

in the deep ultraviolet when bombarded by nuclear particles. Crystals of this type would actuate ordinary G-M counters. The first step in the new procedure was to reconsider the experiments of Glasser and Beaseley. It was concluded that detection of delayed phosphorescence would at least constitute a hopeful indication of good quantum efficiency. Rather than irradiating NaCl with a strong gamma-ray source as in their case, silver-activated NaCl was irradiated with electrons of a high frequency discharge and with the hard beta-rays of Ce^{144}_{β} , Pr^{144}_{β} , Nd^{144} . In each case, a long period phosphorescence was observed, although no appreciable immediate fluorescent pulses were produced. However, when NaCl-Ag was irradiated with the alpha-particles of polonium, the crystals fluoresced vigorously in the deep ultraviolet, emitting quanta at wave-lengths for the most part less than 2600Å. The quantum radiations were detected with a high efficiency in several different photon counters.⁷ The counters had wire gauze cathodes, and the glass sidewalls were made of Corning 9741 glass. When a quartz jacket was coated with NaCl-Ag and slipped over the counter, an absolute efficiency of about 15 percent for the polonium alphas was observed. The counters in which this efficiency was noted were relatively insensitive, and the geometry can be improved enormously. It is certain that the absolute efficiency for alpha-particles can be increased to 100 percent. The activity of the NaCl-Ag crystals was proportional to the concentration of AgCl in the interval 0.03 percent to 1.0 percent by weight. Below this interval the activity decreased rapidly, and above it the crystals lost transmission and became cloudy, perhaps due to the fact that some silver did not remain in solution. The decay constant of NaCl-Ag was kindly measured for us by Dr. W. C. Elmore of Swarthmore College, using a 1P28 photomultiplier and a fast oscilloscope. By a comparison with gamma-rays on NaI-Tl, it was concluded that the decay constant must be less than 0.2 μ sec. Accurate measurements below this value are not permitted by the resolution of his apparatus.

It has often been remarked that secondary pulses or "double" pulses are found in photo-sensitive Geiger counters. The behavior of the photon counter was observed for a period of 500 μ sec. after the initiation of each discharge. This time was several times greater than that necessary for collection of the positive ion sheath. No spurious delayed counts were found.

Now that it has been demonstrated that Geiger counters do possess enough quantum efficiency in the deep ultraviolet to use them as scintillation counters, an effort is being made to find crystals which will give copious ultraviolet fluorescence when irradiated by beta-rays and gamma-rays. Counters of a more advanced and efficient design are under construction.

It is evident that great possibilities are here indicated for the development of a highly efficient gamma-ray counter. Consideration must also be given to the use of scintillation Geiger counters in the proportional region.

Note added August 10, 1950:—Using a highly sensitized scintillation Geiger counter, short-lived fluorescent pulses have been observed when NaCl-Ag is irradiated by the beta-spectrum of RaE. Using a relatively poor geometry, an efficiency of about ten percent was achieved. This value can be increased.

Note added August 31, 1950:—Scintillations from million volt gamma-rays on NaCl-Ag have been detected in a photo-sensitive Geiger counter. On surrounding the counter with crystals, the "apparent efficiency" for gamma-rays at 1 Mev was increased by a factor of two and one-half.

* Assisted by the joint program of the ONR and AEC.

¹ G. L. Locher, Phys. Rev. **42**, 525 (1932).

² G. L. Locher, Phys. Rev. **50**, 1099A (1936); **51**, 386A (1937); **53**, 333A (1938); **55**, 675A (1939).

³ Glasser and Beaseley, Phys. Rev. **47**, 789A (1935).

⁴ Glasser and Beaseley, Phys. Rev. **47**, 570 (1935).

⁵ M. V. Scherb, Phys. Rev. **73**, 86 (1948).

⁶ Mandeville, Scintillation Counter Symposium, Oak Ridge National Laboratory, June 3-4, 1949.

⁷ It should perhaps be mentioned that every precaution was taken to establish the genuine nature of the effect. With 0.01 millicurie of polonium near a counter, only the cosmic-ray background was observed, since the alphas were stopped in the glass wall. Addition to the counter of the crystal-coated quartz jacket gave a counting rate of 50,000 counts per minute. Freshly-prepared untreated Bartol counters equipped with copper cathodes and thin Pyrex bubble windows gave a counting rate a hundred times greater than cosmic-ray background when an NaCl-Ag crystal and a polonium source of strength 0.10 millicurie were placed near them.

Radioactivities of Nb⁹⁹, Ta¹⁸⁵, and W¹⁸⁶, and the Relative (γ, n) and (γ, p) Cross Sections of Mo¹⁰⁰*†

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THE irradiation of molybdenum, enriched to 93 percent in Mo¹⁰⁰, with 23-Mev betatron x-rays has been found to produce radioactive Nb⁹⁹ by a (γ, p) reaction.¹ This hitherto unknown isotope has a half-life of 2.5 min. and decays by the emission of 3.2-Mev β^- -rays. The beta-energy was determined by an aluminum absorption curve. The activity has been chemically identified as niobium.

The radioactivity of this isotope of niobium provides the means of observing the relative probabilities of neutron and proton emission from a nucleus excited by photon absorption, the nucleus being Mo¹⁰⁰. The yields of Mo⁹⁹ and Nb⁹⁹ were measured at betatron energies from 10 to 23 Mev by counting the induced activities. Assuming the x-ray spectrum to be that given by Schiff,² the relative cross section for the two reactions were calculated for discrete x-ray energies. The cross section for the (γ, n) reaction showed a maximum at approximately 17 Mev, that for the (γ, p) reaction continued to increase up to the highest energy which we could reach. The ratio of the (γ, p) to (γ, n) cross sections at all energies is approximately 100 times larger than that predicted by the statistical theory of nuclear reactions, assuming independent competition among different modes of decay of an intermediate excited state.³ This is in agreement with the observations of Hirzel and Waffler⁴ on other photo-nuclear reactions produced by 17.3-Mev gamma-rays from the reaction Li(p, γ), but is somewhat more direct. They did not measure the two cross sections for the same parent nucleus, but rather interpolated $\sigma(\gamma, n)$ between values for nearby isotopes.

Similar irradiations of separated W¹⁸⁶ have been found to produce, in addition to the known 74-day W¹⁸⁵, a 1.85-min. isomer of W¹⁸⁶ by a (γ, n) reaction and a 46-min. Ta¹⁸⁵ by a (γ, p) reaction. Production of the last of these by irradiation of normal tungsten with x-rays has recently been reported by Butement.⁵

Examination of the radiation from the 1.85-min. W¹⁸⁶ isomer with an anthracene scintillation proportional counter and pulse analyzer shows conversion electrons of approximately 75 kev and a very high conversion coefficient.

The Ta¹⁸⁵ decays by the emission of 1.7 Mev β^- -rays and also conversion electrons of the same energy as these observed from the 1.85-min. W¹⁸⁶ isomer, leading to the belief that decay occurs to the metastable state of W¹⁸⁵, but no coincidence work has been done to verify this.

* Assisted by the joint program of the ONR and AEC.

† This material was originally submitted as a contributed paper to the Washington meeting of the American Physical Society, April, 1950. The abstract was lost in the mail, however, and the paper appeared on the post deadline program at the meeting.

¹ The separated isotopes used in this investigation were supplied by Carbide and Carbon Chemicals Corporation, Y-12 Plant, Oak Ridge, Tennessee, and obtained on allocation from the Isotopes Division of the AEC.

² L. I. Schiff, private communication. See also H. W. Koch and R. E. Carter, Phys. Rev. **77**, 165 (1950).

³ V. F. Weisskopf and D. H. Ewing, Phys. Rev. **57**, 472 (1940).

⁴ O. Hirzel and H. Waffler, Helv. Phys. Acta **20**, 373 (1947).

⁵ F. D. S. Butement, Nature **165**, 149 (1950).

Changes in the Activation Energy of Tellurium

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MEASUREMENTS have been carried out by Bridgman¹ on the variation of resistance with pressure in tellurium, the resistance falling off by a factor of several hundreds in the range of measurements. As pointed out by Bardeen² this effect can be