Letters to the Editor

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Radioactivity of Nickel

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IN a recent letter[1] a search for low energy gamma-rays of radioactive nickel by the proportional counter technique, which resulted in the discovery of an x-ray line ascribed to the K x-radiation of cobalt arising from K-capture in Ni^{59}, was described. In view of the results of Thomas and Kurbatov,[2] who reported photon groups of energies 7.5±1, 15±2, 38±3, and 80±5 kev with intensities in the ratios 6:1:1:1 in long-lived nickel, a further search for gamma-rays using a stronger source was carried out. The source was irradiated in a higher slow neutron flux at Harwell, England, the ratio of the intensities of the present and former sources being 21:1. The counter and gas filling were the same as previously described, and the same thorough chemical purification of the source was carried out.[1,3] The results are shown in Fig. 1.

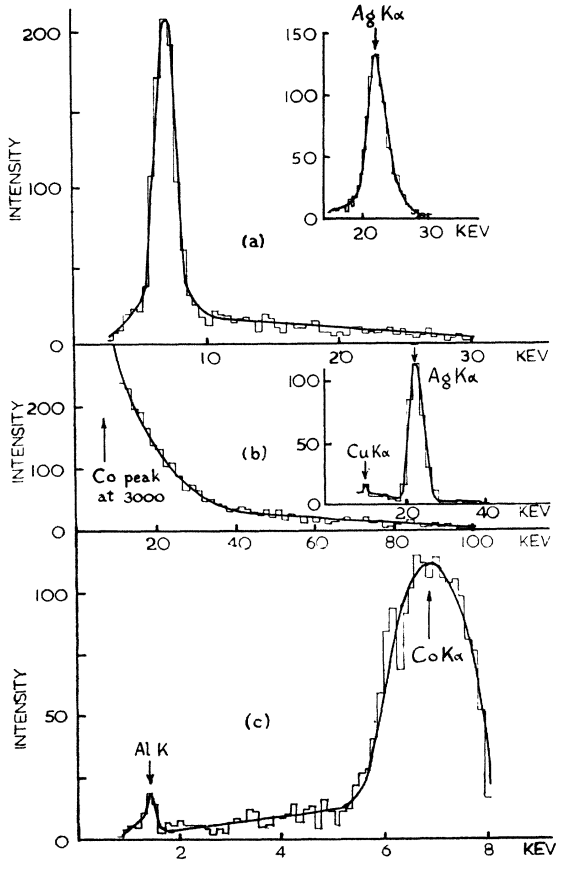

FIG. 1. Histograms of radiations of long-life nickel.

Graph (a), covers the region 0–30 kev; graph (b), 0–100 kev; graph (c), under 8 kev. The K x-radiation of silver was used for calibration (see inset figures in graphs (a) and (b)). The only radiation detected, apart from that due to K-capture in nickel (cobalt K x-rays) was taken to be the K x-rays of aluminium due to excitation of the aluminium cathode in the counter by cobalt x-rays (see graph (c)). Allowing for the efficiency of the counter, the 15- and 38-kev x-rays could have been detected if their intensities were more than one-twentieth and one-tenth of the intensity of the cobalt x-radiation, respectively. The 80-kev radiation would have been detected only if its intensity was of the same order as that of the cobalt x-rays.

The results seem to confirm that Ni^{59} decays by a simple K-capture process, and imply that the gamma-rays detected by Thomas and Kurbatov arise from the decay of some element other than nickel.

The half-lives of Ni^{59} and Ni^{63} have been recalculated using more recent slow neutron cross-section values of Ni^{58} and Ni^{62},[4] i.e., 4.17 and 14.8 barns, respectively. The new values, which are based on the activities produced by a known slow neutron flux density in a given time, are as follows,

$$Ni^{59}: 7.5\times10^{5}\ \text{yr},$$
$$Ni^{63}: 61\ \text{yr}.$$

These values are in reasonable agreement with the value of 2.3×10^{5} yr given by Friedlander for Ni^{59} [5] and 85 yr given by Brosi and Griess for Ni^{63}.[6]

It is a pleasure to thank Dr. S. C. Curran for his continued interest in this work. Also, I should like to thank Mr. J. S. Story, of A.E.R.E., Harwell, for helpful comments on this work.

[1] H. W. Wilson, Phys. Rev. **79**, 1032 (1950).
[2] D. G. Thomas and J. D. Kurbatov, Phys. Rev. **77**, 151 (1950).
[3] H. W. Wilson and S. C. Curran, Phil. Mag. **40**, 631 (1949).
[4] H. Pomerance, Atomic Energy Commission Declassified Document No. 2502 (1949) (unpublished).
[5] G. Friedlander, BNL-AS-2, 49 (unpublished).
[6] A. R. Brosi and J. C. Griess, ORNL-499 (unpublished).

Restriction of Possible Interactions in Quantum Electrodynamics*

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IT can be shown that the integral method of collision theory[1] permits the development of a unitary and causal S-matrix in terms of one or more scalar and hermitian local interaction densities of the type

$$h(x)=\Omega(\partial^{u^\dagger},\partial^{u},\cdots\partial^{A^\alpha},\cdots)_{AB\cdots\alpha\cdots}(u^{\dagger A}u^{B}\cdots A^{\alpha}\cdots)^{\#}(x). \quad (1)$$

Such a density may involve an arbitrary product of quantized fields $u^\dagger, u, \cdots A^\alpha$ and an arbitrary coupling operator Ω containing derivation operators $\partial^{u^\dagger}$ operating upon the different factors. (The symbol # implies that the creation operators operate after the annihilation operators.) To make our problem specific, let u be the field of charged particles and A^α the electromagnetic potential.

To a given term in the development of S, there corresponds a Feynman graph.[2] The derivation operators at a given point x operate upon the free field factors $u^A(x)$ and upon the causal functions $\Delta^{(c)AB}(x-y)$, $D^{(c)\alpha\beta}(x-y)$, $\cdots$ corresponding to the external lines and internal lines ending at x. The anti-hermitian parts in each approximation involve a certain number of arbitrary constants. Their contribution to a conservative process can be shown to be equivalent to the introduction of new local interaction densities of the type (1). Therefore, an arbitrary choice of interaction densities (1) will in general introduce an infinite number of such interactions and will thus introduce, for instance, infinite series of derivatives which correspond to nonlocal interactions contradicting causality.

This contradiction can be avoided in the following way. In the