Comments

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Spin and width of the 4744 keV level of ^{88}Sr†

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A recent study of the $^{87}Sr(d,p)^{88}Sr$ reaction reopened the question of the spin of the 4744 keV level of ^{88}Sr. In an effort to determine this spin, the 4744 keV level has been excited using bremsstrahlung. The observed angular distribution of the resonant γ radiation is compatible only with the assignment of spin 1. With a branching ratio $\Gamma_0/\Gamma = 1$, the observed yield corresponds to a total width $\Gamma(4744) = (95 \pm 20)$ meV.

[NUCLEAR REACTIONS $^{88}Sr(\gamma,\gamma)$, $E < 5$ MeV; measured $\sigma(\theta)$, deduced J, Γ; natural target.]

Spin-parity assignments of 1^-, 1^+, and 2^+ have been suggested for the 4744 keV level in ^{88}Sr. The 1^- assignment was based on the logft value for the β^- branch from the 2^- ground state of ^{88}Rb. According to some measurements,[1-3] this logft value falls into the "allowed-only" range logft ≤ 5.8.[4] Once a logft value of 5.9 had been measured,[5] the 1^+ assignment had to be admitted as another possibility. The strongest support was given to the 2^+ assignment[5-8] because the proton group populating the 4744 keV level in the reaction $^{87}Sr(d,p)^{88}Sr$ had been reported[9] to exhibit a stripping pattern corresponding to $l_n = 2$. Little attention was paid to the remark by the authors[9] that the particular proton group could have had its origin in the "impurity" reaction $^{88}Sr(d,p)^{89}Sr$ to the ground state of ^{89}Sr because the target contained 12.72% of ^{88}Sr.

In a recent study[10] of the reaction $^{87}Sr(d,p)^{88}Sr$, targets with different ^{88}Sr content were used, and it was found that the presence of as little as 6% of ^{88}Sr in the target greatly affected the apparent intensities of the proton groups corresponding to the 4744 and 5780 keV levels in ^{88}Sr because the proton groups from the reaction $^{88}Sr(d,p)^{89}Sr$ to the ground state and the first excited state of ^{89}Sr practically coincided with them. The "impurity" reaction $^{88}Sr(d,p)^{89}Sr$ was shown[10] to account completely for the proton group formerly attributed to a 5780 keV level in ^{88}Sr, and to account for a large fraction of the proton group attributed to the 4744 keV level. Because of the dominance of the impurity reaction, the angular distribution of the protons populating the 4744 keV level could not be determined even with a target containing as little as 6% of ^{88}Sr. This meant that the previous (d,p) experiment,[9] in which a target containing considerably more ^{88}Sr had been used, really did not provide any information concerning the spin of the 4744 keV level, and that spin 1 was once again a possible choice.

For an even even nucleus such as ^{88}Sr, the resonant scattering of γ rays offers a way of deciding between spin 1 and spin 2 because the angular distributions for the spin sequences 0-1-0 and 0-2-0 differ drastically. Excitation of the 4744 keV state with bremsstrahlung appeared feasible because the direct decay to the ground state was known[2,3,5-7,11] to be the prominent decay mode. Based on these considerations, a resonance fluorescence experiment involving the 4744 keV state of ^{88}Sr was initiated, and what follows is a report on the results of this experiment.

The bremsstrahlung was produced in a 35 mg/cm^2 Au foil by electrons from the Bartol van de Graaff accelerator. Incident electron energies ranging from 100 to 200 keV above the level energy were used in various runs. For typical geometries and procedures, the reader is referred to previous publications.[12] The scattering material, 40.5 g of SrO, was contained in plexiglass in a cylindrical volume measuring 5.71 cm in

TABLE I. Comparison of the angular distribution results with theoretical predictions.

		$\frac{N_{sc}(98°)}{N_{sc}(127°)}$
EXPERIMENT	3487 1^+	0.70± 0.05
	4743	0.75± 0.20
THEORY	Spin 1 (0–1–0)	0.75
	Spin 2 (0–2–0)	2.08

diameter and 1.63 cm in length. Yield measurements were carried out for scattering angles of 98° and 127°. The strong direct resonant scattering from the well established 1^+ state of ^{88}Sr at 3487 keV excitation energy served as a convenient monitor.

In Table I, the observed ratios of the resonant yields at the two scattering angles are compared with the ratios expected if the excited state has spin 1 or spin 2. Clearly, the 4743 ±2 keV level excited with photons has spin 1.

It is very probable that this level is identical with the 4743.7 ±0.1 keV level[6] populated in the decay of ^{88}Rb, and with the 4744 ±5 keV level[10] excited in the reaction ^{87}Sr$(d,p)^{88}$Sr.

From the observed average resonant scattering yield, a value

$$\Gamma_0^2/\Gamma = (95 \pm 20) \text{ meV}$$

has been obtained. Here Γ_0 represents the partial radiative width for the ground state transition, while Γ denotes the total width of the level.

With one exception,[6] the studies[2,3,5,6,11,13] of the ^{88}Rb decay reported $\Gamma_0/\Gamma = 1$ for the 4744 keV level in ^{88}Sr. Reference 6 reported the presence of a 1257 keV branch to the 3487 keV level with an intensity which would lead to a branching ratio $\Gamma_0/\Gamma = 0.89$ and thus to a total width $\Gamma = 0.12 \pm 0.03$ eV. The resonance fluorescence experiment cannot confirm or rule out the existence of such a branch because the 3487 keV level is directly excited[14] with an intensity exceeding the intensity of the proposed branch by two orders of magnitude, and because the 1257 keV γ line falls into a region where the background counting rate is several orders of magnitude larger than the expected 1257 peak counting rate. The question of the branching appears to be still open, the more so since a spectrum published by Pratt[13] clearly shows a 1297 keV line but provides no indication of a 1257 keV transition. On the other hand, according to Ref. 6, the 1257 keV transition should be at least as strong as the 1297 keV transition.

The measured width for the ground state transition corresponds to $\approx 7\times10^{-4}$ W.u. if the transition is $E1$, and $\approx 4\times10^{-2}$ W.u. if it is $M1$. A negative parity assignment is favored in view of the previously mentioned low logft values.[1-3] It is worth noticing that the excitation energy of this spin 1 level is close to the sum of the excitation energies of the first 2^+ state (1836 keV) and the first 3^- state (2734 keV) in ^{88}Sr, i.e. that the $1^{(-)}$ state at 4744 keV might arise from the coupling of a quadrupole phonon with an octupole phonon. Strong 1^- excitations at $E_{exc} \approx E(2^+) + E(3^-)$ have already been observed[15] in other vibrational nuclei such as ^{140}Ce and ^{142}Nd.

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[1] R. Hess, Helv. Phys. Acta 41, 77 (1968).
[2] H. Lycklama, N. P. Archer, and T. J. Kennett, Can. J. Phys. 47, 393 (1969).
[3] Y. Kawase, Nucl. Phys. A154, 127 (1970).
[4] Bases for Spin and Parity Assignments, Nucl. Data B1 (No. 1), *vii* (1966).
[5] R. C. Ragaini and J. D. Knight, Nucl. Phys. A125, 97 (1969).
[6] R. C. Ragaini and R. A. Meyer, Phys. Rev. C 5, 890 (1972).
[7] H. Lycklama and T. J. Kennett, Nucl. Phys. A139, 625 (1969).
[8] C. D. Goodman, T. A. Hughes, M. W. Johns, and K. Way, Nucl. Data A8, 345 (1970).
[9] E. R. Cosman and D. C. Slater, Phys. Rev. 172, 1126 (1968).
[10] K. K. Seth, K. A. Buzard, J. Picard, and G. Bassani, Phys. Rev. C 10, 1928 (1974).
[11] R. Hess, F. C. Roehmer, F. Gassmann, and Th. von Ledebur, Nucl. Phys. A137, 157 (1969).
[12] F. R. Metzger, Phys. Rev. 187, 1680, 1700 (1969).
[13] W. W. Pratt, Nucl. Phys. A160, 626 (1971).
[14] F. R. Metzger, Nucl. Phys. A173, 141 (1971).
[15] F. R. Metzger, in *Contributions to the International Conference on Nuclear Structure and Spectroscopy, Amsterdam, 1974,* edited by H. P. Blok and A. E. L. Dieperink (Scholar's Press, Amsterdam, 1974), Vol. 1, p. 209.