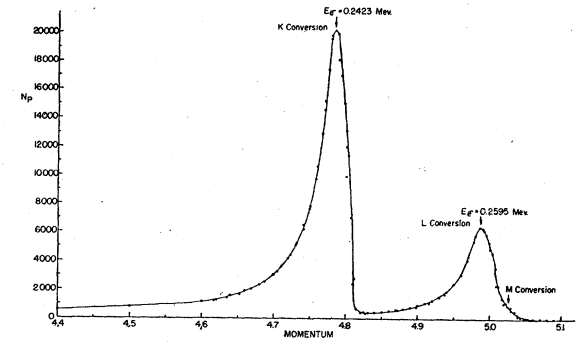

FIG. 2. K, L, M conversion of 0.2622-Mev gamma-ray of Mo^{93m}.

Princeton University. The spectrum obtained is shown in Figs. 2, 3, and 4 and agrees substantially with other results.[1,4] Our measured K/L ratio of 3.09 ± 0.06 for the 262-kev gamma-ray may be compared with values of 2.9 ± 0.2,[4] 2.8 ± 0.3,[5] and 2.79 ± 0.15.[1] Alburger has reported the total conversion coefficient of the 262-kev gamma-ray as $N_{e^-}/N_\gamma=0.7$.[5] Using our measured K/L ratio and the ratio of the numbers of K electrons in the three conversion lines, K conversion coefficients may be calculated for the three gamma-rays in cascade. Using these calculated K electron conversion coefficients and the new K/L ratio for the 684-kev gamma-ray, an attempt was made to assign the multipole order and type of transitions involved. Goldhaber's classification of K/L ratios[6] and the theoretical conversion coefficients of Rose

TABLE I. Gamma-ray transitions of Mo^{93m}.

E_{e^-} (Mev)	$E\gamma$ (Mev)	Ratio of K electrons	$\alpha_K=N_{e^-K}/N\gamma$	K/L	Type of transition
0.2423, 0.2595	0.2622	1	0.53	3.09 ± 0.06	$E4$[a]
0.6640	0.6842	$(4.8\pm1)\times10^{-3}$	$(1.5\pm0.3)\times10^{-3}$	$8.0\ \pm1.$	$M1$
1.459	1.479	$(7.8\pm1.6)\times10^{-4}$	$(2.4\pm0.5)\times10^{-4}$	—	$E2$ or $M1$

[a] See reference 6.

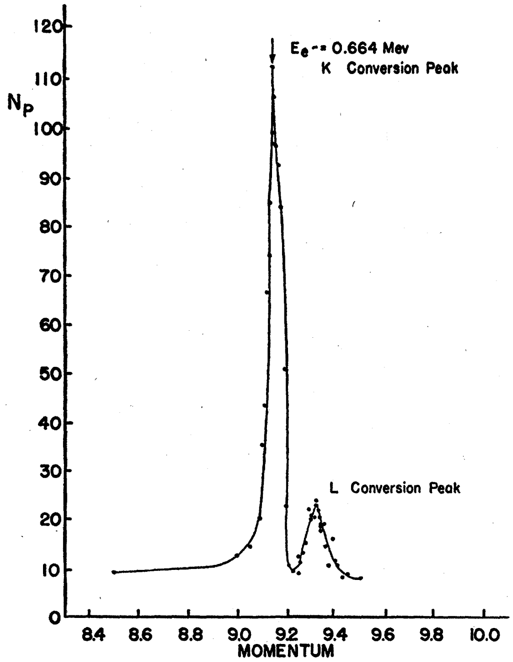

FIG. 3. K, L conversion of 0.6842-Mev gamma-ray of Mo^{93m}.

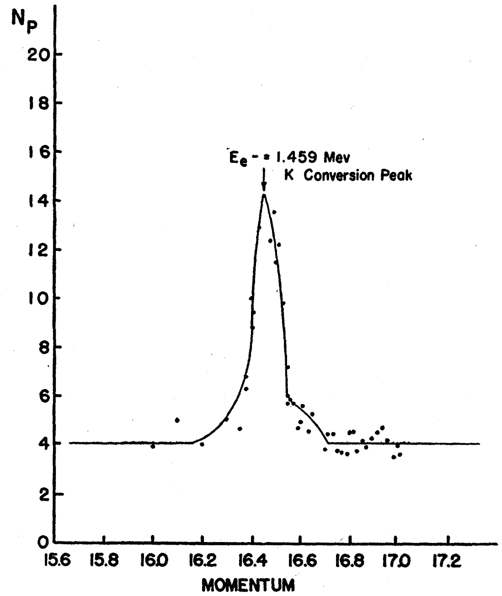

FIG. 4. K conversion of 1.479-Mev gamma-ray of Mo^{93m}.

et al.,[7] were used. We assign an $M1$ type transition to the 684-kev gamma-ray and $E2$ or $M1$ type to the 1479-kev gamma-ray. The results are summarized in Table I.

Goldhaber has suggested that Mo^{93m} is an example of "core isomerism" with the three-step isomeric transition going $8+\rightarrow 4+\rightarrow 2+\rightarrow 0+$.[8] This leads to assignments of $E4$ to the 262-kev transition and $E2$ to the 684-kev and 1479-kev transitions.[9] The α_K value only for the 1479-kev transition cannot distinguish between $E2$ and $M1$ for this transition but is closer to the expected $E2$ value.

† Work supported by the U. S. Atomic Energy Commission and the Higgins Trust Fund. This letter abstracted in part from the Ph.D. thesis of R. A. Naumann accepted by Princeton University in January, 1953.
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Interference Terms of the Electron-Neutrino Angular Correlation

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(Received March 24, 1953)

WE have deduced the electron-neutrino angular correlation functions $\mathfrak{W}$ in the allowed and first forbidden transition of beta-decay for the Fermi theory. The interaction Hamiltonian is assumed to be a linear combination of five relativistic invariants

$$H_\beta=\lambda_S S+\lambda_V V+\lambda_T T+\lambda_A A+\lambda_P P.$$

Although there exist several arguments bearing on the determination of the interaction types,[1] we shall take only the well-known Fierz conditions which exlude mixtures of S and V or T and A.

Since the square terms were derived by Greuling and Meeks,[2] we have recorded only the interference terms. When the properties of the transformation coefficients are used, it is verified that the interferences between the nuclear matrix elements with different ranks all vanish just as in the case of the correction factors. The results are:

1. Allowed. Interferences do not exist.
2. First forbidden:

$$\mathfrak{W}_{1ST}=\lambda_S\lambda_T[\{i\,\mathfrak{M}^*(\beta\mathbf{r})\,\mathfrak{M}(\beta\boldsymbol{\sigma}\times\mathbf{r})+\text{c.c.}\}[\{L_0-M_0\}+\tfrac{2}{3}\{K\mathbf{L}_{12}+K\mathbf{N}_{11}-\mathbf{N}_{12}+\mathsf{M}_1-\Lambda_2\}\cos\theta]-\{i\,\mathfrak{M}^*(\beta\mathbf{r})\,\mathfrak{M}(\beta\boldsymbol{\alpha})+\text{c.c.}\}[\{\tfrac{1}{3}KL_0+N_0\}+\{-\tfrac{2}{3}K\Lambda_1+(4/3)\mathbf{L}_{12}+\tfrac{1}{3}\mathbf{N}_{11}\}\cos\theta]].$$

$$\mathfrak{W}_{1SA}=-\lambda_S\lambda_A\{i\,\mathfrak{M}^*(\beta\mathbf{r})\,\mathfrak{M}(\boldsymbol{\sigma}\times\mathbf{r})+\text{c.c.}\}[\{\tfrac{2}{3}KN_0^-+\tfrac{1}{3}KL_{12}^-+L_1^-+M_0^-\}+\{-\tfrac{2}{3}K\mathbf{L}_{12}^--\tfrac{2}{3}K\mathbf{N}_{11}^-+2\mathbf{N}_{12}^-\}\cos\theta-KL_{12}^-\cos^2\theta].$$

$$\mathfrak{W}_{1SA}=-\lambda_S\lambda_A\{i\,\mathfrak{M}^*(\beta\mathbf{r})\,\mathfrak{M}(\boldsymbol{\sigma}\times\mathbf{r})+\text{c.c.}\}[\{\tfrac{2}{3}KN_0^-+\tfrac{1}{3}KL_{12}^-+L_1^-+M_0^-\}+\{-\tfrac{2}{3}K\mathbf{L}_{12}^--\tfrac{2}{3}K\mathbf{N}_{11}^-+2\mathbf{N}_{12}^-\}\cos\theta-KL_{12}^-\cos^2\theta].$$

$$\mathfrak{W}_{1VV}=\lambda_V^2\{i\,\mathfrak{M}^*(\mathbf{r})\,\mathfrak{M}(\boldsymbol{\alpha})+\text{c.c.}\}[\{\tfrac{1}{3}KL_0-N_0\}+\{\tfrac{2}{3}K\Lambda_1+(4/3)\mathbf{L}_{12}+\tfrac{1}{3}\mathbf{N}_{11}\}\cos\theta].$$

$$\mathfrak{W}_{1VT}=\lambda_V\lambda_T[\{i\,\mathfrak{M}^*(\mathbf{r})\,\mathfrak{M}(\beta\boldsymbol{\alpha})+\text{c.c.}\}[\{\tfrac{1}{3}KL_0^--N_0^-\}+\{-(4/3)\mathbf{L}_{12}^--\tfrac{1}{3}\mathbf{N}_{11}^-\}\cos\theta]+\{i\,\mathfrak{M}^*(\mathbf{r})\,\mathfrak{M}(\beta\boldsymbol{\sigma}\times\mathbf{r})+\text{c.c.}\}[\{\tfrac{2}{3}KN_0^-+\tfrac{1}{3}KL_{12}^--L_1^--M_0^-\}+\{\tfrac{2}{3}K\mathbf{L}_{12}^-+\tfrac{2}{3}K\mathbf{N}_{11}^-+2\mathbf{N}_{12}^-\}\cos\theta-KL_{12}^-\cos_2\theta]-\{\mathfrak{M}^*(\boldsymbol{\alpha})\,\mathfrak{M}(\beta\boldsymbol{\sigma}\times\mathbf{r})+\text{c.c.}\}[\{\tfrac{1}{3}KL_0^--N_0^-\}+\{-\tfrac{2}{3}\mathbf{L}_{12}^-+\tfrac{1}{3}\mathbf{N}_{11}^-\}\cos\theta]-\{\mathfrak{M}^*(\boldsymbol{\alpha})\mathfrak{M}(\beta\boldsymbol{\alpha})+\text{c.c.}\}L_0^-].$$

$$\mathfrak{W}_{1VA}=\lambda_V\lambda_A[\{i\mathfrak{M}^*(\mathbf{r})\,\mathfrak{M}(\boldsymbol{\sigma}\times\mathbf{r})+\text{c.c.}\}[\{L_1-M_0\}+\tfrac{2}{3}\{K\mathbf{L}_{12}+K\mathbf{N}_{11}+\mathbf{N}_{12}-\mathsf{M}_1+\Lambda_2\}\cos\theta]+\{\mathfrak{M}^*(\boldsymbol{\alpha})\mathfrak{M}(\boldsymbol{\sigma}\times\mathbf{r})+\text{c.c.}\}[\{\tfrac{1}{3}KL_0+N_0\}+\{-\tfrac{2}{3}K\Lambda_1+\tfrac{2}{3}\mathbf{L}_{12}-\tfrac{1}{3}\mathbf{N}_{11}\}\cos\theta]].$$

$$\mathfrak{W}_{1TT}=-\lambda_T^2\{\mathfrak{M}^*(\beta\boldsymbol{\sigma}\times\mathbf{r})\,\mathfrak{M}(\beta\boldsymbol{\alpha})+\text{c.c.}\}[\{(\tfrac{1}{3})KL_0-N_0\}+\{\tfrac{2}{3}K\Lambda_1+\tfrac{2}{3}\mathbf{L}_{12}-\tfrac{1}{3}\mathbf{N}_{11}\}\cos\theta].$$

$$\mathfrak{W}_{1TP}=-\lambda_T\lambda_P\{i\,\mathfrak{M}^*(\beta\boldsymbol{\sigma}\cdot\mathbf{r})\,\mathfrak{M}(\beta\gamma_5)+\text{c.c.}\}[\{\tfrac{1}{3}KL_0+N_0\}-\{\tfrac{2}{3}K\Lambda_1+\mathbf{N}_{11}\}\cos\theta].$$

$$\mathfrak{W}_{1AA}=-\lambda_A^2\{i\,\mathfrak{M}^*(\gamma_5)\,\mathfrak{M}(\boldsymbol{\sigma}\cdot\mathbf{r})+\text{c.c.}\}[\{\tfrac{1}{3}KL_0-N_0\}+\{\tfrac{2}{3}K\Lambda_1-\mathbf{N}_{11}\}\cos\theta].$$

$$\mathfrak{W}_{1AP}=\lambda_A\lambda_P[\{i\,\mathfrak{M}^*(\boldsymbol{\sigma}\cdot\mathbf{r})\,\mathfrak{M}(\beta\gamma_5)+\text{c.c.}\}[\{\tfrac{1}{3}KL_0^--N_0^-\}+\mathbf{N}_{11}^-\cos\theta]-\{\mathfrak{M}^*(\gamma_5)\,\mathfrak{M}(\beta\gamma_5)+\text{c.c.}\}L_0^-].$$

L_i, M_i and N_i are given by Konopinski and Uhlenbeck.[3] L_i^-, M_i^- and N_i^- are given by Smith.[4] The other notations are as follows, the arrow in each case indicating the approximation $\alpha Z\ll 1$:

$$\mathbf{L}_{12}=\left(\frac{p^2}{2\pi}F\right)^{-1}\frac{f_1f_2\sin(\delta_1-\delta^2)+g_{-1}g_{-2}\sin(\delta_{-1}-\delta_{-2})}{4\pi\rho}\to\frac{p}{3},$$

$$\mathbf{N}_{11}=\left(\frac{p^2}{2\pi}F\right)^{-1}\frac{(f_{-1}f_1-g_{-1}g_1)\sin(\delta_{-1}-\delta_1)}{4\pi\rho}\to-\frac{p}{W}\frac{\alpha Z}{2\rho}-\frac{p}{3},$$

$$\mathbf{N}_{12}=\left(\frac{p^2}{2\pi}F\right)^{-1}\frac{f_{-1}g_{-2}\sin(\delta_{-1}\delta_{-2})-g_1f_2\sin(\delta_1-\delta_2)}{4\pi\rho^2}\to-\frac{p}{3}\frac{\alpha Z}{2\rho}-\frac{p^3}{9W},$$

$$\mathbf{L}_{12}^-=\left(\frac{p^2}{2\pi}F\right)^{-1}\frac{f_1f_2\sin(\delta_1-\delta_2)-g_{-1}g_{-2}\sin(\delta_{-1}-\delta_{-2})}{4\pi\rho}\to-\frac{p}{3W},$$

$$\mathbf{N}_{11}^-=\left(\frac{p^2}{2\pi}F\right)^{-1}\frac{(f_{-1}f_1+g_{-1}g_1)\sin(\delta_{-1}-\delta_1)}{4\pi\rho.}\to\frac{p}{3W},$$

$$\mathbf{N}_{12}^-=\left(\frac{p^2}{2\pi}F\right)^{-1}\frac{f_{-1}g_{-2}\sin(\delta_{-1}-\delta_{-2})+g_1f_2\sin(\delta_1-\delta_2)}{4\pi\rho^2}\to-\frac{p}{3W}\frac{\alpha Z}{2\rho},$$

$$L_{12}=\left(\frac{p^2}{2\pi}F\right)^{-1}\frac{g_{-1}f_2\cos(\delta_{-1}-\delta_2)-f_1g_{-2}\cos(\delta_1-\delta_{-2})}{4\pi\rho}\to-\frac{p^2}{3W},$$

$$L_{12}^-=\left(\frac{p^2}{2\pi}F\right)^{-1}\frac{g_{-1}f_2\cos(\delta_{-1}-\delta_2)+f_1g_{-2}\cos(\delta_1-\delta_{-2})}{4\pi\rho}\to 0,$$

$$\Lambda_1=\left(\frac{p^2}{2\pi}F\right)^{-1}\frac{g_{-1}f_1\sin(\delta_{-1}-\delta_1)}{4\pi}\to\frac{p}{2W},$$

$$\Lambda_2=\left(\frac{p^2}{2\pi}F\right)^{-1}\frac{g_{-2}f_2\sin(\delta_{-2}-\delta_2)}{4\pi\rho^2}\to\frac{p^3}{18W},$$

$$\mathsf{M}_1=\left(\frac{p^2}{2\pi}F\right)^{-1}\frac{f_{-1}g_1\sin(\delta_{-1}-\delta_1)}{4\pi\rho^2}\to-\frac{p}{2W}\frac{\alpha^2Z^2}{4\rho^2}-\frac{p}{3}\frac{\alpha Z}{2\rho}-\frac{p^3}{18W}.$$

If the electron-neutrino angular correlation measurements are performed for several elements, the interaction type of the beta-decay could be completely decided. For example, it could definitely be decided whether the type is S or V in the allowed 0–0 transition[5] and T or A in the allowed $J+1\to J$[5] and first forbidden $J+2\to J$ transitions, where the spin changes of the nuclei are well defined by any other methods.

The experimental data[6] on P^{32} can be explained by the tensor interaction if the spin of P^{32} is 1. The complete formulation of our results will be published elsewhere.

The author wishes to express his sincere thanks to Professor S. Nakamura, Mr. M. Umezawa, and Mr. M. Yamada.

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