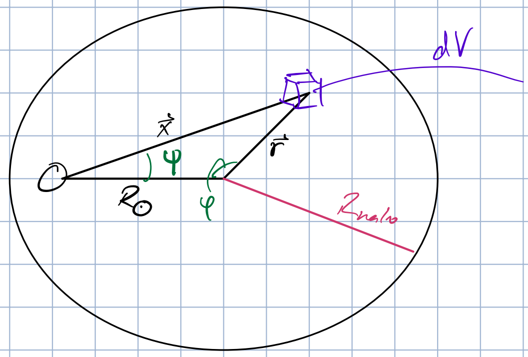
¡AHHHH!

Indirect Detection



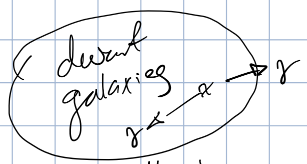
DM may decay or annihilate

decay must be super rare : $\tau_\chi^{decay} \gg 10\,\text{Gyr}$

$\tau_\chi = (R_\chi)^{-1}$
└ decay rate

$\chi \; - - - - < \begin{matrix} f \\ \bar{f} \end{matrix}$

time →



$M \sim \frac{M_{gal}}{10-100}$

$\chi \to e^+e^-$
$\sim \gamma\gamma \qquad (E_\gamma = \frac{m_\chi}{2})$

isotropic!

Mass distribution:

$$\rho_\chi(r) = \frac{4\rho_s}{\left(\frac{r}{r_s}\right)\left(1+\frac{r}{r_s}\right)^2}$$

r_s – scale radius $O(10s\,\text{kpc})$
ρ_s – scale density

what is flux from $\chi \to \gamma\gamma\gamma\gamma\ldots$ decay

for each decay channel $\chi \to f\bar{f} \to \frac{dN_\gamma}{dE_\gamma}$, model dependent γ-distribution

flux in detector from dV?

$$\frac{dN_\gamma^{obs}}{dA_{det}} = \frac{1}{4\pi x^2} \underbrace{dN_\chi}_{\#\,\chi \text{ particles in box } dV} \underbrace{P_{decay}}_{\text{probability of decay}}$$

$$dN_\chi = n_\chi(r(\vec{x}))\,dV = \frac{\rho_\chi(\vec{r}(\vec{x}))}{m_\chi}\, r^2 \sin\theta\, dr\, d\Omega$$

$$P_{decay} = R_\chi \cdot dt = \frac{dR_\chi}{dE_\gamma} \cdot dE_\gamma \cdot dt$$

decay rate into photons γ

$$\frac{dN_\gamma^{obs}}{dA_{dt}} = \frac{n[\vec{r}(\vec{x})] \cdot x^2 dx\, d\Omega_\psi}{4\pi x^2} \cdot \frac{dR_\alpha}{dE_\gamma} \cdot dE_\gamma \cdot dt$$

$$\frac{dN_\gamma^{obs}}{dA_{det} \cdot dt \cdot dE_\gamma} = \frac{n[\vec{r}(\vec{x})] \cdot dx\, d\Omega_\psi}{4\pi} \left(\frac{dR_\alpha}{dE_\gamma}\right)$$

ϕ = flux $\sim \frac{1}{\text{area} \cdot \text{time}}$

$$\frac{d\phi_\gamma}{dE_\gamma} = \frac{n[\vec{r}(\vec{x})] \cdot dx\, \underbrace{d\Omega_\psi}_{}}{4\pi} \left(\frac{dR_\alpha}{dE_\gamma}\right)$$

→ integrate over all lines of sight

add all box contributions along line of sight $\vec{x}$

$$\frac{d\phi_\gamma}{dE_\gamma} = \frac{1}{4\pi} \frac{dR_\alpha}{dE_\gamma} \cdot \int d\Omega_\psi \int d^3\vec{x} \cdot \frac{\rho_\alpha[\vec{r}(x)]}{m_\alpha}$$

what's $\vec{r}(x)$? $\quad \vec{r}^{\,2} = \vec{x}^{\,2} + \vec{R}_\odot^{\,2} - 2\,\vec{x} \cdot \vec{R}_\odot \cos\psi$

maximum x: $\quad x_{max}^2 = R_\odot^2 + R_{halo}^2 - 2 R_\odot R_{halo} \cos\psi$

$$\frac{d\phi_\gamma}{dE_\gamma} = \frac{1}{4\pi} \frac{dR_\alpha}{dE_\gamma} \int d\Omega_\psi \cdot \int_0^{x_{max}(\psi)} \frac{\rho_\alpha[r(x)]}{m_\alpha} dx$$

@ $x_{max}(\psi)$ $\quad |\vec{r}| = R_{halo} \sim 200\,kpc$

$x_{max}^2 = R_\odot^2 + R_H^2 - 2 R_H \cdot R_\odot \cos\psi$

$d\Omega_\psi = d(\cos\psi)$

$\int d\Omega_\psi = \sin\psi\, d\psi\, d\varphi$

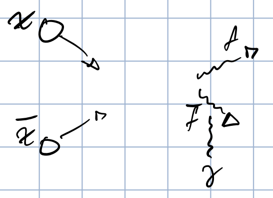
$$\frac{d\phi_\psi}{dE_\gamma} = \frac{1}{4\pi m_\alpha} \cdot \underbrace{\left(\frac{dR_\alpha}{dE_\gamma}\right)}_{} \cdot J$$

↳ particle physics

J - factor: $\quad J \equiv \int d\Omega_\psi \int_0^{x_{max}(\psi)} dx\; \rho_\alpha[r(x)]$

OK, cool, what about annihilation? $\chi \cdot \bar{\chi} \longrightarrow f\bar{f} \rightarrow f\bar{f} + \gamma\gamma\ldots$

(χ could be its own antiparticle)



if 2 body annihilation: $E_i \approx 2m_\chi$

$|\vec{p}|_f = |\vec{p}|_i$

$E_f = E_f + E_{\bar{f}} \longrightarrow E_f = E_{\bar{f}} = m_\chi$