

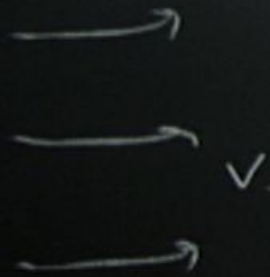
Title: Explorations in Particle Theory - Lecture 10

Date: Apr 21, 2011 10:15 AM

URL: <http://pirsa.org/11040032>

Abstract:

DM

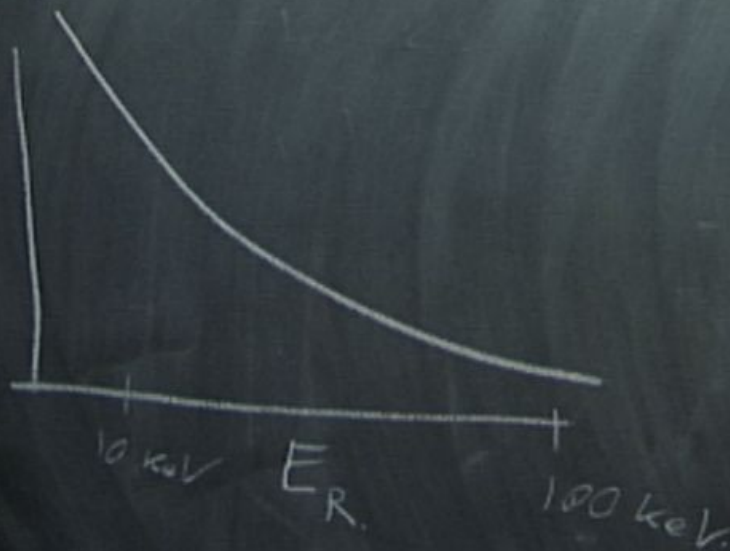


$$\frac{dR}{dE_R} = N_{\text{target}} \frac{\rho}{m}$$

$R = \text{scatter rate}$

$E_R = \text{nuclear recoil}$

$$\frac{dR}{dE_R}$$



$$\frac{dR}{dE_R} = N_{\text{target}} \frac{\rho_{\text{DM}}}{m_{\text{DM}}}$$

$$\int d^3v v \cdot f(v, v_E) \frac{d\sigma}{dE_R}$$

0 keV.

$$= N_{\text{tegel}} \frac{\rho_{\text{DM}}}{m_{\text{DM}}} \int_{V_{\text{min}}(E_R)}^{V_{\text{esc}}} d^3v \cdot v \cdot f(v, v_E) \frac{d\sigma}{dE_R} \xrightarrow{\text{DM} + \text{nuc}} \text{DM} + \text{nuc}$$

$$V_{\text{esc}} \sim 500 - 600 \frac{\text{km}}{\text{s}}$$

$$V_{\text{earth}} \sim 220 \frac{\text{km}}{\text{s}}$$

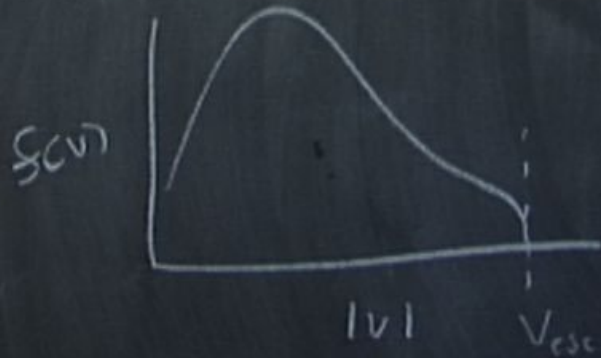


$$= N_{\text{tegel}} \frac{\rho_{\text{DM}}}{m_{\text{DM}}} \int_{V_{\min}(E_R)}^{V_{\text{esc}}} d^3v \cdot v \cdot f(v, v_E) \frac{d\sigma}{dE_R} \xrightarrow{\text{DM} + \text{nuc} \rightarrow \text{DM} + \text{nuc}}$$

$$V_{\text{esc}} \sim 500 - 600 \frac{\text{km}}{\text{s}}$$

$$V_{\text{earth}} \sim 220 \frac{\text{km}}{\text{s}}$$

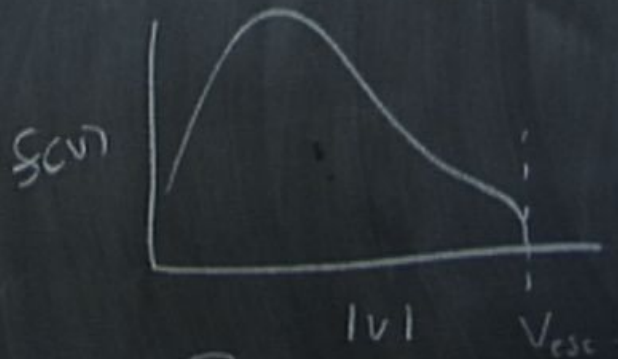
$$V_{\min}(E_R) = \frac{\sqrt{2m_{\text{DM}} E_R}}{2\mu_{\text{DMN}}}$$



$$= N_{\text{target}} \frac{\rho_{\text{DM}}}{m_{\text{DM}}} \int_{V_{\min}(E_R)}^{V_{\text{esc}}} d^3v \cdot v \cdot f(v, v_E) \frac{d\sigma}{dE_R} \xrightarrow{\text{DM} + \text{nuc} \rightarrow \text{DM} + \text{nuc}}$$

$$V_{\text{esc}} \sim 500 - 600 \frac{\text{km}}{\text{s}}$$

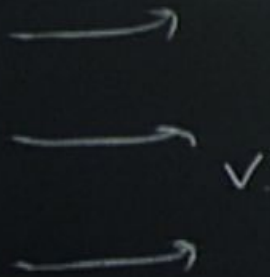
$$V_{\text{earth}} \sim 220 \frac{\text{km}}{\text{s}}$$



$$V_{\min}(E_R) = \frac{\sqrt{2m_{\text{Nucleus}} E_R}}{2\mu_{\text{DMN}}} + \frac{S}{\sqrt{2m_{\text{nuc}} E_R}}$$

$$S = m_{\text{DM}}^*$$

DM

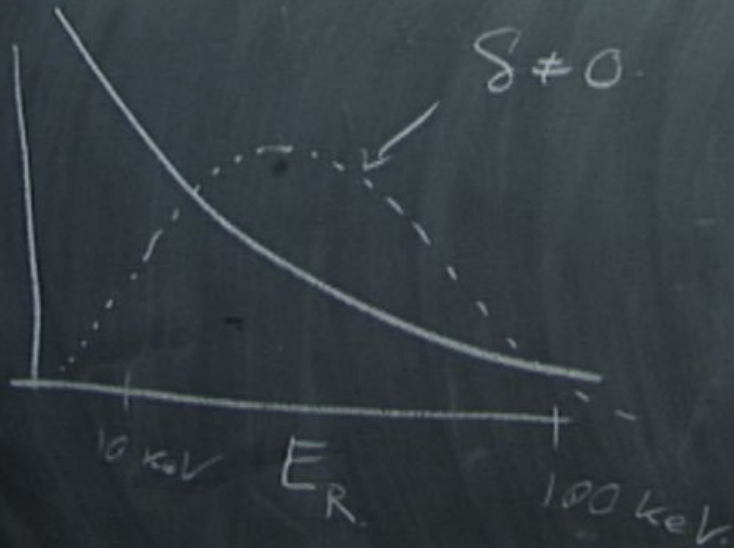


$$\frac{dR}{dE_R} = N_{\text{target}} \frac{\rho}{m}$$

$R =$ scatter rate

$$\frac{dR}{dE_R}$$

$E_R =$ nuclear recoil



From
Grains of
Pollen to
Evidence
for Atoms

How
Big Is A
Molecule?

arXiv: 1008.1591

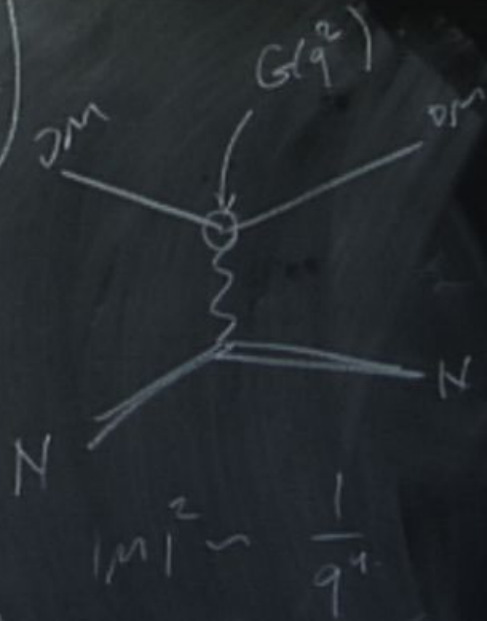
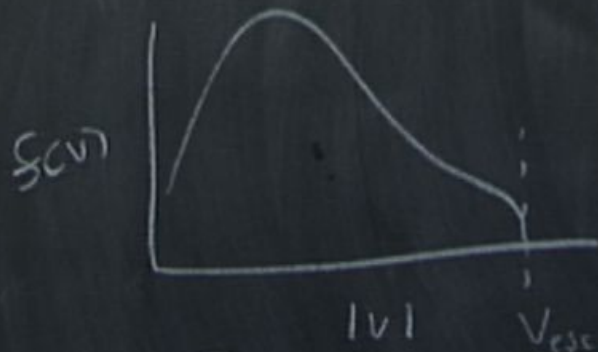
$$d^3 v \cdot v \cdot f(v, v_E) \frac{d\sigma}{dE_R} \xrightarrow{DM + nuc \rightarrow DM + nuc}$$

V_{esc}

$V_{min}(E_R)$

$$V_{esc} \sim 500 - 600 \frac{km}{s}$$

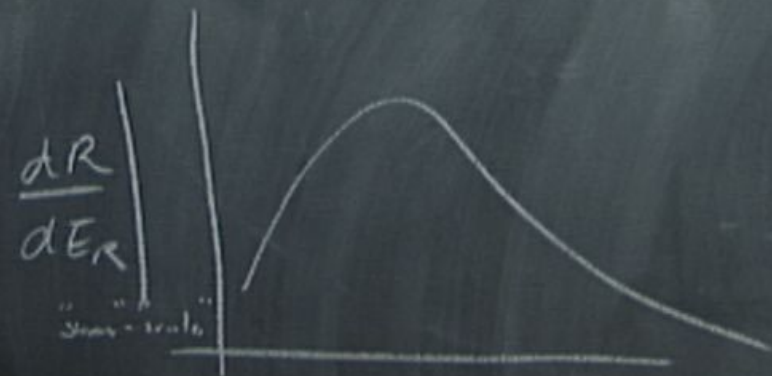
$$V_{earth} \sim 220 \frac{km}{s}$$



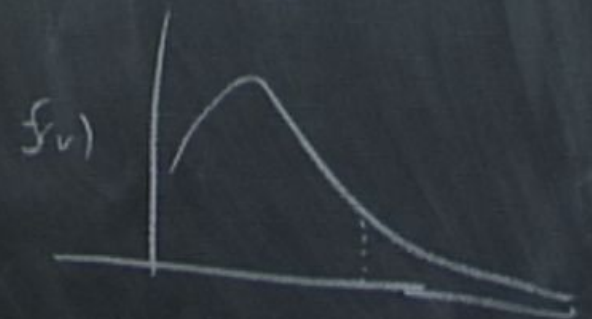
$$V_{min}(E_R) = \frac{\sqrt{2m_{nucleus} E_R}}{2\mu_{DMN}} + \frac{S}{\sqrt{2m_{nucleus} E_R}}$$

$$S = M_{DM}^* - M_{DM}$$

$$S \approx 100 \text{ keV} \quad \frac{dR}{dE_R} = N_{\text{target}} \frac{d\sigma}{dE_R}$$



$$S \approx 100 \text{ keV} \quad \frac{dR}{dE_R} = N_{\text{target}} \frac{d\sigma}{dE_R}$$



$$\gamma_{10}'' \begin{pmatrix} 1 & & & \\ & 1 & & \\ & & 1 & \\ & & & 1 \end{pmatrix}$$

$$\gamma_{11}'' \begin{pmatrix} 0 & & & \\ & a_1 & & \\ & & \ddots & \\ & & & a_n \end{pmatrix}$$

$$\gamma_{12}'' \begin{pmatrix} 0 & & & \\ & 0 & & \\ & & -1 & \\ & & & 0 \end{pmatrix}$$

$$(\not{p} - m)\Psi = 0$$

$$m(\psi - 1)\Psi = 0$$

$$v^0 = 1 - \frac{|\vec{v}|^2}{2} + \mathcal{O}(|\vec{v}|^4)$$

$$(\psi - 1) \begin{pmatrix} \psi \\ \chi \end{pmatrix} = \left[(v^0 \gamma^0 - 1) + \vec{v} \cdot \vec{\gamma} \right] \begin{pmatrix} \psi \\ \chi \end{pmatrix}$$

$$\begin{pmatrix} -\frac{|\vec{v}|^2}{2} & \vec{v} \cdot \vec{\sigma} \\ -\vec{v} \cdot \vec{\sigma} & -2 + \mathcal{O}(|\vec{v}|^2) \end{pmatrix} \begin{pmatrix} \psi \\ \chi \end{pmatrix} = 0 \longrightarrow \chi = -\frac{1}{2} \vec{v} \cdot \vec{\sigma} \psi + \mathcal{O}(|\vec{v}|^2)$$

$$\gamma_{11}^0 \begin{pmatrix} 1 & \\ & -1 \end{pmatrix}$$

$$\gamma_{11}^2 \begin{pmatrix} 0 & g_2 \\ -g_2 & 0 \end{pmatrix}$$

$$\gamma_{11}^3 \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$$

$$\psi_{11} = \begin{pmatrix} \psi \\ -\frac{1}{2} \sqrt{\frac{2m}{\hbar^2}} \psi \end{pmatrix} \sqrt{2m} (1 + \sigma_{11}^2)$$

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$$\bar{\Psi} \Psi \rightarrow \psi^\dagger \psi \sim 2m$$

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$$\bar{\Psi} \Psi \rightarrow \psi^\dagger \psi \sim 4m \cdot m$$

$$\bar{\Psi}(\vec{v}) \gamma^5 \Psi(\vec{v}) = (\psi^\dagger \quad -\frac{1}{2} \frac{\vec{v} \cdot \vec{\sigma}}{v}) \begin{pmatrix} 1 \\ -1 \end{pmatrix} \begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix} \begin{pmatrix} \psi \\ -\frac{1}{2} \frac{\vec{v} \cdot \vec{\sigma}}{v} \psi \end{pmatrix} \sim 2m$$

$$= (\vec{v} - \vec{v}) \cdot \psi^\dagger \vec{\sigma} \psi$$

