SINGLE-PARTICLE ESTIMATE OF THE GAMMA-GAMMA TRANSITION PROBABILITY IN ^{85}Rb

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Nuclear transitions from an excited state j_1 to a lower-energy state j_2 may proceed via two-quantum emission, e.g., simultaneous emission of two quanta of energies $\hbar\omega_1$ and $\hbar\omega_2$. Conservation laws require

$$\hbar\omega_1 + \hbar\omega_2 = \hbar\omega_0 \quad \text{and} \quad L = \vec{L}_1 + \vec{L}_2 = \vec{j}_1 - \vec{j}_2$$

where $\hbar\omega_0$ is the transition energy, and L_1 and L_2 are the angular momenta of photons.

The relative transition probability of the gamma-gamma decay of the 514-keV state in ^{85}Rb was calculated following the theory of Grechukhin$^{1)}$. The ratio of the double-photon to the single-photon transition probability was given by

$$\frac{W_{\gamma\gamma}(EL_1ML_2)}{W_\gamma(ML)} = \frac{e^2}{\pi} S(L_1L_2L) \frac{\omega_0^2 \, \Phi(L_1L_2L;\, j_1j_2)}{|<j_2||ML||j_1>|^2}$$

where $S(L_1L_2L)$ is an explicit function of the angular momenta, $<j_2||ML||j_1>$ the reduced matrix element of the direct transition, and Φ a sum of products of squares of reduced matrix elements of two-quantum decay and of appropriate hypergeometric functions. The sum is over all intermediate states that are allowed by conservation of angular momentum and of parity. The direct transition from the (514 keV, $(9/2^+)$) state to the $(0, 5/2^-)$ state is predominantly an M2 transition. Various possible intermediate states were considered, but the $7/2^-$ and $7/2^+$ states were found to yield the strongest amplitudes. These intermediate states yield E1M1 or M1E1 two-quantum decay, for which the $L_1+L_2 = j_1-j_2$ rule is satisfied. Only the lowest $7/2^-$ and $7/2^+$ states were taken into account, because the excitation energy of higher states is not known.

Single-particle states were assumed for all states involved in the transitions. Radial wave functions were approximated by constants within the nuclear volume. The result of the calculation for the gamma-gamma transition probability per one single-gamma decay is

$$\frac{W_{\gamma\gamma}}{W_\gamma} = 2\cdot 10^{-5}$$

Reference

1. D.P. Grechukhin, Nucl. Phys. 35 (1962) 98, 47 (1963) 273 and 62 (1965) 273