purity current corresponding to mass 156 decreased rapidly from 0.3 percent to 0.05 percent of the total dysprosium content and thereafter remained constant. This indicated that the residual peak of 0.05 percent was not $Ce^{140}O^{16}$, and that it was probably due to a previously undetected isotope of dysprosium of mass 156. It does not, however, rule out the faint possibility that the cerium fractionates to a fixed ratio with the dysprosium and thereafter remains constant. Study of the 156 position in the oxide group of ions with this sample was not possible due to the lower intensity of this group and to the presence of gadolinium and ytterbium impurities.

In order to check further the possibility that the cerium impurity might be the cause of the current at mass 156, a second sample of dysprosium oxide was obtained from Dr. E. R. Tompkins of Oak Ridge. This sample had been prepared in an ion exchange column. With this method of purification, impurities are expected to be only the adjacent elements. The optical analysis supplied with the material showed impurities of terbium and gadolinium as "weak" and erbium as "very weak." The mass spectrometer analysis showed in addition ion current corresponding to holmium, lathanum, and samarium. With this sample, the 156 peak appeared initially at 0.05 percent and remained constant throughout the run. However, as with the previous sample, it was not possible to obtain the additional verification of the isotope by observing the DyO^+ position because of the gadolinium impurity.

A final sample of much higher purity prepared by the ion exchange process was obtained from Dr. D. H. Harris of Oak Ridge. No rare earth ions other than the known dysprosiums and the new peak at mass 156 were detectable to greater than one part in seventy thousand. Again with this sample the ion current appeared initially at 0.05 percent and did not change detectably with time or temperature. It was possible with this sample to observe the $Dy^{156}O^{16}$ position free of impurities. The abundance was again about 0.05 percent of the total dysprosium isotopes.

We therefore conclude that dysprosium has a previously unknown isotope of mass 156 which is present to about 0.05 percent of the total. A future publication will give more accurate data on the abundance of this rare isotope and new values for the abundances of the remaining isotopes.

---

[1] F. W. Aston, Proc. Roy. Soc. **146**, 46 (1934).

[2] A. J. Dempster, Phys. Rev. **53**, 727 (1938).

[3] M. G. Inghram, R. J. Hayden, and D. C. Hess, Jr., Phys. Rev. **72**, 967 (1947).

The Gamma-Ray Spectrum from $F^{19}+H^1$ Using Photographic Emulsions Containing D_2O

Gerson Goldhaber
Department of Physics, University of Wisconsin, Madison, Wisconsin

October 13, 1948

ONE method of measuring gamma-ray energies is to observe the range in photographic emulsions of the protons from the photo-disintegration of deuterium. The major problem of the method is to load the emulsions with sufficient deuterium. Gibson, Green, and Livesey[1] have realized 6 percent D_2O by weight by using emulsions loaded with $Ca(NO_3)_2$ and D_2O as water of crystallization. In the present investigation, by soaking Ilford (C2200μ, stripped) nuclear emulsions in D_2O, from 30- to 80-percent D_2O by weight can be introduced into the emulsions.

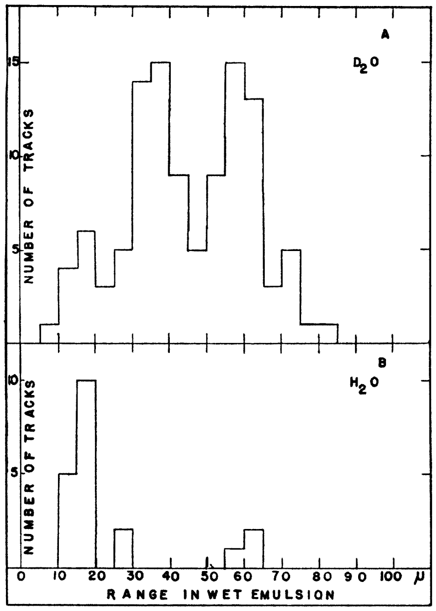

FIG. 1. (A) Emulsion *A*. Histogram of 109 tracks found on 26 mm² of nuclear emulsion exposed to $F^{19}(p\alpha',\gamma)O^{16}$ gamma-rays while wet with D_2O, $E_p=2.6$ Mev. (B) Emulsion *B*. Histogram of 20 tracks found on 16 mm² of nuclear emulsion exposed together with emulsion *A* while wet with H_2O (control emulsion).

Emulsions containing approximately 50-percent D_2O were exposed while wet to $F^{19}(p\alpha',\gamma)O^{16}$ gamma-rays obtained by bombarding a thick CaF_2 target with 2.6-Mev protons from the Wisconsin electrostatic generator. The maximum exposure that could be tolerated before background gamma-ray fog interfered with the track measurements was 0.2-μ ampere hours.

Two emulsions were exposed together; emulsion *A* was soaked in D_2O and emulsion *B* (control emulsion) in H_2O for 5 minutes. They were then placed perpendicular to the proton beam, at a distance of 6 and 8 mm, respectively, from the target, and with 1.8 g per cm² of intervening material.

As a provisional range energy relation in wet emulsions, the "range in wet emulsions (R_w)" was converted to "equivalent range in dry emulsions (R_d)" by taking $R_d=0.93R_w$. This is based on a rough calibration with *d-d* neutrons at $E_n=4.25$ Mev. The range energy relation given by Lattes, Fowler, and Cuer[2] was then used for R_d.

Results. On emulsion *A* and *B* 26 and 16 mm², respectively, were viewed in the microscope, and 109 and 20 tracks, respectively, were measured (Fig. 1A and 1B).

All tracks found with angle of dip $\alpha<50°$ were measured. Corrections (factor second α) being applied to those tracks

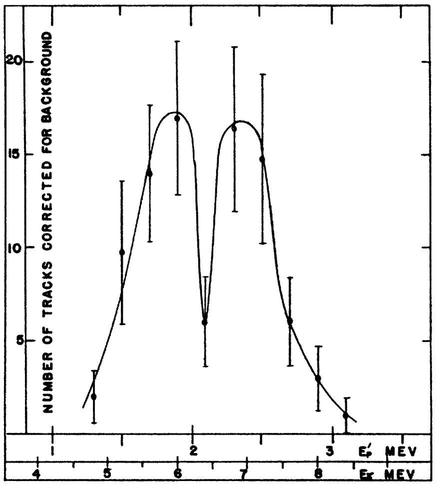

FIG. 2. Number of photo-proton tracks in nuclear emulsion from $D^2(\gamma n)H^1$ due to $F^{19}(p\alpha',\gamma)O^{16}$ gamma-rays, corrected for background, as a function of the photo-proton energy E_p'. The corresponding gamma-ray energy E_γ is also shown. R.m.s. errors are indicated.

with $\alpha > 15°$. No attempt was made to get accurate data on the tracks of length $<20\mu$. Most of these may be caused by alpha-particles (from radioactive contaminations in the emulsions). In Fig. 2 the number of tracks of length $>20\mu$ on emulsion A, corrected for background (from emulsion B), has been plotted against the energy of the photo-protons E_p'. The corresponding gamma-ray energy is also given, assuming the simplified relation:

$$E = 2E_p' + 2.2 \text{ Mev.}$$

The position of the two peaks obtained at about 6 and 7 Mev agrees with the recent results of Walker and McDaniel.[3] The relative intensities of the two peaks is ~ 1. Neglecting variations in the cross section for photodisintegration of the deuteron, this is compatible with a smooth extrapolation of the relative intensities as a function of proton energy as given by Walker and McDaniel.

Further work is in progress to improve the technique and to apply it to gamma-ray spectra.

The author wishes to thank Professors R. G. Herb and H. T. Richards for many helpful discussions and their continued interest in this work. The work was supported in part by the Wisconsin Alumni Research Foundation and in part by the Atomic Energy Commission.

[1] Gibson, Green, and Livesey, Nature (London) **160**, 534 (1947).
[2] Lattes, Fowler, and Cuer, Proc. Phys. Soc. (London) **59**, 883 (1947).
[3] R. L. Walker and B. D. McDaniel, Phys. Rev. **74**, 315 (1948).

The Elastic Constants of Beta-Brass*

DAVID LAZARUS
Institute for the Study of Metals, University of Chicago, Chicago, Illinois

October 8, 1948

THE elastic constants of β-brass have been measured at 25°C as part of an investigation of the elastic properties of solids at high pressures. Inasmuch as the present values differ markedly from the previously accepted values,[1] it seems worth while to report them at this time.

TABLE I. Adiabatic elastic constants of beta-brass.

Constant	Present	Previous
C_{11} (in dynes/cm^2)	1.279×10^{12}	0.520×10^{12} dynes/cm^2
C_{12}	1.091	0.335
C_{44}	0.822	1.730

Large single crystals of 3.5-cm diameter and 10-cm length were grown from the melt in graphite crucibles. Small sections of about 2-cm diameter and 2.5-cm length with faces parallel to (100) and (110) planes were cut from the large crystal. The orientations were determined by back-reflection diffraction pictures. Chemical analysis of the crystals gave a composition of 51.06 percent Cu, 48.94 percent Zn, by weight. The measured density of the crystals was 8.297 g/cm^3.

The elastic constants were measured at 12 mc using the pulsed ultrasonic technique employed by Huntington[2] and others. Using this technique with (100) and (110) crystals, independent measurements are obtained C_{11}, $\frac{1}{2}(C_{11}-C_{12})$, $\frac{1}{2}(C_{11}+C_{12}+C_{44})$, and C_{44} (twice), from which the three principal elastic constants C_{11}, C_{12}, and C_{44} may be calculated, with two internal checks. The results are shown in Table I compared with those of Good.

Computed shear modulus G and isothermal compressibility K are shown in Table II, compared with experimental values measured on polycrystalline β-brass.

The values of compressibility and shear modulus computed from the present constants are in good agreement with measured values. The measured value of G quoted in Table II is subject to some considerable uncertainty as a result of preferred orientation of grains in the specimens measured.

In addition, the theoretical difficulties in interpreting the previous anomalously large value for C_{44}, pointed out by Zener,[3] are removed.

The values of the elastic constants given in Table I have been corrected for slight misorientation of the crystal specimens. The internal consistency of the measurements in such that the two measured values of C_{44} check to within ±0.1 percent, and the two computed values of C_{12} to within ±0.5 percent.

The data are also corrected for the thickness of the quartz crystal transducer used in these measurements. In this connection, it may be remarked that previous investigators using this technique[2,4] have not discussed this

TABLE II. Compressibility and shear modulus of beta-brass.

Modulus	Present (calc.)	Previous (calc.)	Measured
K (in cm^2/dyne)	0.913×10^{-12}	2.52	0.913*; .93**
G (in dynes/cm^2)	0.387×10^{12}	0.740	0.342***

* P. W. Bridgman, Proc. Am. Acad. **70**, 285 (1935).
** R. F. Mehl and B. J. Mair, J. Am. Chem. Soc. **50**, 55 (1928).
*** M. J. Druyvesten and J. L. Meyerling, Physica, VIII, **9**, 1059 (1941).