tively insensitive to its precise form, a fact which permits the use of the same function for all nuclei. From these considerations Eq. (3) becomes

$$\rho_p=(\rho/2)[1-3eV_af(\xi)/4\mu]=(\rho/2)[1-3Zf(\xi)/4\mu A^{\frac{1}{3}}], \quad (6)$$

in which the empirical result (4) has been used. Integrating (6) over the nuclear volume and solving for Z, we obtain

$$Z=A/[2+(9K/4\mu)A^{\frac{1}{3}}], \quad (7)$$

where $K=\int_0^1 f(\xi)\xi^2 d\xi$, and μ is expressed in Mev.

Equation (7) has the same form as that of the accepted stability relation (1) and may be made identical with it by setting $9K/4\mu=0.0146$. In the two extreme distributions considered above, f is, respectively, unity or the function (5), giving K the corresponding values of $\frac{1}{3}$ or $\frac{2}{5}$. Adopting the latter value as more realistic, we find $\mu\approx 60$ Mev. This maximum kinetic energy is greater, by a factor ~ 2.5, than those commonly quoted for the Fermi-Dirac gas model. It is noteworthy that a similar factor is necessary to bring into line with experiment the energy-level spacing predicted by the usual degenerate-gas treatment.[5] A fuller discussion of this discrepancy and of other consequences of the model will be given at a later date.

I wish to thank Professor E. Teller for helpful criticism of some aspects of this work.

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[2] For many refinements and earlier references see E. Feenberg, Revs. Modern Phys. **19**, 239 (1947).
[3] L. Rosenfeld, *Nuclear Forces* (Interscience Publishers, New York, 1948), Secs. 2.3, 9.4 and following.
[4] E. Fermi, *Nuclear Physics* (University of Chicago Press, Chicago, 1950), pp. 159 ff.
[5] See reference 2, Sec. H.

Large NaI Scintillation Counter Study of the Neutron Capture Gamma Rays from Hydrogen

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SCINTILLATION counter studies of capture gamma-ray[1] spectra using a $\frac{3}{8}$-in.$\times 1\frac{1}{2}$-in. right cylinder of NaI showed that only the most prominent lines of such spectra could be detected. The counting rates rise very rapidly with decreasing energy because of the Compton electrons formed in the crystal by the higher-energy gamma rays. The lower energy lines are located on top of this background of pulses (see Fig. 4 of reference 1).

In order to reduce this effect, a $3\frac{1}{2}$-in.$\times 3\frac{1}{2}$-in. right cylinder of NaI(Tl) was obtained. It was hoped that any degraded photons formed as a result of a Compton process would be absorbed by photoelectric effect and a full height pulse would result. The crystal was packaged by Swank and Moenich[2] of the Argonne Instrument Research Division.

The scintillations were detected by a bundle of three 5819 photomultipliers which was placed next to one of the flat faces of the crystal. A previously used method, in which a single tube and long conical light pipe were used, resulted in poor energy resolution. Resolution studies show that this large cyrstal with the bundle of photomultipliers is very similar in resolving power to our best small crystals[3] ($\frac{3}{8}$-in. high by $1\frac{1}{2}$-in. diameter right cylinders). This result, combined with the behavior of the crystal in suppressing the effect of Compton processes, makes the crystal very useful for capture gamma-ray studies.

As an example of the improvement in the operation of the scintillation spectrometer obtained by the use of the large crystal, a study was made of the capture gamma rays from hydrogen.[4] Recent similar work was performed using 1.3-cm cubes of NaI. A comparison of Fig. 1 of reference 4 with Fig. 4 in reference 1 shows the usual rapidly rising background present at lower energies. The suppression of this background by our large crystal

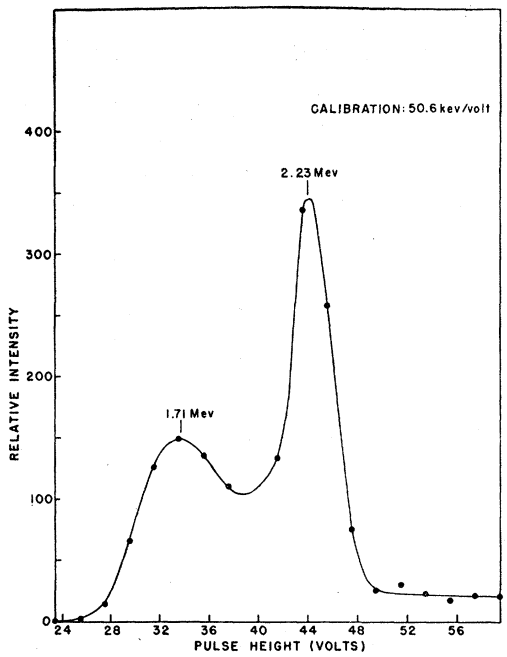

FIG. 1. Thermal neutron capture gamma-ray spectrum of hydrogen.

makes the gamma-ray peaks stand out much more clearly over the background.

In the experiment a sample of H_2O contained in a bundle of four lusteroid test tubes, each 1 in. in diameter and 6 in. long, was used. (See Fig. 1 of reference 1 for experimental arrangement.) Since the capture cross section in hydrogen is only 0.3 barn, a complete cycle of measurements was needed, namely:

1. Source in, no cadmium in beam,
2. Source in, cadmium in beam,
3. Source out, no cadmium in beam,
4. Source out, cadmium in beam.

The desired effect is given by 1–2–(3–4). The difference 3–4 is usually very small compared with 1–2 (see Fig. 2 of reference 1); however, in this case it was significant.

A 20-channel pulse-height analyzer was used to study the pulses. A complete pulse-height analysis was obtained in the energy range 20 kev—3 Mev. Figure 1 shows the result. From 20 kev to 1 Mev and above the high-energy region shown, the relative intensity is zero. The two peaks occur at 2.23 Mev and 1.71 Mev measured relative to the lines from Na^{24}. This energy comparison is made between the 2.23-Mev line and the peak due to pair production produced by the 2.76-Mev gamma ray from Na^{24} followed by absorption of one annihilation quantum. This latter peak is at 2.25 Mev, so that the 2.23 value can be obtained quite accurately.

The peak at 2.23 Mev is due to full energy absorption of a 2.23-Mev gamma ray, while the peak at 1.71 Mev is caused by pair production processes from a 2.23-Mev gamma ray in which one of the annihilation quanta escapes. At 2.23 Mev the peak due to the escape of both annihilation quanta from the large crystal is not observed in the analyzer.

The value of the large crystal in capture gamma work is readily apparent. From the height of the 2.23-Mev peak and the flatness of the background, one may conclude that in the energy range 20 kev—3 Mev there are no other gamma rays of intensity greater than 5 percent of the 2.23-Mev line.

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