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MEASUREMENTS OF THE SPIN-LATTICE RELAXATION TIMES OF Cr^{3+} *IN CORUNDUM*

P. P. PASHININ and A. M. PROKHOROV

P. N. Lebedev Physics Institute, Academy of Sciences, U.S.S.R.

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KNOWLEDGE of the spin-lattice relaxation times in ferromagnetic compounds has assumed particular significance in connection with recently developed investigations on the production of low-noise molecular amplifiers using ferromagnetics.

We measured the spin-lattice relaxation time for the Cr^{3+} ion in the lattice of corundum $Al_2O_3 - Cr_2O_3$ for the $3/2 \rightarrow 1/2$ electron transition (Ref. 1).

The measurements were carried out at 9370 Mc at two temperatures ($T = 300°K$ and $T = 77°K$), and the saturation effect in ferromagnetic resonant absorption was observed for the case when the constant field was parallel to the symmetry axis of the crystal.

The values obtained for the spin-lattice relaxation time, $T_1 = 1.4 \times 10^{-7}$ sec for $T = 300°K$ and $T_1 = 7 \times 10^{-4}$ sec for $T = 77°K$, make it possible to conclude that the basic mechanism of the relaxation in this temperature ranges consists of "Raman effect" processes, which lead to a temperature dependence of the spin-lattice relaxation time in the form $T_1 \sim T^{-7}$ (Ref. 2).

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CONCERNING THE HYPERON-NUCLEON INTERACTION

L. I. LAPIDUS

Joint Institute for Nuclear Research

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1. What little is known of the character of the forces between hyperons and nucleons is learned by analysis of hyperfragments or of the interactions between hyperons and nuclei.[1,2]

Parity nonconservation in hyperon decay can be used to study the interaction between hyperons and free nucleons, and also to investigate hypernuclei.

The direct method of establishing the spin-orbit dependence of the $Y - N$ forces can be the observation of the up-and-down asymmetry of the decay products relative to the scattering plane. The fact that the hyperons produced in $p - N$ and $K - N$ interactions are polarized is apparently evidence in favor of the presence of a (LS) dependence of the forces, but for direct proof the up-and-down asymmetry must be observed in the decay of hyperons that are polarized in elastic $Y - N$ scattering.

A study of the up-and-down assymetry with respect to the plane of hypernucleus production can be used to study the structure of the hypernucleus and for a direct determination of the spin of the hyperfragment. Proof that the spins of the baryons are compensated in $_{\Lambda}He^4$ would be the absence of such an asymmetry, which would be observed in $_{\Lambda}H^3$ at the same time.

2. Let us consider certain consequences of the unitarity and symmetry of the S matrix for $Y - N$ interactions. At Λ^0-particle energies below 150 Mev, only elastic scattering is possible in $\Lambda - N$

collisions. This situation was analyzed in connection with N — N scattering. At Λ^0-particle energies above 150 Mev, the conversion of Λ particles into Σ hyperons becomes energetically feasible in addition to elastic scattering, and the unitary and symmetric S matrix covers the following processes

$$\begin{array}{l}\Lambda^0 p \rightarrow \Lambda^0 p\,(S_{11});\ \Sigma^+ n \rightarrow \Lambda^0 p\,(S_{12});\ \Sigma^0 p \rightarrow \Lambda^0 p\,(S_{13});\\ \Lambda^0 p \rightarrow \Sigma^+ n\,(S_{21});\ \Sigma^+ n \rightarrow \Sigma^+ n\,(S_{22});\ \Sigma^0 p \rightarrow \Sigma^+ n\,(S_{23});\\ \Lambda^0 p \rightarrow \Sigma^0 p\,(S_{31});\ \Sigma^+ n \rightarrow \Sigma^0 p\,(S_{32});\ \Sigma^0 p \rightarrow \Sigma^0 p\,(S_{33}),\end{array} \qquad (1)$$

provided one considers the energy range where there is no additional pion production. In analogy with the procedure used for the combined analysis of scattering and photoproduction of pions with Compton effect on nucleons,[3] account of the symmetry and unitarity of the S matrix makes it possible to express the six independent elements of the S matrix in terms of the three scattering phases δ_1, δ_2, and δ_3 and the three mixing parameters φ, θ, and ψ.*

When the isotopic invariance of the amplitude is taken into account, the interactions between the Σ particles and the nucleons can be expressed in terms of the amplitudes R_3 and R_1 of the Σ—N scattering in states with $T = 3/2$ and $T = 1/2$, the same as is done for π — N scattering:

$$3R_{22} = R_3 + 2R_1,\ 3R_{23} = \sqrt{2}(R_3 - R_1);$$
$$3R_{33} = 2R_3 + R_1\,(R_{ik} = S_{ik} - \delta_{ik}). \qquad (2)$$

Comparison of (2) with the general expressions for a 3 × 3 S matrix, given in the appendix to Ref. 3, shows that if the isotopic invariance is taken into account (for arbitrary δ_1, δ_2, δ_3, and φ), we get

$$\cos^2\psi = 1,\ \cot\theta = \sqrt{2} \qquad (3)$$

and the number of necessary parameters is reduced to four. Here

$$S_{11} = e^{2i\delta_1}\cos^2\varphi + e^{2i\delta_2}\sin^2\varphi,$$
$$S_{12}\sqrt{3} = \sqrt{2}\, ie^{i(\delta_1+\delta_2)}\sin 2\varphi \sin(\delta_1 - \delta_2),$$
$$S_{13}\sqrt{3} = ie^{i(\delta_1+\delta_2)}\sin 2\varphi \sin(\delta_1 - \delta_2), \qquad (4)$$
$$3S_{22} = e^{2i\delta_3} + 2\,[e^{2i\delta_1}\sin^2\varphi + e^{2i\delta_2}\cos^2\varphi] = S_3 + 2S_1,$$
$$3S_{23} = \sqrt{2}(S_3 - S_1);\ 3S_{33} = 2S_3 + S_1;\ |S_{11}|^2 = |S_1|^2.$$

As can be seen from comparison of (2) and (4), information concerning δ_3 can be obtained from the data on the scattering of Σ^+ hyperons by protons. The quantities δ_1, δ_2, and φ characterize Λ — N scattering, the $\Lambda \rightleftarrows \Sigma$ conversion, and also Σ — N scattering in a state with isotopic spin $T = 1/2$.

Comparison of the expressions for S_{12} and S_{13} in (4) shows the correctness of the equation

$$S_{12} = \sqrt{2}\, S_{13}, \qquad (5)$$

which can also be obtained directly, taking into account the isotopic invariance of the conversion of Λ particles into Σ hyperons.

Let us note the interesting circumstance that, in in this analysis, Eq. (5) results quantitatively from the isotopic invariance of the Σ— N scattering. Conversely, were we to lean on (5), then we would obtain as the result

$$\sqrt{2}(S_{33} - S_{22}) = S_{23}, \qquad (6)$$

which, on the other hand, follows directly from (2).

Equation (5) leads to a relation between the cross sections, and also to the equality of the polarizations of the Λ particles and the nucleons.

Generalization of the Vol' fenshteyn theorems[4,5] makes it possible to connect, for example, in the case of the $\Lambda \rightarrow \Sigma$ conversion, the azimuthal asymmetry of the nucleons and Σ hyperons, when the Λ particles are polarized, with the polarization of the same beams when the Λ particles are not polarized.

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*Here we neglect mixing of the $^3P_2 \rightleftarrows {}^3F_2$ type.

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