

INDIRECT DETECTION

... A PARTICLE THEORIST'S
PERSPECTIVE

KEY PROCESS: $\chi A \rightarrow SM$ IN LATE
UNIVERSE
(ALSO: $\chi \rightarrow SM$ DECAY)

KEY INGREDIENTS

- (i) PRODUCTION RATES $\rightarrow \langle \sigma v \rangle$
- (ii) ENERGY SCALE $\rightarrow m_x$
- (iii) ANNIHILATION PRODUCTS $\rightarrow ??$

RATE FOR ANY SM SPECIES $e^\pm, \nu, \nu^c, \bar{p}, \dots$

$$= \underbrace{\left(\begin{array}{c} \# \text{ DM} \\ \text{PAIRS} \\ \text{IN } V \end{array} \right)}_{\int \frac{\rho_{DM}}{m_x^2} dV} \times \underbrace{\left(\begin{array}{c} \text{PAIR} \\ \text{ANNIHILATION} \\ \text{RATE} \end{array} \right)}_{\langle \sigma v \rangle_{T=0}} \times \left(\begin{array}{c} \# \text{ OF} \\ \text{PARTICLES} \\ \text{PER ANN.} \\ \text{EVENT} \end{array} \right)$$

$m_x,$
ANN. FINAL
STATE

DM ANNIHILATION FINAL STATE

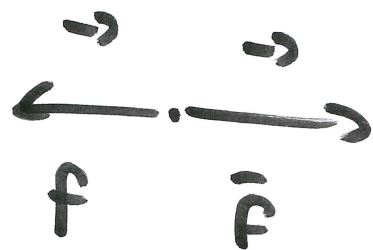
... HIGHLY MODEL DEPENDENT, BUT A FEW GENERAL REMARKS ARE POSSIBLE

● DM IS MAJORANA

$\chi\chi \rightarrow \bar{f}f$ REQUIRES HELICITY FLIP

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HAVE OPPOSITE SPINS IN S-WAVE



$$\text{so } |M|^2 \propto m_f^2$$

→ NO LIGHT FERMIONS!

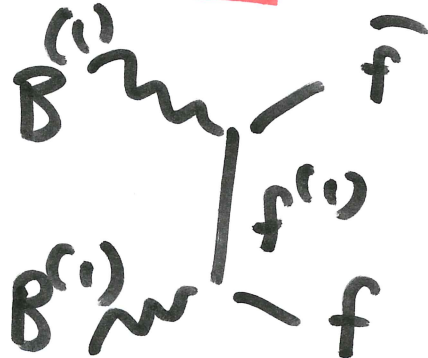
IF $m_x < m_{top}$ AND X DOESN'T LIKE W^+W^-
 ZZ
 $hh...$

→ $ZZ \rightarrow \underbrace{\bar{b}b}_{3 \times color}, \tau^+\tau^-$

→ THIS IS WHY JSG & CO LIKE THINGS LIKE $\bar{b}b, \tau^+\tau^-...$



UED IS TOTALLY OPPOSITE!



$$|M|^2 \sim |Y_f|^4$$

SO IN UED WE LIKE $U_L : |Y_F| = \frac{4}{3}$

$e_R : |Y_F| = 2$



SU(2) MULTIPLETS

(e.g. WINOS \rightarrow TRIPLET
HIGGSINOS \rightarrow DOUBLET)

WINOS: $M_2 = \begin{matrix} \tilde{\chi}^+ \\ \tilde{\chi}^0 \end{matrix} \quad \uparrow \sim 10's \text{ MeV}$

$$\langle \sigma \rangle \approx \frac{3}{16\pi} \frac{g^4}{M_2^2} \rightarrow \Omega_{\tilde{W}} h^2 \sim 0.1 \left(\frac{M_2}{2.9 \text{ TeV}} \right)^2$$

$$\tilde{W}\tilde{W} \rightarrow W^+W^- \sim 100\% \text{ OF TIME!}$$

HIGGSINONS :

$$\tilde{H}^{\pm} \equiv \begin{matrix} \tilde{H}_2^{\pm} \\ \tilde{H}_1^{\pm} \end{matrix}$$

SCALE $\sim \mu$
SPLITTING $\sim 10^5 \text{ MeV}$

$$\langle \sigma v \rangle_{\tilde{H}} \approx \frac{g^4}{512\pi\mu^2} (21 + 3 \tan^2 \beta_w + 11 \tan^4 \beta_w)$$

$$\Omega_{\tilde{H}} h^2 \sim 0.1 \left(\frac{M}{1 \text{ TeV}} \right)^2$$

$$\tilde{H}\tilde{H} \rightarrow W^+W^-, Z^0Z^0$$

NINOS, HIFFSINOS

