Extranuclear Effects on Angular Correlations of Successive γ-Radiations from the Nucleus Cd^{111}*

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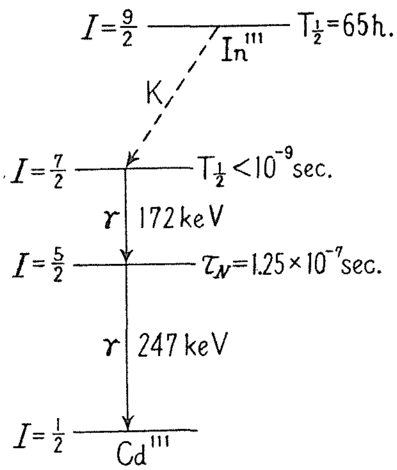
One of the important experimental evidences of an influence of extranuclear parameters was, as is well-known, found by investigating the angular correlation of successive γ-rays emitted from the nucleus Cd^{111} which follow the electron capture decay of In^{111}. The intermediate nuclear level involved in this γ-cascade has a lifetime of $\tau_N = 1.25 \times 10^{-7}$ sec, long enough that one expects an appreciable attenuation of the angular correlation by interaction of the nuclear moments with extranuclear fields.



A conveient quantity to be used in discussing angular correlation experiments is the *anisotropy*:

$$A = W(\pi)/W\left(\frac{\pi}{2}\right) - 1$$

which characterizes the anisotropic behaviour of the correlation at 180° relative to 90°. The correlation function $W(\Theta)$ expresses the relative probability that the second nuclear radiation is emitted at an angle Θ with respect to the propagation direction of the first radiation.

Then the attenuation factor proposed by the Zürich group[1)]

$$A_{max}/A_{min} = 1/1 + (\omega\tau_N)^2$$

is given by a function of the interaction parameters in the intermediate state, where ω is the coupling energy of the nuclear moments with external fields.

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The experiments were performed by making use of the face centered cubic crystal of Ag, in which the excited In^{111} nuclei were homogeneously embedded. Therefore it was expected by the group that the electric quadrupole interaction should vanish because of the symmetry of extranuclear fields, then the interaction of the higher multipole moment (*i.e.* electric hexadecapole moment) with the third derivative of crystalline fields became appreciable. In fact the attenuation factor mentioned above was determined as 1.032 from their experiments, then they had the coupling energy $\omega=2\times10^{6}$ cycle/sec. If the value of the third derivative d^3E_z/dz^3 of the crystalline field estimated by using a simple model could be given by the order of magnitude of 10^{-38} e. cm^{-5}, the value of the electric hexadecapole moment of the excited state of Cd^{111} should become 10^{-40} e. cm^4. On the other hand, however, the value of the above nuclear moment calculated by the theory of nuclear shell structure was given by 10^{-51} e. cm^4. We think that this discrepancy is too large to regard their interpretation as sufficient, although there exist some ambiguities in extranuclear parameters.

Thereupon it is expected as one of the possible considerations about these results that the order of magnitude of the nuclear electric hexadecapole moment calculated by the collective model may become larger than that calculated by the individual particle model. But our value estimated by using the former gave the order of magnitude of 10^{-48} e. cm^3, which is still much smaller than the value given by angular correlation experiments. In fact the value of electric hexadecapole moments of Sb^{121} ($d_{\frac{5}{2}}$, odd proton) and Sb^{123} ($g_{\frac{5}{2}}$, odd proton) was estimated as 10^{-51} e. cm^4 from pure quadrupole resonance experiments,[2] whose value might not so differ from the calculated value by a simple collective models.

On the contrary we should examine the states of extranuclear fields, where a possibility is expected in their experiments at room temperature that in some excitations of lattice vibrations a mode of deformation vibrations gives away cubic symmetries of the crystalline fields. So we can expect the effect of an interaction between the nuclear electric quadrupole moments of the intermediate state and an extranuclear electric field gradient induced by phonons on the angular correlation of the $\gamma-\gamma$ cascade. Our calculated value of the coupling energy based upon this quadrupole coupling, $|\omega|\sim10^{6}$ cycle/sec proved to give a good agreement with their experimental value, where the value of the electric quadrupole moment of the excited Cd^{111} nucleus was assumed as 5×10^{-25}cm^2.[3]

In conclusion, it seems to us that the effect of the existence of the electric hexadecapole moment of the intermediate state of the Cd^{111} nucleus cannot be appreciable in the above angular correlation experiments.

REFERENCES

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