

N151 021

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M-meson fusion reaction

Feb. 1, 1957 (1)

1. 湯川秀樹
 K-meson

$7500 \text{ ka} \rightarrow 250 \text{ ka}$

15 ka

ie 15,000 gammas

range 17 cm (5.4 MeV)

π^- μ decay range 1.0 cm (4.1 MeV)

D_0 μ π $\approx \pi$ 2×10^{-4} 3×10^{-3}

MeV μ 2500 1600

μ μ " 18 38

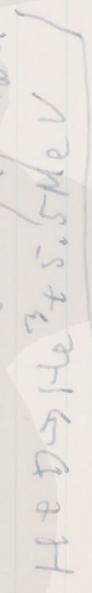
5×10^{-12} (estimated)

1000

30

150 40 33

$$y = \frac{\text{MeV}}{\mu \text{ mada}}$$



$$y = \frac{1}{ax} + \frac{1}{b}$$

$$a = 43, b = \frac{1}{33}$$

2. Moderation and capture of μ -mesons

liquid hydrogen $T = 20^\circ K$, $\rho = 0.068 \text{ g/cm}^3$

$$n_H = 4 \times 10^{22} / \text{cm}^3$$

($T \approx 26^\circ K$)

$$kT = 2 \times 10^{-3} \text{ eV}$$

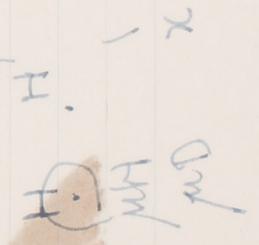
Wigner: $4 \text{ MeV} \approx 0.13 \text{ MeV} (\mu^+ \nu_e)$ 10^{-10} sec ,

$0.13 \text{ MeV} \approx 1.9 \text{ keV}$ $10^{-12} \text{ sec} (\nu_e \nu_e)$

$1.9 \text{ keV} \approx 0.13 \text{ eV}$ $10^{-12} \text{ sec} (\nu_e \nu_e)$

wheeler $0 \rightarrow K \text{ orbit}$ $< 10^{-10} \text{ sec}$

$$a_{\mu} = \frac{\hbar^2}{m_{\mu} e^2} = 2.6 \times 10^{-11}, \frac{e^2}{2a_{\mu}} \approx 2.8 \text{ keV}$$



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3. Rearrangement, molecular formation

MH (i) μ -e decay $w_d = \frac{1}{2 \times 10^{-6}} \text{ sec}^{-1}$
 (ii) $\mu H + H \rightarrow \mu H H$ $w_f \equiv f w_d$

(iii) $\mu H + D \rightarrow \mu D + H + 135 \text{ eV}$ $w_e \equiv e w_d$

(iv) elastic scattering

a) w_f : $\begin{cases} \mu H + H \rightarrow \mu H H \\ \mu D + H \rightarrow \mu D H \end{cases}$

$$\sigma_f \approx \pi \lambda^2 \frac{\Gamma_{\text{ortho}}}{\omega}$$

$$\sigma_f (\text{thermal}) \approx 3 \times 10^{-23} \text{ cm}^2 \frac{v}{v_0}$$

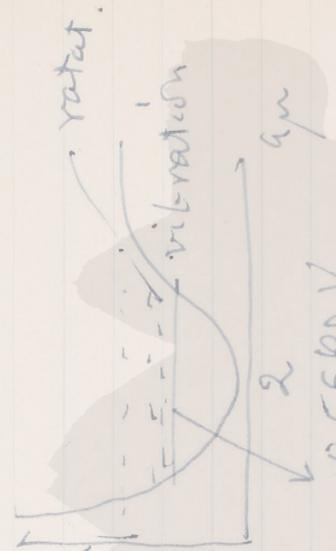
or dispersion formula

$$\sigma_f = 8 \zeta^2 \frac{\zeta}{K} \frac{\Gamma}{D}$$

$$\zeta = \frac{1}{2} \frac{D}{E_{\text{res}}}$$

$$w_f = \pi H \sigma_f v = \int \approx 9 \times 10^4 \text{ sec}^{-1} \approx \rho^2 \times 6 \times 10^3 \text{ sec}^{-1}$$

$$w_d = 5 \times 10^5 \text{ sec}^{-1}$$



b) exchange reaction: $\mu H + D \rightarrow \mu D + H + 135 \text{ eV}$

$$\Gamma_H / \Gamma_D \approx \nu H \nu_D = 2 \times 10^{12} \frac{\Gamma_H}{\Gamma_D} \quad \Gamma_H \approx \frac{2D}{\pi \lambda H}$$

$$\sigma_e \approx 8 \zeta^2 \frac{\Gamma_H}{\Gamma_D} \frac{\Gamma_H}{D} \approx 3^2 \times 1.0 \times 10^{-18} \text{ cm}^2 > \sigma_f$$

$$e \equiv \frac{w_e}{w_d} = 6 \times 10^3 \zeta^{12}$$

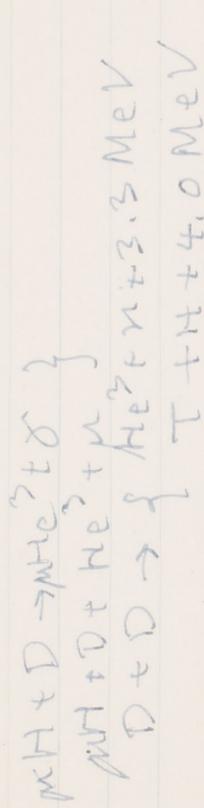
c) elastic scattering

$$\sigma_s \approx \zeta^{12} \cdot 5 \times 10^{-21} \text{ cm}^2 \quad (\approx \zeta^{12} \cdot \pi a_{\mu}^2) > 100 \sigma_f \text{ (thermal)}$$

4. $\pi^+ \pi^- \pi^0 \rightarrow \mu^+ \mu^- \nu_e$

$H + H \rightarrow D + e^+ + \nu + 0.42 \text{ MeV}$ X

(3)



$P = e^{-2g} \approx 10^{-5} \quad (10^{-4} \sim 10^{-6})$



Plane wave = $\frac{0.1 \text{ MeV} \times p \times 10^{-30} \text{ cm}^2}{E}$

$\delta \delta^* \sim \delta^2 \sim \frac{1}{\mu^2}$
 $W_\delta = \mu \cdot v \cdot \sigma$

$W_\delta = \frac{1}{1.7 \times 10^8} \text{ sec}^{-1} \sim \text{nd}$
 $n = \frac{(2a\mu)^3}{(4\pi)^2} \approx 10^{21}$
 $(n_H \approx 4 \times 10^{22})$



1. Interval conversion (mag. dipole)

$\beta = \frac{\mu \delta \delta^*}{\delta^2 \delta^*} = \frac{1}{2} 2^3 a^4 \left(\frac{2k_0}{m_{\mu c^2}} \right)^{5/2} \approx 1.0 \times 10^{-4}$

2. 0-0-Transition

$W' = \sum_{i=1,2} \frac{E_i}{|R - x_i|}$

$\delta \delta^* : \mu$
 $\delta_i : \text{proton}$

$R < x_i$

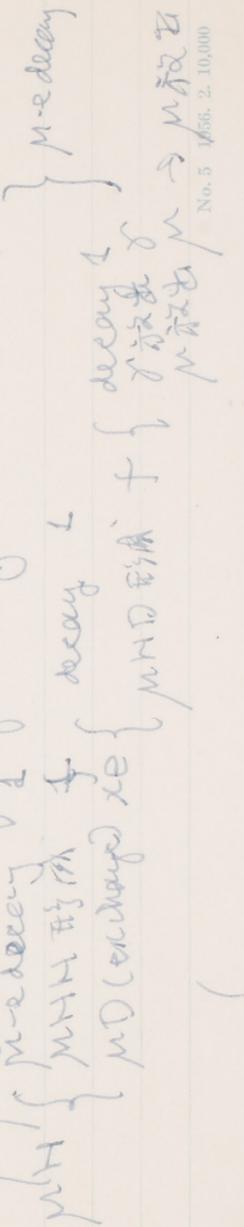
$\beta_{00} = \frac{16}{9} \times 2^3 \left(\frac{R^2}{a^2} \right)^2 \left(\frac{2k_0}{m_{\mu c^2}} \right)^{5/2} \mu \text{ sec}^{-1}$

$R^2 = \sum_{i=1,2} 4 \delta_i^* \gamma_i^2 a \delta_i \approx (3 \times 10^{-13})^2 \text{ cm}^2$

$\beta_{00} \approx 0.04 \text{ eV}$
 $\beta_\delta \approx 0.2 \text{ eV}$

$W_\delta \sim \mu p \sim \text{nd}$

5. μH without a frequency



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$$y = \frac{ne_0 Q_0}{\mu_0 n_0 \omega} = \frac{14 f + x e_0 (14 f + 14 f + 14 f)}{\mu_0 n_0 \omega} \quad (4)$$

$$x = \mu = 1: f = 10, e = 1.4 \times 10^3 (= 6 \times 10^3 \frac{1}{2})$$

6. Pure D of $\omega \approx 10^6$

$$\frac{1}{y} = \frac{\mu \mu}{\mu e} = f$$

exact resonance $f = 200$

7. slowing down

$$h = \frac{1}{n \omega_0} = 1.5 \times 10^{-2} \text{ cm}$$

8. ω of $\omega \approx 10^6$ D $\omega \approx 10^6$