

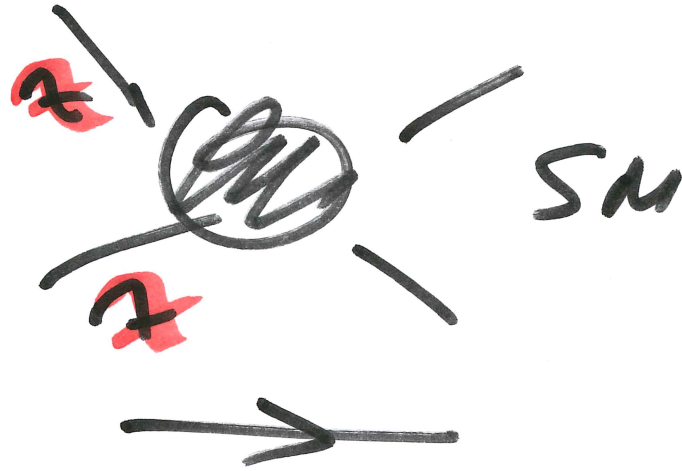
PARTICLE PHYSICS

AND THE

SMALLEST, OLDEST

DARK MATTER HALOS

SO FAR TALKED ABOUT PROCESSES LIKE



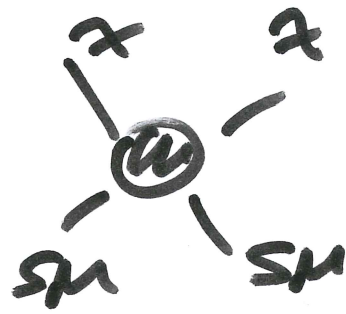
... KEEP DM IN
"CHEMICAL"
(# DENSITIES)
EQUILIBRIUM

... IN EARLY UNIVERSE, IMPORTANT PROCESS IS
THE CROSS SYMMETRIC



→ KEEPS DM IN
KINETIC EQ.

NOTE THAT



IS SAME LATE-UNIVERSE

PROCESS INVOLVED IN DIRECT DM DETECTION
(SEE B. SADOULET'S TALK!)

... ESTIMATE KINETIC DECOUPLING TO
UNDERSTAND SMALL-SCALE CUTOFF TO THE
MATTER POWER SPECTRUM

→ MUCH TALKED-ABOUT **BOOST
FACTOR**

$\chi F \leftrightarrow \chi F$ INVOLVE

$$\Gamma = h_{REL} \sigma$$

$\chi A \leftrightarrow \bar{F} F$ INVOLVE

$$\Gamma = h_{N.P.} \sigma$$

$\llll h_{REL}$

SO TYPICALLY

$$\Gamma_{CHEM F.O.} \gg \Gamma_{KINETIC F.O.}$$

ASSUME WIMP $\rightarrow \Gamma_{freeze} = G_F^2 T^2$



MOMENTUM TRANSFER IS STOCHASTIC (i.e. INEFFICIENT)

$$\delta p \sim T$$

BUT FOR COLD RELICS

$$\frac{p^2}{2m} \sim T \quad p \sim \sqrt{mT} \Rightarrow \delta p$$

IT TAKES $\frac{1}{N} \sim \left(\frac{\delta p}{p}\right)^2 \sim \frac{T^2}{mT} = \frac{T}{m}$

SCATTERING TO "ESTABLISH" EQUILIBRIUM.

... SO NOW WE HAVE

$$\Gamma \cdot \left(\frac{1}{N}\right) \sim H$$

$$\underbrace{T^3}_{n_f} \cdot G_F^2 T^2 \cdot \frac{T}{m_x} \sim \frac{T}{M_p}, \text{ OR } \Gamma_{\text{kd}} \sim \left(\frac{m_x}{M_p G_F^2}\right)^{11/4}$$

$$T_{kd} \sim \left(\frac{100 \text{ GeV}}{10^{18} \text{ GeV} \cdot 10^{-10} \text{ GeV}^{-4}} \right)^{1/4} \text{ GeV} \sim \boxed{30 \text{ MeV} \left(\frac{m_x}{100 \text{ GeV}} \right)^{1/4}}$$

WHAT DOES THIS IMPLY FOR STRUCTURE FORMATION?

CUTOFF \sim SIZE OF HORIZON @ KINETIC DECOUPL.

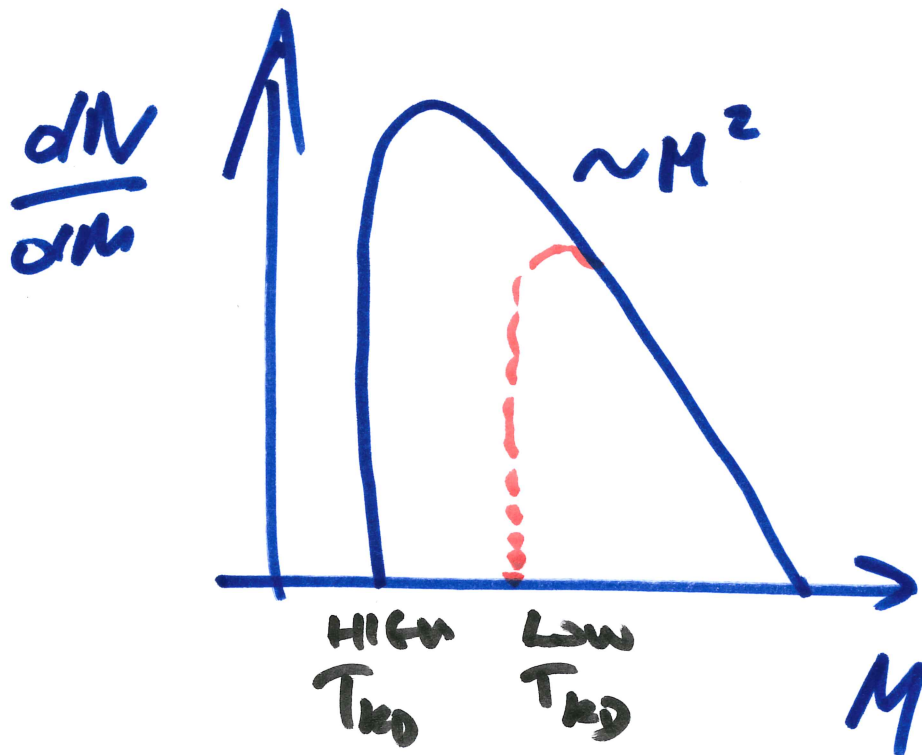
$$M_{kd} \sim \frac{4\pi}{3} \left(\frac{1}{H(T_{kd})} \right)^3 \rho_{DM}(T_{kd})$$

$$\boxed{M_{\text{Cutoff}} \sim 30 M_{\oplus} \left(\frac{10 \text{ MeV}}{T_{kd}} \right)^3}$$

... FOR TYPICAL WIMPS, MINI (PROTO) HALOS
HAVE MASS $\sim M_{\oplus} \sim 10^{-6} M_{\odot}$

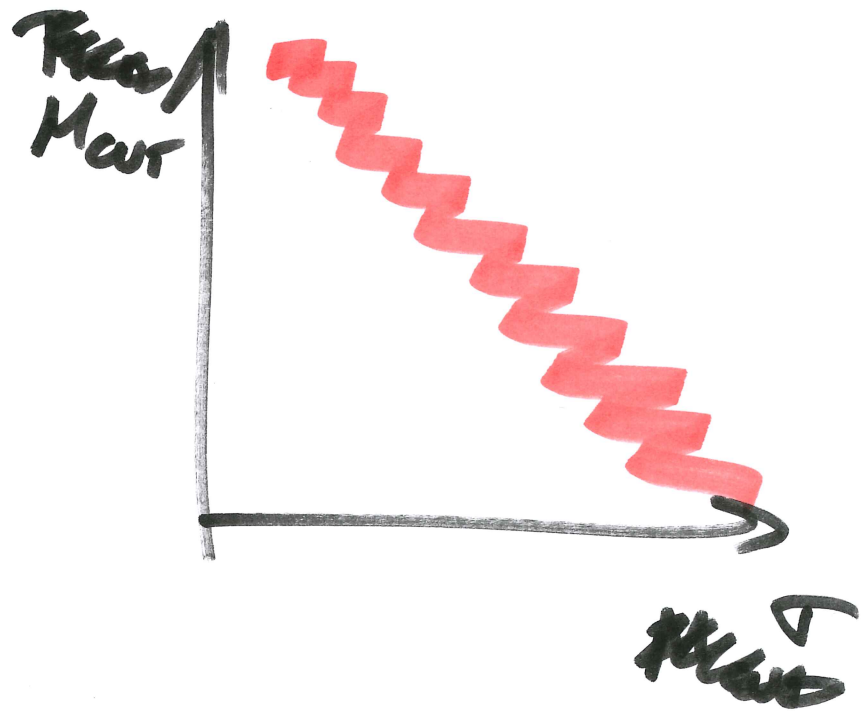
→ BOOST FACTOR

→ SMALL SCALE ISSUES? (ASK JOEL)



... CAN CORRELATE, FOR CERTAIN THEORIES,

T_{hd} WITH Δ_{KN} (DIRECT DETECTION)



(CORNELL + PRUFUMU)
1263.1100, JCAP