pendent of the material properties of the system. Any perturbation in the material properties α, β and the multiplication factor γ is expressed as a variation of $\beta^{(0)}$. The usual first-order perturbation formula is

$$\delta\epsilon = (\psi^{+}\cdot(\delta\beta^{(0)})K^{(0)}q^{(0)}) \tag{9}$$

The scalar product $(\psi^{+}\cdot\varphi)$ of ψ^{+} with a vector $\varphi(\mathbf{v}, \mathbf{r})$ is defined as

$$\iint \psi^{+}(-\mathbf{v}, \mathbf{r})\varphi(+\mathbf{v}, \mathbf{r})\, d^3v\, d^3r$$

in the physical case $\epsilon = 1$, and therefore we equate $\delta\epsilon$ to zero. Using (7) and (5), the above expression for $\delta\epsilon$ may be rewritten as follows

$$\delta\epsilon = 0 = \iiint \psi^{+}(-\mathbf{v}, \mathbf{r})(\delta\beta^{(0)}(\mathbf{v}, \mathbf{v}'; \mathbf{r}))\psi(\mathbf{v}', \mathbf{r})\, d^3v\, d^3v'\, d^3r$$

$$= \iiint \psi^{+}(-\mathbf{v}, \mathbf{r})\delta(\beta(\mathbf{v},\mathbf{v}'; \mathbf{r})/\gamma)\psi(\mathbf{v}', \mathbf{r})\, d^3v, d^3v'\, d^3r \tag{10}$$

$$- \iint \psi^{+}(-\mathbf{v}, \mathbf{r})\psi(\mathbf{v}, \mathbf{r})\delta\alpha(\mathbf{v}, \mathbf{r})\, d^3v\, d^3r$$

In general the variation $\delta\alpha$ consists of a variation $\delta\Sigma$ of the cross sections and a variation $\delta\lambda/v$ of the fictitious absorption cross section λ/v due to a time variation $\exp \lambda t$ of the system (*4*).

In the same way any number of terms in the perturbation series for $\epsilon(= 1)$ may be written down immediately and equated to zero. Thereby we get relations between the changes in α, β and γ. For example the second-order perturbation formula

$$\delta\epsilon = (\psi_1{}^{+}\cdot\delta\beta^{(0)}K^{(0)}q_1^{(0)}) + \sum_{\epsilon\neq 1} \frac{(\psi_1{}^{+}\cdot\delta\beta^{(0)}K^{(0)}q_\epsilon^{(0)})(\psi_\epsilon{}^{+}\cdot\delta\beta^{(0)}K^{(0)}q_1^{(0)})}{1-\epsilon} \tag{11}$$

yields the relation

$$\begin{aligned}\delta\epsilon = 0 = {}& \left(\frac{\delta\gamma}{\gamma}\right)^2 \sum_{\epsilon\neq 1} \frac{1}{1-\epsilon}\left\langle 1 \left| \frac{\beta}{\gamma} \right| \epsilon \right\rangle \left\langle \epsilon \left| \frac{\beta}{\gamma} \right| 1 \right\rangle \\ & - \left(\frac{\delta\gamma}{\gamma}\right)\left\{\left\langle 1 \left| \frac{\beta}{\gamma} \right| 1 \right\rangle + \sum_{\epsilon\neq 1}\frac{1}{1-\epsilon}\left[\left\langle 1 \left| \frac{\beta}{\gamma} \right| \epsilon \right\rangle \left\langle \epsilon \left| \left(\frac{\delta\beta}{\gamma} - \delta\alpha\right) \right| 1 \right\rangle \right.\right. \\ & \left.\left. + \left\langle 1 \left| \left(\frac{\delta\beta}{\gamma} - \delta\alpha\right) \right| \epsilon \right\rangle \left\langle \epsilon \left| \frac{\beta}{\gamma} \right| 1 \right\rangle \right]\right\} \\ & + \left\{\left\langle 1 \left| \left(\frac{\delta\beta}{\gamma} - \delta\alpha\right) \right| 1 \right\rangle \right. \\ & \left. + \sum_{\epsilon\neq 1}\frac{1}{1-\epsilon}\left\langle 1 \left| \left(\frac{\delta\beta}{\gamma} - \delta\alpha\right) \right| \epsilon \right\rangle \left\langle \epsilon \left| \left(\frac{\delta\beta}{\gamma} - \delta\alpha\right) \right| 1 \right\rangle \right\}\end{aligned} \tag{12}$$

where

$$\langle \epsilon' \mid \delta\alpha \mid \epsilon'' \rangle = \iint \psi^{+}_{\epsilon'}(-\mathbf{v}, \mathbf{r})\psi_{\epsilon''}(\mathbf{v}, \mathbf{r})\delta\alpha\cdot d^3v\, d^3r$$

$$\left\langle \epsilon' \left| \frac{\beta}{\gamma} \right| \epsilon'' \right\rangle = \frac{1}{\gamma}\iint \psi^{+}_{\epsilon'}(-\mathbf{v}, \mathbf{r})q_{\epsilon''}(\mathbf{v}, \mathbf{r})d^3v\, d^3r \tag{13}$$

$$\left\langle \epsilon' \left| \frac{\delta\beta}{\gamma} \right| \epsilon'' \right\rangle = \frac{1}{\gamma}\iiint \psi^{+}_{\epsilon'}(-\mathbf{v}, \mathbf{r})\delta\beta(\mathbf{v}, \mathbf{v}'; \mathbf{r})\psi_{\epsilon''}(\mathbf{v}', \mathbf{r})\, d^3v\, d^3v'\, d^3r$$

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4. See reference *3*, chapter III.

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Errata

Volume 7, Number 3, March 1960, in the article by Morton R. Fleishman and Harry Soodak entitled "Methods and Cross Sections for Calculating the Fast Effect," pp. 217–227:

Page 224, Table II change:

σ_{1t} for U^{238} from 4.52 to 4.541
σ_{1c} for U^{238} from 0.054 to 0.032
σ_{1t} for UO_2 from 7.77 to 7.796
σ_{1c} for UO_2 from 0.099 to 0.077