Coincidences Between Beta- and Gamma-Rays in Indium

Cloud chamber determinations of the beta-ray spectrum of In^{116} (54 min.) yielded an end point between 1.3 and 1.4 Mev.[1] It was pointed out by Brown and Mitchell that the use of a thick source would distort the shape of the distribution and prevent any possible resolution into groups. In an attempt to determine whether the spectrum is simple or complex, we have recorded gamma-gamma and beta-gamma coincidences produced in two fast and reliable Geiger-Mueller counters. The details of the experimental arrangement are described in another paper.[2]

The source, a 4.5×6.0 cm sheet of In 0.038 cm thick, after irradiation by slow neutrons from a paraffin bucket containing a 211-milligram source of radium mixed with beryllium, was mounted midway between the two counters. Aluminum of 0.60 cm thickness, sufficient to stop completely all beta-particles, was placed between the source and the gamma-ray counter. In order to obtain gamma-gamma coincidences, a similar thickness was placed between the source and the beta-ray counter. Beta-gamma coincidences were obtained as a function of the beta-ray energy, by performing experiments with different thicknesses of absorber between the source and the beta-ray counter. Corrections were made for decay, for gamma-rays recorded by the beta-ray counter, and for chance coincidences. The resolving time of the apparatus for coincidences is 0.56×10^{-7} min.

The experiments on gamma-gamma coincidences yielded a value of 0.65 ± 0.06 per 1000 gamma-rays recorded. The existence of gamma-gamma coincidences, of course, demands that there be more than one gamma-ray emitted per disintegration.

In Fig. 1, the number of beta-gamma coincidences per beta-particle recorded is plotted against the thickness of the beta-absorber, and therefore as a function of the beta-ray energy. It will be noted that, within the experimental error, the value of the ordinate remains constant. There is, therefore, no indication of a complex spectrum such as was found by the authors for the 148-min. period of manganese.[2]

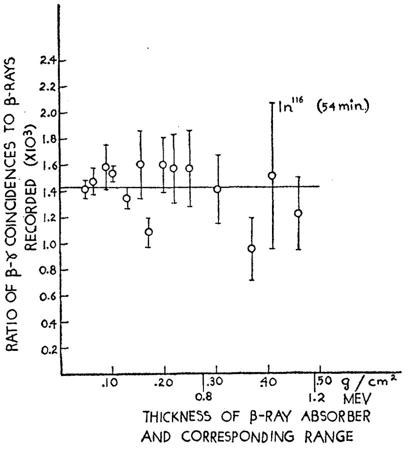

Fig. 1. Beta-gamma coincidence measurements.

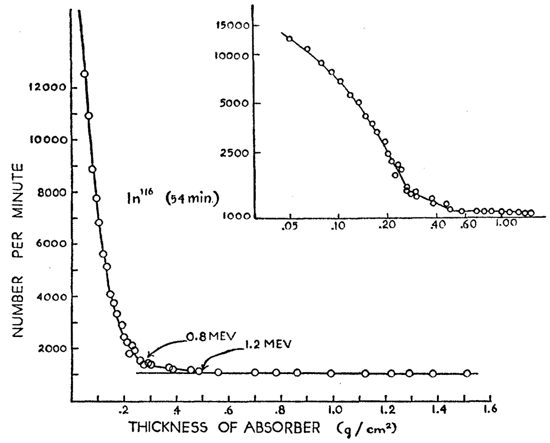

Fig. 2. Absorption in aluminum.

Recently, some question has arisen as to the value of the beta-ray end point. It has been suggested that the true end point is about 0.8 Mev and that the higher energy electrons recorded in the cloud chamber experiments were due to recoil electrons from the gamma-rays. With this in mind, a careful study was made of the absorption of the total radiation in aluminum. A typical run is shown plotted in Fig. 2. It will be noted that there appear to be two discontinuities, one at 0.8 Mev, and the other at 1.2 Mev. These discontinuities are demonstrated more clearly in the logarithm *vs.* logarithm plot shown in the insert. It is interesting to note, also in this connection, that, as shown in Fig. 1, the numerical value of the coincidences per particle detected remains constant out to an absorption thickness corresponding to the 1.2-Mev end point. One may still argue that the coincidences obtained for thicknesses of absorber corresponding to energies above 0.8 Mev are due to Compton electron-gamma coincidences, and that the numerical value of the Compton-gamma per Compton ratio is fortuitous. To test this point, an attempt was made to repeat the experiment with a different geometrical arrangement. However, the loss of intensity due to this change prevented our coming to any definite conclusions on this point.

If one makes the plausible assumption that the sensitivities of the counter to the different gamma-rays emitted per disintegration are not very different from an average sensitivity (including solid angle), S_γ, one may calculate K, the average number of gamma-rays per disintegration. Let N_β and N_γ be the number of beta- and gamma-rays emitted by the source, and let $N_\beta S_\beta$ and $N_\gamma S_\gamma$ be the respective number recorded, then

$$N_{\beta\gamma}/N_\beta S_\beta = S_\gamma K = 1.4\times10^{-3}, \qquad (1)$$

$$N_{\gamma\gamma}/N_\gamma S_\gamma = \tfrac{1}{2}S_\gamma K(K-1) = 0.65\times10^{-3}; \qquad (2)$$

therefore,

$$K \approx 1.9. \qquad (3)$$

It appears then that the disintegration from In^{116} to Sn^{116} is, for the 54-min. isomer, a simple beta-transition followed on the average by two gamma-rays. It follows also that the disintegration leads to an excited state of Sn^{116}.

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Raman Effect in Samarium Nitrate Solutions

Rasetti[1] has adduced evidence for the possibility of an electronic Raman effect in the case of the diatomic *molecule* NO, where the Raman band corresponds to the transition $^2\Pi_{1/2}-{}^2\Pi_{3/2}$. While all attempts at discovering an electronic Raman effect in *atoms* by one of us (L. Sibaiya) in thallium vapor (after a suggestion by Jevons[2]) failed, it was surmised that samarium *ion*, Sm^{+++}, with a ground state ^6H, was perhaps more suitable for the study of such an effect because of the ease with which the ions could be had at high concentrations in solution. But the examination of the Raman spectrum (Fig. 1*A*) of a dilute solution of samarium nitrate (about 8 percent) revealed no new features except the nitrate frequency at 1047 cm^{-1}, the water bands and the characteristic fluorescent bands of samarium with intensity maxima at λλ5600, 5950, 6030 and 6390A (Fig. 2). When the investigation was, however, repeated at a higher concentration (about 40 percent), three entirely new bands made their appearance (Fig. 1*B*). Since even the Raman band of water arising from λ4047A is here completely absent due to the strong absorption of the solution for this radiation, the three new bands have to be ascribed to the incident radiation λ4358A. As no trace of these bands is seen in the dilute solution, it follows first, that the new bands do not arise from fluorescence and second, that they appear because of the increased concentration of samarium ions in solution. No such effect arising from an increased concentration of the nitrate ion in the case of potassium nitrate, for instance, could be observed. The new bands therefore with approximate frequency shifts of 950, 680 and 2770 cm^{-1} at their maxima from the incident line λ4358A have been *tentatively* ascribed to an electronic Raman effect in samarium ions. A calculation of the frequency separation between $^6H_{5/2}$ and $^6H_{7/2}$ from Goudsmit's formula yields a value 932 cm^{-1}, which agrees fairly satisfactorily with the observed Raman shift of 950 cm^{-1}; the band at 2770 cm^{-1} requires the assumption of a transition from $^6H_{7/2}$ to $^6H_{11/2}$. The width of these bands, however, remains to be explained. An analysis of the absorption spectrum of samarium salts at low temperatures by Spedding and Bear[3] has shown that the ground level $^6H_{5/2}$ is a close group of about five levels with a total separation of about 250 cm^{-1}. Frank[4] concludes that the ground level can split only into a doublet in an ionic field with cubic symmetry; this possibly explains the existence of another band at 680 cm^{-1}. If it is assumed that the larger number of low lying levels postulated by Spedding and Bear is correct, Van Vleck[5] sees no other possibility of explaining them but as an interaction between vibration and electronic states. The sharpness of these close levels observed at such low temperatures as 20°K−78°K cannot obtain at ordinary temperatures and to this cause is traced the bandlike appearance of what ought to have been Raman "lines." The provisional explanation here put forth for the new bands observed at greater concentration of samarium ions is being tested with other salts of samarium and europium. In Fig. 2 the Raman band of water in concentrated solution (*B*) is seen to be widened out as compared with the same band in dilute solution (*A*); this possibly arises from an interaction of the ionic fields with the OH bond.

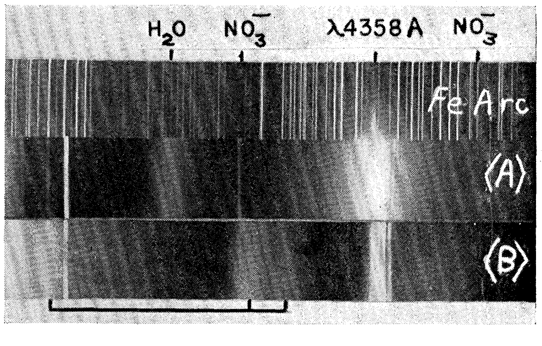

Fig. 1.

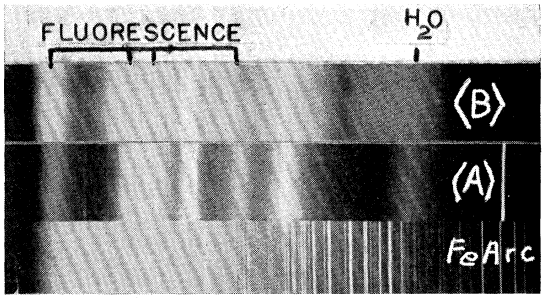

Fig. 2.

Another very interesting feature in Fig. 1 is the rotational wing accompanying the incident radiation λ4358A present only in the Raman spectrum of the dilute solution and entirely absent in the spectrum of the concentrated solution brought about by an enormous increase of fluid viscosity. Attention to this point has been recently drawn by Raman and Venkateswaran[6] who have worked with four liquids of increasing viscosity; we have in the present instance a case where the increase in concentration of the same solution suppresses the wings on account of enhanced viscosity.

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