COMMENTS AND ADDENDA

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Intermediate-State Reorientation of Co^{57} in a Fluorosilicate Lattice

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Application of a recently developed model for the calculation of reorientation due to electron-shell rearrangement following K capture to the case of Co^{57} nuclei oriented in a fluorosilicate lattice yields results which further support the validity of the model.

In a recent paper by the author[1] (hereafter referred to as I; the same notation as in I will be used throughout this paper), a model was developed for the calculation of reorientation following K capture employing a technique developed by Daniels and Misra[2] and was applied to the cases of Sm^{145} and Co^{57} oriented in a double-nitrate lattice, and of Sm^{145} oriented in an ethyl sulfate lattice. It was found that the model is capable of accounting for the observed reorientation in all these cases. It is the purpose of this paper to further test the validity of the model of I by applying it to the case of Co^{57} oriented in a fluorosilicate lattice. This appears to be a relevant case to consider, since the attenuation factor of nuclear alignment Q_2 has been observed to be 0.32 by Stone for the 137-keV γ rays.[3]

We now discuss the details of the electronic shell of Co^{57} after K capture.[4] The electronic shell after decay has most probably the same configurations as either[5] that of Fe^{++} or of Fe^{+++} (other charge configurations are also observed[6]). We expect no reorientation if the end state is Fe^{++}, since for it either the parameters $g_\perp$ and B are zero, or a singlet state lies lowest making the shell nonmagnetic for the trigonal symmetry of the fluorosilicate lattice.[2,7] For a final configuration of Fe^{+++} which is of the same structure as that of Mn^{++}, we have

$$\mathcal{H}_{\text{eff}} = g\mu_B \vec{H}\cdot\vec{S} + D[S_z^2 - \tfrac{1}{3}S(S+1)] + A\vec{S}\cdot\vec{I}\,.$$

For the present case, we choose $g=2$ (i.e., the same as that for Mn^{++}) and obtain A from its value for Mn^{++} by scaling in the ratio of magnetic moments of the 137-keV state of Fe^{57} and the Mn^{55}

TABLE I. Orientation parameter $A_2[=\langle \mathcal{Y}_2^0(\vec{I})\,\mathcal{Y}_0^0(\vec{S})\rangle]$ for Co^{57} oriented in fluorosilicate lattice. The superscripts p and d refer to the parent and daughter states, respectively, whereas the superscripts τ and ∞ refer to the nuclear lifetime and hard-core averages, respectively. (a) refers to the configuration of the electron shell being of the Mn^{++} type with the same spin-Hamiltonian parameters as those for Mn^{++} in $ZnSiF_6\cdot 6H_2O$ lattice but with the parameter A scaled in the ratio of magnetic moment of Fe^{57} nucleus to that of Mn^{55} nucleus. Configurations (b)–(f) are characterized by the same spin-Hamiltonian parameters as (a) save for the parameter D which is, respectively, twice, five times, one-thousand times, one-fifth, and one-tenth that for (a).

	T(°K)	$A_2^p\times 10$	$A_2^d\times 10$
	0.02	1.32	1.34
	0	3.78	3.82
T(°K)	Configuration	$A_2^\tau(=A_2^\infty)\times 10$	$Q_2^\tau(=Q_2^\infty)$
	(a)	0.694	0.52
	(b)	0.703	0.52
	(c)	0.706	0.53
0.02	(d)	0.707	0.53
	(e)	0.463	0.35
	(f)	0.329	0.25
	(a)	1.96	0.51
	(b)	1.99	0.52
	(c)	2.00	0.52
0	(d)	2.00	0.52
	(e)	1.32	0.35
	(f)	0.944	0.25

ground state ($A = 0.0091$ cm^{-1} for Mn^{++} in $ZnSiF_6 \cdot 6H_2O$ lattice). For D, which is not known experimentally (and there being no obvious way to obtain it theoretically), we assume several values, namely, (a) -0.0134 cm^{-1} (i.e, that for Mn^{++}), (b) twice the value given in (a), (c) five times the value given in (a), (d) one-thousand times the value given in (a) [i.e., of the same order of magnitude as in ferrous fluorosilicate[7]], (e) one-fifth the value given in (a), and (f) one-tenth the value given in (a).

The results for the various cases of final Fe^{+++} configurations are presented in Table I. It is seen that Q_2 ranges anywhere from 0.25 to 0.53.[8] We will not make any attempt to calculate a final value of Q_2, which requires a knowledge of the branching ratios to the various end-state configurations, namely, Fe^{++}, Fe^{+++}, ... since these ratios are not at all known. However, it is clear from the results that a final value of $Q_2 = 0.32$ is possible.

We thus conclude that the model of I includes in its range the observed reorientation for the case of Co^{57} in a fluorosilicate lattice.

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[1] S. K. Misra, Phys. Rev. B 3, 176 (1971).

[2] J. M. Daniels and S. K. Misra, Can. J. Phys. 44, 1965 (1966).

[3] N. J. Stone, Ph. D. thesis (Oxford University, 1963) (unpublished); and private communication. We are grateful to Dr. Stone for suggesting the investigation of this problem.

[4] The spin Hamiltonian of the parent state is of the form $g_{\parallel}\mu_B H_z S_z + A S_z I_z + g_{\perp}\mu_B (H_x S_x + H_y S_y) + B(S_x I_x + S_y I_y)$, with $g_{\parallel} = 5.82$, $g_{\perp} = 3.44$, $A = 0.0184$ cm^{-1}, and $B = 0.0047$ cm^{-1} {i.e., those for Co^{59} in $ZnSiF_6 \cdot 6H_2O$ lattice at 20 °K [see K. D. Bowers and J. Owen, Rept. Progr. Phys. 18, 304 (1955)]; since the magnetic moments of Co^{57} and Co^{59} are almost the same, we have used the same values of A and B}.

[5] G. K. Wertheim, Phys. Rev. 124, 764 (1961).

[6] The Fe^{1+} and Fe^{4+} states are also observed in some oxide hosts, but the Fe^{2+} and Fe^{3+} states occur most commonly. See, e.g., W. Triftshäuser and D. Schroeer, Phys. Rev. 187, 491 (1969).

[7] R. S. Rubins and H. R. Fetterman, Bull. Am. Phys. Soc. 16, 522 (1971). Their measurements yield a spin Hamiltonian of the form $g_{\parallel}\mu_B H S_z + D S_z^2 + E(S_x^2 - S_y^2)$ in ferrous fluorosilicate with $S = 2$, $g_{\parallel} = 2$, $D = 11.8$ cm^{-1}, and $E = 0.54$ cm^{-1}.

[8] The nuclear alignment parameter is proportional to A_2. Then $Q_2 = A_2$ (average)$/A_2(0+)$. Because of increased decoupling between $\vec{S}$ and $\vec{I}$, as seen from the form of $\mathcal{H}_{\text{eff}}$, lesser reorientation is obtained for larger values of D.

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Comparison of Mass Absorption Coefficients of Positive and Negative Beta Particles in Aluminum and Tin

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Mass absorption coefficients for six negative and three positive β-particle sources have been determined for aluminum and tin absorbers. Most of the large difference in the μ/ρ values relevant to ^{86}Rb and ^{68}Ga reported for aluminum by Takhar is shown to be due to the difference in their end-point energies; however, a significant difference in μ/ρ values for tin remains.

Takhar[1] compared the transmission of positive β particles from ^{68}Ga (having the end-point energy $E_0 = 1.88$ MeV) with that of negative β particles from ^{86}Rb ($E_0 = 1.77$ MeV) in various substances and reported that the mass absorption coefficient μ/ρ for positive β particles is less than that for negative β particles by about 12% for aluminum, 19% for copper, 25% for tin, and 35% for lead. The aluminum results were in disagreement with the results of Chang *et al.*[2] and of Baskova and Gorbachev,[3] who observed no significant difference in the transmission through aluminum foils of monoenergetic positive and negative β particles. Commenting on the results of Takhar for aluminum, Cook[4] observed that the β-particle spectra of ^{68}Ga and ^{86}Rb are complex and not sufficiently similar to allow direct comparison of transmission through various foils of the positive and negative β particles. He also pointed out that if one accepts the energy-dependent formula of Gleason *et al.*[5] for