TRAINING SCHOOL LIBRARY

MARTIN MARIETTA ENERGY SYSTEMS LIBRARIES
3 4456 0353053 3

ORNL 1324
Physics

8a

THE INTERNAL CONVERSION CORRELATION FOR MIXED CONVERSION TRANSITIONS

CENTRAL RESEARCH LIBRARY
DOCUMENT COLLECTION
LIBRARY LOAN COPY
DO NOT TRANSFER TO ANOTHER PERSON
If you wish someone else to see this document, send in name with document and the library will arrange a loan.

OAK RIDGE NATIONAL LABORATORY
OPERATED BY
CARBIDE AND CARBON CHEMICALS COMPANY
A DIVISION OF UNION CARBIDE AND CARBON CORPORATION
UCC
POST OFFICE BOX P
OAK RIDGE, TENNESSEE

UNCLASSIFIED

ORNL 1324

This document consists of 9 pages. No. 8 of 307 copies, Series A

Contract No. W-7405, eng 26

PHYSICS DIVISION

THE INTERNAL CONVERSION CORRELATION FOR MIXED CONVERSION TRANSITIONS

M. E. Rose
L. C. Biedenharn

Date Issued: JUL 10 1952

OAK RIDGE NATIONAL LABORATORY
operated by
CARBIDE AND CARBON CHEMICALS COMPANY
A Division of Union Carbide and Carbon Corporation
Post Office Box P
Oak Ridge, Tennessee

UNCLASSIFIED

MARTIN MARIETTA ENERGY SYSTEMS LIBRARIES
3 4456 0353053 3

INTERNAL DISTRIBUTION

1. G. T. Felbeck (C&CCC)
2-3. Chemistry Library
4. Physics Library
5. Biology Library
6. Health Physics Library
7. Metallurgy Library
8-9. Training School Library
10. Reactor Experimental Engineering Library
11-14. Central Files
15. C. E. Center
16. C. E. Larson
17. W. B. Humes (K-25)
18. L. B. Emlet (Y-12)
19. A. M. Weinberg
20. E. H. Taylor
21. E. D. Shipley
22. A. H. Snell
23. F. C. VonderLage
24. R. C. Briant
25. J. A. Swartout
26. S. C. Lind
27. F. L. Steahly
28. A. Hollaender
29. M. T. Kelley
30. G. H. Clewett
31. K. Z. Morgan
32. J. S. Felton
33. A. S. Householder
34. C. S. Harrill
35. C. E. Winters
36. D. S. Billington
37. D. W. Cardwell
38. E. M. King
39. E. O. Wollan
40. A. J. Miller
41. L. D. Roberts
42. R. N. Lyon
43. W. C. Koehler
44. W. K. Ergen
45. E. P. Blizard
46. M. E. Rose
47. D. D. Cowen
48. P. M. Reyling
49. L. C. Biedenharn
50. J. A. Lane
51. M. J. Skinner
52. Central Files (O.P.)

EXTERNAL DISTRIBUTION

53-307. Given distribution as shown in TID-4500 under Physics category.

DISTRIBUTION PAGE TO BE REMOVED IF REPORT IS GIVEN PUBLIC DISTRIBUTION

THE INTERNAL CONVERSION CORRELATION FOR MIXED CONVERSION TRANSITIONS

M. E. Rose and L. C. Biedenharn

In a recently published paper[1] the angular correlation problem in a double cascade in which one or both transitions involves the emission of a conversion electron was treated. In the aforementioned work the restriction to pure multipoles for the conversion transition was made. The purpose of this report is to make the extension to the case in which the conversion transition is a mixture and we present results for the practical case of a mixture of 2^L pole magnetic plus 2^{L+1} pole electric radiation.

The procedure is exactly like that presented in reference 1. The electron current is now calculated with a perturbing interaction given in terms of the vector potential

$$\vec{A} = \alpha \vec{A}_m + \beta \vec{A}_e \tag{1}$$

Here $\vec{A}_m$ and $\vec{A}_e$ are the vector potentials for a magnetic 2^L pole and an electric 2^{L+1} pole respectively. This, of course, defines the scalar potential as a mixture with the same weight factors. We can normalize to

$$\alpha^2 + \beta^2 = 1 \tag{2}$$

and α^2/β^2 is the intensity ratio of magnetic to electric multipoles.

It is a straightforward matter to obtain the electron current by the methods of reference 1. We find for the correlation function giving the coincidence rate in a mixed conversion pure gamma correlation*

---

1. M. E. Rose, L. C. Biedenharn and G. B. Arfken, Phys. Rev. 85, 5 (1952).

* Here and below we present only the results. Details of the derivation may be found in a forthcoming article to be submitted to the Reviews of Modern Physics.

$$W(\vartheta) = \alpha^2 \frac{C_m}{\bar{C}} W_m(\vartheta) + \beta^2 \frac{C_e}{\bar{C}} W_e(\vartheta) + 2\alpha\beta b' \sqrt{\frac{C_m C_e}{\bar{C}}} W'(\vartheta) \qquad (3)$$

Here $W_m(\vartheta)$ is the correlation function given in reference 1 for a cascade in which the conversion transition is a pure 2^L pole magnetic transition (M_L); $W_e(\vartheta)$ is the corresponding correlation function when the conversion transition is a pure 2^{L+1} pole electric transition (E_{L+1}); $W'(\vartheta)$ is the interference term for the γ-γ transition of the cascade. Thus, if the cascade is designated by $j_1(E_{L+1} + M_L)\, j(E_{L'}$ or $M_{L'})j_2$ (read from left to right or from right to left) then

$$W_m = (2L+1) \sum_{\nu} b_\nu(m)\, C_{1-1}^{LL\nu}\, C_{1-1}^{L'L'\nu}\, W(jjLL;\nu j_1)$$

$$\cdot\, W(jjL'L';\nu j_2)\, P_\nu(\cos\vartheta) \qquad (3a)$$

$$W_e = (2L+3) \sum_{\nu} b_\nu(e)\, C_{1-1}^{L+1\,L+1\,\nu}\, C_{1-1}^{L'L'\nu}\, W(jjL+1\;L+1;\nu j_1)$$

$$W(jjL'L';\nu j_2)\, P_\nu(\cos\vartheta) \qquad (3b)$$

and the interference term W' is the one characteristic of the γ-γ cascade,

$$W' = \sqrt{(2L+1)(2L+3)} \sum_{\nu} C_{1-1}^{LL+1}\, C_{1-1}^{L'L'\nu}\, W(jjLL+1;\nu j_1)$$

$$W(jjL'L';\nu j_2)\, P_\nu(\cos\vartheta) \qquad (3c)$$

As usual ν is even and the $b_\nu(m)$ and $b_\nu(e)$ are given for the K-shell in reference 1 and also in ORNL report No. 1097. In (3) C_m is the internal conversion coefficient for the pure M_L radiation, C_e is the corresponding coefficient for the pure E_{L+1} radiation and

$$\bar{\bar{C}} = \alpha^2 C_m + \beta^2 C_e$$

is the conversion coefficient which would be actually observed in the mixed transition. Numerical values of the conversion coefficients for the K-shell are published elsewhere.[2]

The remaining factor b' is the physical parameter which converts the mixed term for γ-γ cascades to c.e. - γ (or γ - c.e.) cascades. It is to noted that b' is independent of ν so that the interference term has the same angular dependence in the two cases. The mixture parameter b' is given by

$$b' = \sqrt{\frac{L(L+2)}{(2L+1)(2L+3)}} \; \frac{\mathrm{Re}\left[e^{i(\theta_e - \theta_m)}\left(1 + \frac{L+1}{L\,T_m}\right)^{*}\left(1 - \frac{L+1}{T_e}\right)\right]}{\sqrt{\left[1 + \frac{L+1}{L\left|T_m\right|^2}\right]\left[1 + \frac{(L+2)(L+1)}{\left|T_e\right|^2}\right]}} \qquad (4)$$

where Re means real part and T_e and T_m are defined in reference 1, Eq's. (46a) and (48a); in the same notation

$$e^{i\theta_e} = i\,\frac{\left[(L+1)(R_1+R_2) - (2L+3)\,R_3 - R_4\right]}{\left|(L+1)(R_1+R_2) - (2L+3)\,R_3 - R_4\right|}\;; \quad \mathcal{H} = L+1$$

$$e^{i\theta_m} = \frac{i\,(R_3' + R_4')}{\left|R_3' + R_4'\right|}\;; \qquad \mathcal{H} = L+1$$

The following tables give b' for L = 1, 2, 3, 4 and for the same range of Z and energy (k) values used in previous work on the K-shell conversion processes.[1,2] As an aid to extrapolation we give the following limiting values

---

2. M. E. Rose, G. H. Goertzel, B. Spinrad, J. Harr and P. Strong, Phys. Rev. 83, 79 (1951).

(a) for $Z = 0$

$$b' = \left[1 + 4\,\frac{L+1}{L+2}\,\frac{1}{k^2}\right]^{-1/2}$$

(b) for $k \rightarrow \infty$

$$b' = -1$$

Of course, for the correlation in which the pure γ is replaced by any other radiation we have only to insert the appropriate b_ν as additional factors of the Legendre polynomials P_ν in (3a), (3b) and (3c). These are given in reference 1 for α-particles and for pure conversion transitions while for β-decay transitions the appropriate factors can be obtained (for not too large Z) from the thesis of M. Fuchs.[3]

---

3. Fuchs, The Effect of Nuclear Charge and Interference on Beta-Gamma Angular Correlation, Ph. D. dissertation, University of Michigan (1951).

TABLES OF b'

k	Z	L 1	2	3	4
.3	10	-.1928	-.1899	-.1898	-.1909
	20	-.1989	-.2083	-.2166	-.2243
	30	-.1979	-.2287	-.2491	-.2669
	40	-.1894	-.2536	-.2905	-.3225
	54	-.1483	-.2916	-.3692	-.4311
	64	-.08891	-.3130	-.4353	-.5235
	72	-.006616	-.3200	-.4825	-.5857
	78	.08917	-.2972	-.4953	-.6059
.5	10	-.3094	-.3032	-.3016	-.3020
	20	-.3203	-.3288	-.3365	-.3447
	30	-.3244	-.3567	-.3772	-.3958
	40	-.3198	-.3877	-.4251	-.4576
	54	-.2924	-.4383	-.5106	-.5658
	64	-.2490	-.4759	-.5785	-.6460
	72	-.1908	-.5003	-.6242	-.6947
	78	-.1266	-.5126	-.6486	-.7094
	83	-.05448	-.5077	-.6527	-.7118
	88	.03913	-.4913	-.6447	-.6951
	92	.1322	-.4610	-.6231	-.6728
	96	.2419	-.4144	-.5895	-.6410

TABLES OF b'

k	Z \ L	1	2	3	4
1.0	10	-.5417	-.5324	-.5291	-.5287
	20	-.5557	-.5643	-.5715	-.5792
	30	-.5623	-.5948	-.6150	-.6324
	40	-.5593	-.6267	-.6610	-.6869
	54	-.5324	-.6665	-.7209	-.7563
	64	-.4902	-.6867	-.7552	-.7903
	72	-.4370	-.6976	-.7697	-.7986
	78	-.3822	-.6966	-.7694	-.7907
	83	-.3246	-.6882	-.7620	-.7792
	88	-.2547	-.6717	-.7461	-.7596
	92	-.1892	-.6490	-.7241	-.7404
	96	-.1148	-.6272	-.7056	-.7181
1.8	10	-.7533	-.7473	-.7451	-.7449
	20	-.7608	-.7709	-.7785	-.7850
	30	-.7609	-.7906	-.8075	-.8200
	40	-.7504	-.8063	-.8314	-.8472
	54	-.7104	-.8159	-.8506	-.8675
	64	-.6574	-.8100	-.8505	-.8651
	72	-.5958	-.7979	-.8400	-.8501
	78	-.5363	-.7819	-.8248	-.8317
	83	-.4768	-.7634	-.8075	-.8129
	88	-.4078	-.7411	-.7868	-.7901
	92	-.3453	-.7170	-.7640	-.7703
	96	-.2763	-.6955	-.7455	-.7489

TABLES OF b'

k	Z \ L	1	2	3	4
3.0	10	-.8826	-.8805	-.8805	-.8813
	20	-.8829	-.8909	-.8977	-.9033
	30	-.8770	-.8981	-.9101	-.9181
	40	-.8614	-.8991	-.9148	-.9236
	54	-.8149	-.8878	-.9093	-.9170
	64	-.7564	-.8674	-.8926	-.8990
	72	-.6895	-.8443	-.8717	-.8761
	78	-.6255	-.8230	-.8525	-.8544
	83	-.5623	-.8009	-.8325	-.8339
	88	-.4897	-.7758	-.8101	-.8108
	92	-.4248	-.7535	-.7903	-.7912
	96	-.3540	-.7296	-.7696	-.7705
5.0	10	-.9507	-.9501	-.9509	-.9521
	20	-.9481	-.9531	-.9572	-.9604
	30	-.9410	-.9511	-.9579	-.9632
	40	-.9263	-.9463	-.9549	-.9590
	54	-.8835	-.9266	-.9382	-.9410
	64	-.8271	-.9014	-.9162	-.9184
	72	-.7591	-.8759	-.8940	-.8941
	78	-.6915	-.8508	-.8721	-.8722
	83	-.6229	-.8266	-.8514	-.8523
	88	-.5430	-.8004	-.8292	-.8296
	92	-.4712	-.7763	-.8085	-.8110
	96	-.3931	-.7527	-.7888	-.7909