success for ground state assignments. This assignment is consistent with a first forbidden transition as suggested by the $\log_{10}(ft)$ value.

The observed angular correlation functions for the cascades via the 10^{-8} sec intermediate state indicate an appreciable attenuation by perturbing interactions in the intermediate state of the nucleus by its surroundings even in the liquid state. Also, the measured anisotropy of the 132–480 kev angular correlation for polycrystalline Hf metal and Hf compounds indicates that the attenuation coefficients are smaller than the "hard core" values for a static electric quadrupole interaction.

Since the expected unperturbed angular correlation functions are known with fair certainty, the cascades 132–480 kev and 132–345 kev provide a good case in which to study the influence of electric and magnetic fields on angular correlations. The coefficients of $P_2(\cos\theta)$ and $P_4(\cos\theta)$ for both cascades are reasonably large so that all attenuation coefficients can be measured with reasonable precision. For the cascade in Cd^{111}, which follows the decay of In^{111}, the unperturbed coefficient of $P_4(\cos\theta)$ is rather small ($A_4=-0.001$). However, Hf^{181} possesses the disadvantage that Hf compounds are difficult to prepare.

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Mixed Gamma-Mixed Gamma Angular Correlation

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The γ-γ correlation in which both radiations are mixed, with arbitrary admixture ratios, is discussed.

Recent experimental evidence indicates that the occurrence of mixed γ radiation (E_L+M_{L+1} or M_L+E_{L+1}) is not uncommon.[1] There are also several cases in which the intensity ratio δ^2 of 2^{L+1} pole to 2^L pole is of order unity (δ^2 neither $\ll 1$ nor $\gg 1$). Therefore it should not be surprising if a γ-γ cascade occurs in which both radiations are mixed. Indeed, the 345–135 kev cascade in Ta^{181} appears to be such a case[2] (both radiations $E2+M1$) and for both $\delta^2 \sim 1$. For this reason it seems worth while to give the correlation function applicable in such cases.

The general theory of angular correlation covers the case of an arbitrary γ-γ cascade, and the required correlation function can be obtained from the general formula given by several authors.[3] For the cascade $j_1(L_1,L_1')j(L_2,L_2')j_2$ with δ_i^2 equal to the intensity ratio of $2^{L_i'}$ to 2^{L_i} poles, the correlation function is

$$W(\vartheta)=\sum_\nu P_\nu(\cos\vartheta)\{F_\nu(L_1j_1j)+\delta_1^2F_\nu(L_1'j_1j)+2\delta_1(-)^{j_1-j-1}[(2j+1)(2L_1+1)(2L_1'+1)]^{\frac{1}{2}}G_\nu(L_1L_1'j_1j)\}\times\{F_\nu(L_2j_2j)+\delta_2^2F_\nu(L_2'j_2j)+2\delta_2(-)^{j_2-j-1}\times[(2j+1)(2L_2+1)(2L_2'+1)]^{\frac{1}{2}}G_\nu(L_2L_2'j_2j)\}. \quad (1)$$

The normalization is to $\langle W(\vartheta)\rangle_{Av}=(1+\delta_1^2)(1+\delta_2^2)$. In practice $L_1'=L_1+1$ and $L_2'=L_2+1$. The coefficients F_ν and G_ν are defined in BR [Eqs. (69b) and (70d)] and are tabulated in Tables I and II of that reference. Of course, when spin coupling is present the correlation function is modified in the usual way by inserting attenuation factors Q_ν which are independent of the properties of the emitted radiations.[4]

The presence of two adjustable intensity ratios (the signs of δ_1 and δ_2 may be $\pm$) makes the case under consideration somewhat overly flexible. However, it is quite likely that the study of the mixed-mixed correlation will be useful in conjunction with other experimental data which serve to fix one of the δ's (or δ^2's). For example, there may be internal conversion data for one of the transitions or, as in the case of Ta^{181}, one of the radiations participates in another cascade the correlation for which can be measured separately.[2]

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[1] The evidence has been summarized by R. M. Steffen, Indiana Conference on Nuclear Spectroscopy and the Shell Model (unpublished).

[2] F. K. McGowan, preceding paper [Phys. Rev. **93**, 471 (1954)].

[3] For small admixture ratios the explicit correlation function was given by S. P. Lloyd, Phys, Rev. **83**, 716 (1951). For the more general case one obtains the desired result by using, for example, Eq. (64) in L. C. Biedenharn and M. E. Rose, Revs. Modern Phys. **25**, 729 (1953), referred to as BR. We use the notation of this reference. Further references to the general formulation are to be found in that paper.

[4] K. Alder, Helv. Phys. Acta **25**, 235 (1952); A. Abragam and R. V. Pound, Phys. Rev. **92**, 936 (1953). These authors denote the attenuation coefficients by G_ν.