very high degree of precision, limited by the theoretical approximations in the relationship between ν_H and μ_H.

* Supported in part by the ONR.
[1] J. E. Nafe and E. B. Nelson, Phys. Rev. **73**, 718 (1948).
[2] E. B. Nelson and J. E. Nafe, Phys. Rev. **75**, 1194 (1949).
[3] J. R. Zacharias, private communication; R. Julian, thesis, Massachusetts Institute of Technology, 1947.
[4] Smaller, Yasaitas, and Anderson, Bull. Am. Phys. Soc. **25**, No. 4, 22 (1950).
[5] Hipple, Sommer, and Thomas, Phys. Rev. **76**, 1877 (1949).
[6] F. Low, Phys. Rev. **77**, 361 (1950).
[7] H. Taub and P. Kusch, Phys. Rev. **75**, 1481 (1949).
[8] L. H. Gardner and E. M. Purcell, Phys. Rev. **76**, 1262 (1949).
[9] N. F. Ramsey, Phys. Rev. **78**, 699 (1950).
[10] R. Karplus and N. M. Kroll, Phys. Rev. **76**, 846 (1949).
[11] J. W. M. DuMond, Informal report to the N.R.C. Committee on Constants at The Bureau of Standards, April 27, 1950.

The Nuclear Magnetic Moment of Scandium[45]

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July 28, 1950

IN a recent letter with the above title in this journal, Sheriff and Williams[1] present a value of 4.7617 ± 0.0010 nuclear magnetons for the magnetic moment of Sc^{45} after having made a diamagnetic correction of 0.260 percent in accordance with Lamb's[2] formula.

It is the purpose of this note to point out that the diamagnetic correction according to Lamb's formula is 0.151 instead of 0.260 percent. When Sheriff and Williams' experimental results are recalculated with this value of the Lamb correction they give for the magnetic moment of Sc^{45}

$$\mu(Sc^{45})=4.7564\pm0.0010 \text{ nuclear magnetons.}$$

Although the result of Sheriff and Williams originally disagreed with the recent results of Proctor and Yu[3] and Hunten,[4] the above correction brings it into agreement within the experimental limit of error.

[1] R. E. Sheriff and D. Williams, Phys. Rev. **79**, 175 (1950).
[2] W. E. Lamb, Phys. Rev. **60**, 817 (1941).
[3] W. G. Proctor and F. C. Yu, Phys. Rev. **78**, 471 (1950).
[4] D. M. Hunten, Phys. Rev. **78**, 806 (1950).

Gamma-Rays of Ag^{105} and Ag^{106}

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THE gamma-rays of Ag^{106} (8.2*d*) and Ag^{105} (45*d*) have been measured by Enns[1] and Deutsch *et al.*[2] The results are shown in Table I.

Since the measurements were made a number of years ago when techniques had not been developed to their present state, it was decided to repeat these measurements. In addition it was hoped that the energy levels of Pd^{106} determined from K-capture in Ag^{106} could be checked against those determined from the disintegration of Rh^{106}.

In the present experiments Ag^{106} and Ag^{105} were produced by bombarding Pd with deuterons or Rh with alpha-particles in the Indiana University cyclotron. The first reaction also gave some Ag^{111} in addition to Ag^{105} and Ag^{106}. In no case were Ag^{106} and Ag^{105} produced separately since in the bombardment with alpha-particles both $Rh(\alpha, n)$ and $Rh(\alpha, 2n)$ reactions took place. Chemical separations to isolate silver were made. The assignment of the lines to the several isotopes was made by watching the decay of the source.

The lines having an 8-day period, and hence attributed to Ag^{106}, have energies of 0.515, 0.722, 1.04 and 1.54 Mev. In comparing these results with those of Peacock[3] on Rh^{106} it is to be noted that he finds lines at 0.51, 0.75 and 1.25 Mev but none at 1.04 and 1.54 Mev, while the line at 1.26 Mev is not seen in Ag^{106}.

The gamma-rays associated with the 45-day period, Ag^{105}, have energies of 0.064, 0.278, 0.340 Mev with two weak lines at 0.220 and 0.437 Mev. From energy considerations it would appear that the line at 0.340 Mev is probably in parallel with the lines at 0.278 and 0.064 Mev which are in cascade. The lines 0.220 and 0.437 Mev are probably in another branch of the K-capture process.

TABLE I. Early measurements on gamma-rays of Ag^{106}, Ag^{105}.

	Ag^{105} (Energy in Mev)	Ag^{106} (Energy in Mev)
Enns	0.29, 0.42, 0.51, 0.62	0.69, 1.06
Deutsch, Roberts, Elliott	0.282, 0.345, 0.430, 0.650	0.505, 1.06, 1.63, 0.72(?)

The source produced from the $Pd(dn)$ reaction contained Ag^{111} (7.5 days). The beta-ray spectrum was measured and a Fermi plot made of the data. The beta-ray spectrum of Ag^{111} appears to be simple with an end point at 1.06 Mev, in agreement with the work of Helmholtz, *et al.*[4] In addition, internal conversion lines for gamma-rays at 0.515 (Ag^{106}), 0.338, 0.278 and 0.064 (Ag^{106}) were obtained. An Auger line at 19 kev was observed which corresponds to the $K-L-M$ energy difference in Pd.

We are indebted to Dr. M. B. Sampson and the cyclotron crew for making the bombardments.

* This work was supported by the joint program of the ONR and AEC.
[1] T. Enns, Phys. Rev. **56**, 872 (1939).
[2] Deutsch, Roberts, and Elliott, Phys. Rev. **61**, 389 (1942).
[3] W. C. Peacock, Phys. Rev. **72**, 1049 (1947).
[4] Helmholz, Hayward, and McGinness, Phys. Rev. **75**, 1469 (1949).

Detection of Scintillations from Crystals with a Photo-Sensitive Geiger-Müller Counter*

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July 26, 1950

PHOTO-SENSITIVE Geiger-Müller counters have been the subject of long study at this laboratory. Very high quantum efficiencies, as indicated by his often-mentioned starlight experiments, were achieved by Locher[1,2] who employed a multitude of photo-cathode surfaces in making his photon counters at Bartol. Locher's account[1] of his work in photo-sensitive surfaces at the Rice Institute remains even today one of the very best available discussions of photon counting.

Glasser and Beaseley[3,4] describe interesting measurements in which long-period *phosphorescence* from gamma-rays on NaCl was observed with the use of a photo-sensitive G-M counter. This type of emission is to be differentiated from instantaneous fluorescence employed in the detection of nuclear particles by photo-multipliers.

Interest in photon counting was revived at Bartol when Scherb[5] discovered a discharge technique at liquid air temperatures which increased considerably the photo-sensitivity of the thus treated counter. The use of scintillating phosphors in conjunction with photo-multipliers again focused attention at this laboratory on the possibility of detecting fluorescent scintillations with G-M counters, and the feasibility of photon counters for scintillation detection was speculated upon in discussions at Oak Ridge.[6]

In the past several months, the writers have devoted considerable effort to reproducing many of Locher's early photon counters in an effort to attain sufficient quantum efficiency to detect scintillations from currently used crystals such as NaI. However, difficulties were encountered in matching the wave-lengths of the scintillations from the crystals with the peak of the spectral response of the cathode surfaces of the various counters. The alkali metals were usually employed, but it was found that appreciable response at wave-lengths greater than 3600A was difficult to obtain. Moreover, counters of the alkali metals seemed to have a high background arising, perhaps, from thermionic effects.

Finally it was decided to abandon the attempt to find cathode surfaces suitable for use with currently available crystals and to concentrate upon development of crystals which might fluoresce

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 $Ce^{144} \xrightarrow{\beta} Pr^{144} \xrightarrow{\beta} Nd^{144}$. 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 2600A. 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 μsec. 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 μsec. 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 Nb^{99}, Ta^{185}, and W^{185}, and the Relative (γ,n) and (γ,p) Cross Sections of Mo^{100}*†

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THE irradiation of molybdenum, enriched to 93 percent in Mo^{100}, with 23-Mev betatron x-rays has been found to produce radioactive Nb^{99} 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 Mo^{100}. The yields of Mo^{99} and Nb^{99} 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 Wäffler[4] on other photo-nuclear reactions produced by 17.3-Mev gamma-rays from the reaction $Li(p, \gamma)$, 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 W^{186} have been found to produce, in addition to the known 74-day W^{185}, a 1.85-min. isomer of W^{185} by a (γ, n) reaction and a 46-min. Ta^{185} 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. W^{185} isomer with an anthracene scintillation proportional counter and pulse analyzer shows conversion electrons of approximately 75 kev and a very high conversion coefficient.

The Ta^{185} 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. W^{185} isomer, leading to the belief that decay occurs to the metastable state of W^{185}, 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. Wäffler, 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 Bridgman[1] 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 Bardeen[2] this effect can be