Capture of Neutrons

Bethe, Bulletin. Feb. 1935

Neutron m, Nucleus M, Product Nucleus M'

$$\vec{p} + \vec{P} = \vec{P}'$$

$$\varepsilon + E = E'$$

$$m^2 = M^2 + M'^2 - 2(EE' - \vec{P}\vec{P}')$$

$$= (M'-M)^2 - 2(EE' - MM' - \vec{P}\vec{P}')$$

$$= (M'-M)^2 - 2\left\{\sqrt{M^2+P^2}\sqrt{M'^2+P'^2} - MM' - \vec{P}\vec{P}'\right\}$$

$$\leqq (M'-M)^2 - 2\left(\frac{MP^2}{2M} + \frac{M'P'^2}{2M'} - \vec{P}\vec{P}'\right\}$$

$$= (M'-M)^2 - \left(\sqrt{\frac{M}{M'}}\vec{P} - \sqrt{\frac{M'}{M}}\vec{P}'\right)^2$$

$$m \leqq M'-M$$

$P=0$; $\quad m^2 \leqq (M'-M)^2 - \frac{M}{M'}P'^2$

$\vec{p} = \vec{P}'$

$$\varepsilon + M = E' + \gamma \quad \cdots m^2$$

$$m^2 = (E'+\gamma-M)^2 - P'^2$$

$$= M'^2 + M^2 - 2E'M + 2\gamma(E'-M)$$

$$= (M'-M)^2 - 2\{(E'-M')M - \gamma(E'-M)\}$$

$$\gamma > \frac{E'-M}{(E'-M')M} = \frac{M'+\frac{P^2}{2M'}-M}{\frac{P^2}{2M'}M} = \frac{2M'^2+P^2-2M'M}{P^2M}$$

$$= \frac{2M'(M'-M)+P^2}{P^2M}$$