Failure to Detect Radioactivity in Beryllium with the Linear Amplifier

We have attempted to confirm the pressure of radioactivity in beryllium, as observed in the ionization-chamber-electrometer measurements of Langer and Raitt,[1] by using a linear amplifier that will detect individual alpha-particles; but we have obtained negative results. In the present experiments an ionization chamber resembling that used by Wynn-Williams and others, 20 mm in diameter and 4.5 mm deep, with only a coarse wire-grid as first electrode, was connected to a Wynn-Williams linear amplifier. The output of the amplifier operated a loudspeaker, an oscilloscope, and a Thyratron counter. Standardization with polonium showed that the amplifier recorded each alpha-ray whose path in the chamber was 2 mm or greater in length. Qualitative tests showed the amplifier responsive to the alpha-particles emitted from the surface of a granite rock containing 10^{-12} g radium per g of rock.

A flat boss 20 mm in diameter was ground on a face of a lenticular block of beryllium, and this fresh beryllium surface was mounted 1 mm from the entrance to the ionization chamber. All alpha-particles emitted from the beryllium block with a range of 3 mm or greater should therefore have been recorded. Langer and Raitt postulate that each decaying atom of Be^9 emits 2 alpha-particles and a neutron and they ascribe a decay constant of 10^{-21} sec.$^{-1}$ and an alpha-particle range of 10 mm to beryllium. The Be alpha-particles should therefore have a range of about 5.2μ in Be, if the Bragg-Kleeman rule is assumed to hold. Thus there should escape from the Be boss used in our experiments some 2.9 alpha-particles per minute having a range greater than 3 mm of air, or 1.9 per minute having a range greater than 5.5 mm of air. The background count of the amplifier was about 0.5 per minute, hence less than one tenth of the expected beryllium activity could have been detected.

The experiments have been repeated four times during the past six weeks, always with negative results within the probable error. The last set of measurements will be given in some detail. Actually, the time of occurrence of each count was recorded, and analyses of these data, in the light of the Bateman criteria, demonstrated the true random character of the counting.

Table I shows the results of four measurements: first, unscreened beryllium; second, beryllium screened by aluminum foil of 1.5 cm air stopping power; third, unscreened beryllium; fourth, beryllium screened by aluminum foil of 3.5 cm air stopping power. The aluminum foil was fresh stock, and samples of it were tested in an ionization chamber and found to be free from radioactive contamination. The probable errors given were obtained from analysis of the data, using Peter's formula. These observations show the absence of alpha-ray emission from the beryllium block, well within the probable error, which is about 1/30 of the reported activity.

TABLE I.

	Run	Total counts	Duration	Counting rate
I	Be	24	45 min	0.53 ± 0.10
II	Be+1.5 cm Al	48	73	0.66 ± 0.10
III	Be	59	90	0.66 ± 0.09
IV	Be+3.5 cm Al	42	76	0.55 ± 0.09

Naturally, the results reported above do not prove that beryllium is wholly nonradioactive, but they do indicate that if beryllium is active it either emits very short (*ca.* 3 mm) alpha-particles, or has a decay constant which is much smaller than has been suggested by Langer and Raitt. Geological evidence, as Lord Rayleigh points out[2] is not in agreement with the second alternative, and mass defect considerations do not suggest a very short range alpha particle. The present experiments are therefore regarded as suggesting that beryllium is stable.

ROBLEY D. EVANS*
M. C. HENDERSON

Physics Department,
University of California,
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* National Research Fellow.

[1] Langer and Raitt, Phys. Rev. **43**, 585 (1933).

[2] Lord Rayleigh, Nature **131**, 724 (1933).

Extension of Fowler's Theory of Photoelectric Sensitivity as a Function of Temperature

Fowler's highly successful application of the Fermi-Dirac statistics to photoelectric emission, in explaining the temperature variation of the apparent threshold, is valid for frequencies close to the threshold. The analysis starts with the following expression (in Fowler's notation) for the number of "available" electrons (with normal kinetic energies exceeding a particular value $\epsilon' = \chi_0 - h\nu$),

$$N_B = (4\pi kTm^2/h^3)\int_{\epsilon'}^{\infty} \log\left[1+\exp\left(\epsilon^* - \tfrac{1}{2}mu^2\right)/kT\right]du$$

$$= (2\pi kTm^2/h^3)(2kT/m)^{\frac{1}{2}}\int_0^{\infty}\left[y+(\chi_0-h\nu)/kT\right]^{-\frac{1}{2}} \times \log\{1+\exp\left[-y+(h\nu-\chi)/kT\right]\}dy,$$

where

$$y=(\epsilon-\chi_0+h\nu)/kT, \qquad \epsilon = \tfrac{1}{2}mu^2, \qquad \epsilon^* = \chi_0 - h\nu_0.$$

Fowler's ensuing treatment is restricted to cases where the frequency lies near the threshold by the assumption (a) that, before integration, y may be neglected in comparison with $(\chi_0 - h\nu)/kT$ in the denominator, and (b) that, in the final working expression, $\chi_0 - h\nu$ is approximately constant under these conditions.

It was thought desirable to investigate the extent to which these approximations are valid for frequencies removed from the threshold. A more general expression for the number of available electrons may be obtained somewhat more readily by integrating with respect to the normal velocity component, u, instead of the kinetic energy. Thus

$$N_B = (4\pi m^2 kT/h^3)\int_{u'}^{\infty} \log\left(1+Ae^{-au^2}\right)du,$$