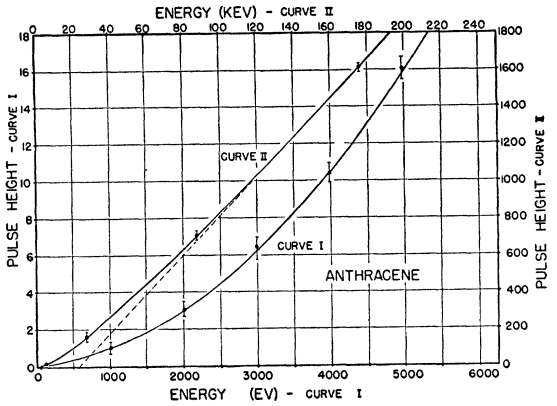

FIG. 1. Response of anthracene to electrons.

nificant charge collection should occur on these insulating crystals. The number of elastically scattered electrons which do not contribute to the pulse height was less than ten percent. The measured pulses were normalized using the conversion electrons of a Cs^{137} source which could be located with the same geometry as the electron beam.

Amplified pulses from the RCA 5819 photomultiplier tube were photographed on a Tektronix high speed oscilloscope. To extend the data of these low energy electrons, internal conversion electrons with energies from 27 kev to 624 kev were obtained from radioactive sources of Te^{127}, Nb^{91}, Hg^{203}, In^{114}, and Cs^{137}. The pulses from these electrons were analyzed with a twelve-channel pulse amplitude analyzer.

The pulse height *vs* energy curves are given in Figs. 1 and 2. The linear portions of the curves for anthracene and stilbene extrapolate to an intercept of about 22 kev on the energy axis, this agreeing with Hopkins' investigation of anthracene.[2] Sodium iodide shows a linear response throughout the energy region from 1000 ev to 624 kev, in agreement with the Stanford group,[3] while below 1000 ev there are indications of a small deviation from linearity.

The response of the anthracene crystal, whose behavior is probably typical of the organic crystals, to different ionizing radiation has been compared in Fig. 3 by considering the variation of the specific fluorescence dL/dx (expressed in arbitrary units per cm air equivalent) with the specific energy loss.

Both the heavy particles and electrons seem to give a region of linear response (the specific fluorescence increasing linearly with energy) but starting at quite different values of dE/dx. At some larger dE/dx, the response becomes nonlinear for both types of particles, and at even larger values of dE/dx the specific

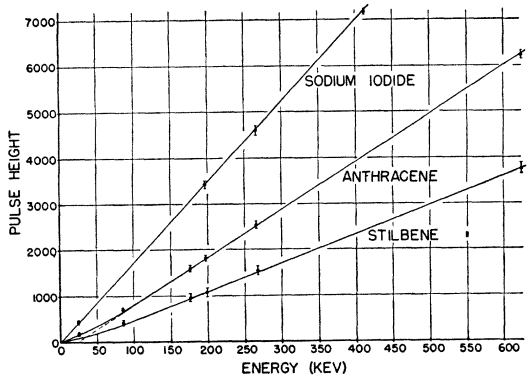

FIG. 2. Response of anthracene, stilbene, and sodium iodide to electrons.

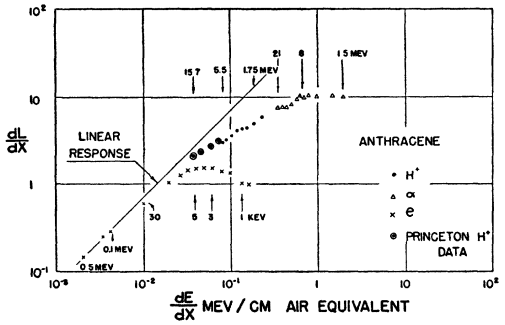

FIG. 3. Dependence of the fluorescence efficiency upon the specific energy loss for heavy particles and electrons in anthracene.

fluorescence saturates. The data for electrons of less than 1000 ev indicate a decrease in dL/dx, but these effects might be due to surface influences of the crystal since the range of a 1000-ev electron in anthracene is only 2.5×10^{-6} cm. However, we do not believe that the different results for the electrons and heavy particles could be due to surface effects, since x-rays of 27 kev which produce electrons inside the crystal gave agreement with the above results.

The valuable assistance of Mr. Chester Lob and the use of the facilities of the Tube Laboratory of the Electrical Engineering Department are deeply appreciated. A complete account of this work will appear at a later date.

* Assisted by the joint program of the ONR and AEC.
† Now at North American Aviation, Inc.
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[3] West, Meyerhof, and Hofstadter, Phys. Rev. **81**, 141 (1951).

Coherent Neutron Scattering Cross Section of V^{51}*

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ALTHOUGH the total thermal neutron scattering cross section for vanadium is 5.0 barns, comparable to other nuclei, the coherent part, σ_{coh}, is an order of magnitude less than any other nucleus studied. Shull and Wollan[1] give $\sigma_{coh}<0.1$ barn, since it was too low to be measured by diffraction methods. As V is monoisotopic (spin 7/2), this almost complete incoherence can be accounted for by assuming the two spin scattering amplitudes ($J=3$, $J=4$) times their weight factors ($\frac{7}{16}$, $\frac{9}{16}$) to be equal in magnitude and opposite in sign. Hamermesh and Muehlhause[2] have computed $\sigma_{coh}=0.03b$ (negative phase) using data on the 2700-ev scattering resonance.[3]

The coherent cross section has been determined by the total reflection of a thermal neutron beam from a mirror surface of vanadium. Using a technique previously described by one of us[4] σ_{coh} was compared to σ_{coh} of N_2 ($=9.1$ barns)[1] by observing the decrease in reflectivity as the pressure of nitrogen gas surrounding the mirror was increased until its index of refraction equaled the index of refraction of vanadium, giving no reflection. The difference from unity, δ, of the index of refraction of solids is given by

$$\delta=n\sigma_{coh}{}^{\frac{1}{2}}\lambda^2/4\pi^{\frac{1}{2}},$$

where n=number of nuclei/cc. This formula has been verified for gases.[5]

Figure 1 shows the reflection from a 1-min wide beam, incident at ~2.5 min on a 2.5-in. diameter mirror at different gas pressures. In Fig. 2 is shown the reflected intensity of the entire beam,

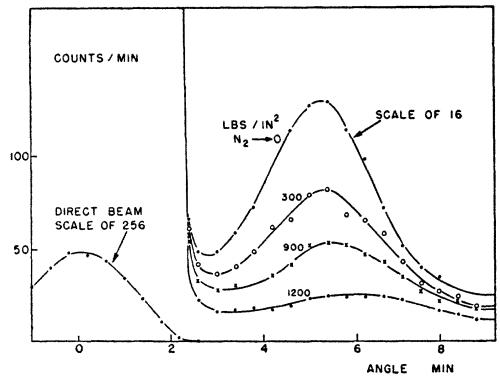

FIG. 1. Thermal neutron beam incident at about 2.5-min angle on vanadium-nitrogen interface and reflected beam at various pressures of N_2.

corrected for background and for scattering in the gas, as a function of pressure. The reflected beam contains all neutrons of wavelength

$$\lambda > \lambda_c = \theta/(2\pi^{\frac{1}{2}})(n_0\sigma_0^{\frac{1}{2}} - n\sigma^{\frac{1}{2}})^{\frac{1}{2}}$$

in the long wavelength portion of the pile flux, $N(\lambda)d\lambda \approx d\lambda/\lambda^5 \times$constant; n and n_0 are nuclei/cc in the gas and mirror, respectively; θ is the incident angle, and λ_c is the critical wavelength. It follows that the reflected intensity, I, varies as $(I/I_0)^{\frac{1}{2}} = 1 - P/P_0$, where P=pressure and P_0=pressure at which the indexes of refraction are equal. Then we obtain

$$\sigma_0 \text{ (mirror)} = [n(P_0)/n_0]^2\sigma \text{ (gas)}.$$

From the intercept P_0 in Fig. 2, we have

$$\sigma_{\text{coh}} \text{ (vanadium)} = 0.028b \pm 0.005 \text{ (positive phase)}.$$

On the basis of the above result for σ_{coh} Hamermesh's calculations[2] need be modified only to the extent of adjusting the potential scattering radius, R, from $0.508b^{\frac{1}{2}}$($b = 10^{-24}$ cm²) to $R = 0.602b^{\frac{1}{2}}$. We may further add that if the resonance at 2700 ev accounts for the entire thermal absorption cross section ($\sigma_{\text{abs}} = 4.8b$ at 0.025 ev), then from

$$\sigma_{\text{abs}}{}^{\text{th}} = \pi g \lambda\!\!\!^{-}_0{}^2 \Gamma_n \Gamma_\gamma [40E_0 \text{ (ev)}]^{\frac{1}{2}}/E_0^2 = 4.8b,$$

$$\sigma_0{}^{\text{abs}} = 4\pi \lambda\!\!\!^{-}_0{}^2 g \Gamma_\gamma/\Gamma_h = \text{absorption cross section at resonance},$$

we obtain $\Gamma_\gamma = 1.3$ ev and $\sigma_0{}^{\text{abs}} = 0.7b$.

Spectrographic analysis of the vanadium gives V=99.7 percent, Fe=0.22 percent, Mn=0.006 percent, Ti=0.001 percent, C=0.09 percent. The iron contributes ~0.001 barn to the coherent cross section. The presence of $\frac{1}{4}$ percent of V^{50} likewise has negligible effect.

We wish to thank Dr. P. Bendt for the use of the vanadium.

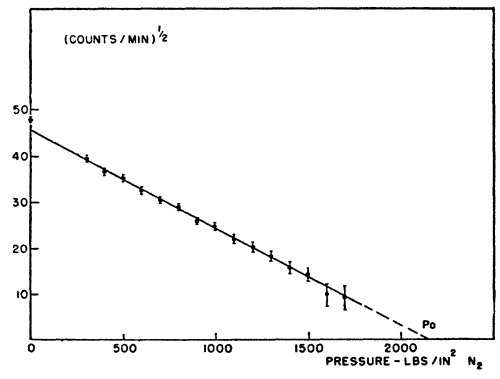

FIG. 2. Total intensity of a thermal neutron beam reflected from a vanadium-nitrogen interface as a function of nitrogen pressure. The intercept (P_0=2130 lb/in.²) is the pressure at which the index of refraction of nitrogen equals the index of refraction of vanadium.

* Research carried out under contract with AEC.

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[2] M. Hamermesh and C. O. Muehlhause, Phys. Rev. **78**, 175 (1950).
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Gravitational Acceleration of Neutrons*

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SINCE the acceleration of gravity is observed to be a universal constant for all matter, including nuclei which are aggregates of nucleons, it is reasonable to assume that a neutron, free of nuclear forces but in a gravitational field, is subject to the same acceleration. The high neutron flux from a reactor makes possible a direct check of this otherwise unsupported assumption.

Acceleration was determined by measurement of the drop of a highly collimated beam of thermal neutrons from the Brookhaven reactor in 12 meters of path, or more specifically the difference in drop of neutrons of different velocity but defined by the same collimating system. Boron carbide and Lucite slits 0.075-cm high ×5 cm wide, spaced 150-cm apart in the shield, defined the beam. Its position at 11.6-m range was measured by vertical scanning of a 0.9-cm wide slit in front of a BF_3 proportional counter. A 25-cm filter of BeO was then interposed between the reactor and first slit and the beam position determined by a second scanning. The first beam contains the entire thermal distribution $N(E)dE = Ee^{-E/kT}dE$ with peak at about 0.07 ev, 1A wavelength, or velocity 3.95×10^5 cm/sec. The filtered beam contains only that small part of the distribution with wavelengths greater than the BeO cut-off of 4.4A or 9.00×10^4 cm/sec. In Fig. 1 is shown a typical plot of the two beams, adjusted to the same peak height, indicating a downward shift of the slower neutron beam of about 1.2 mm in 12-m path.

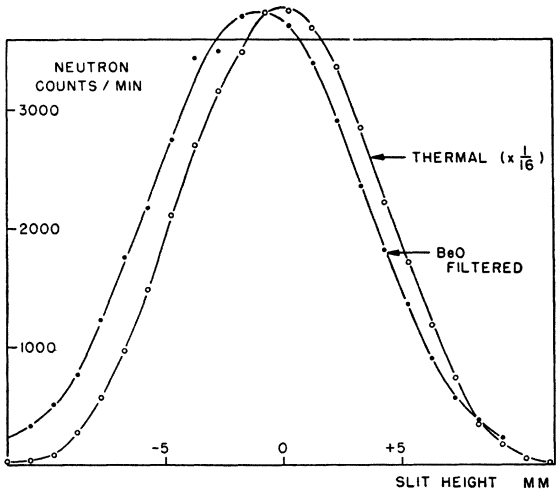

FIG. 1. Positions of thermal and very slow neutron beams at 11.6 meters range showing separation by free fall.

A value of g for neutrons can be calculated from the separation of the centers of gravity of the two beams, the geometry of the collimator and scanning slits, and velocity distributions in the two