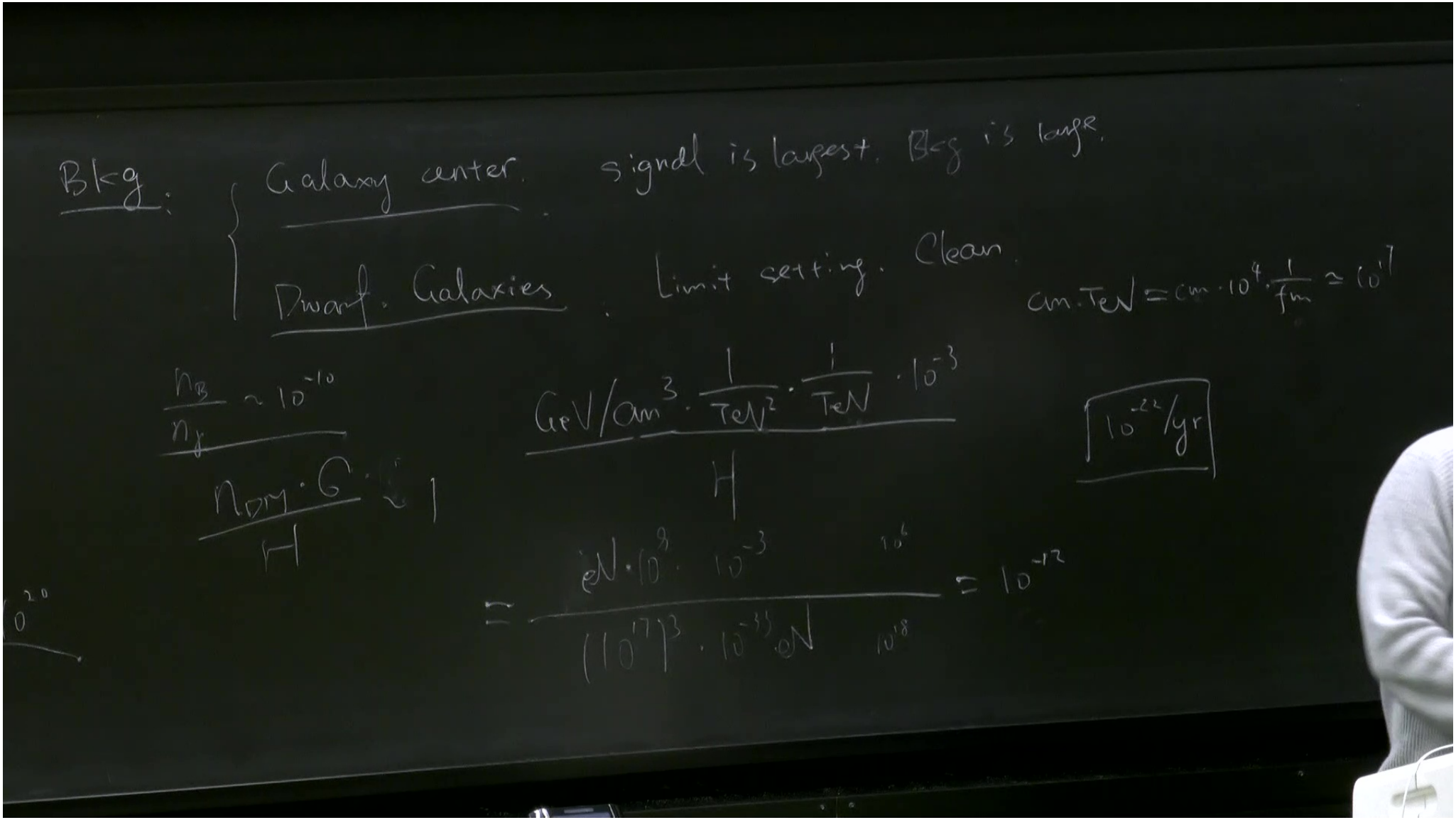
Signal

$P \sim V_{det}$

Volume $\propto d^3$

Fraction $\propto \frac{A}{d^2}$ solid angle.

$V \cdot F \sim \boxed{d_\odot / R_{det}} \sim \frac{1\ \text{solar}}{10\ \text{m}} \sim 10^{20}$


Bkg:
Galaxy center. signal is largest. Bkg is large.
Dwarf Galaxies. Limit setting. Clean.
cm · TeV = cm · 10^4 · 1/fm ≈ 10^1
n_B / n_χ ~ 10^-10
n_DM · G / H ≪ 1
GeV/cm^3 · 1/TeV^2 · 1/TeV · 10^-3 / H
10^-22/yr
= eN · 10^8 · 10^-3 · 10^6 / (10^17)^3 · 10^-35 eN · 10^8 = 10^-12