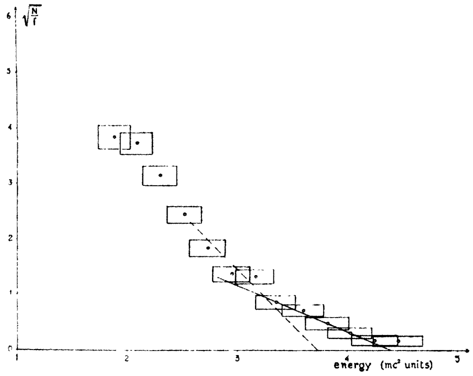

FIG. 1. End of the K^{40} β-spectrum.

The conclusion we draw is that the γ-quantum might as well be attributed to the β-disintegration of K^{40}. If this is so we should expect a weak band in the β-spectrum with an end point at $(1.7\pm0.1-1.5)\times10^6$ ev $=(0.2\pm0.1)\times10^6$ ev. A confirmation of this might be seen in an integral curve obtained by D. Bocciarelli,[4] using a magnetic deflection method (with counter revelation) with a relatively thin layer of KCl (7 mg/cm²). This curve shows in the region of $H\rho=1300$ an inflection which appears to be just above statistical errors.

[1] E. Gleditsch and T. Gráf, Phys. Rev. **72**, 640 (1947); O. Hirzel and H. Wäffler, Helv. Phys. Acta **19**, 216 (1946).
[2] Dželepov, Kopjova, and Vorobiov, Phys. Rev. **69**, 538 (1946).
[3] S. Franchetti and M. Giovannozzi, Rend. Acc. Linc. **1**, 1078 (1946).
[4] For instance, Mühlhoff, Ann. d. Physik **7**, 205 (1930); D. Bocciarelli, Rend. Acc. Linc. **15**, 686 (1932).
[5] A. W. Tyler, Phys. Rev. **56**, 125 (1939).
[6] This value lies very near the inflection point of a Fermi curve with $E_0=1.7\times10^6$ ev.
[7] These values correspond to the last 9 points on the diagram. The energy intervals cannot, however, be exactly compared, as in drawing the diagram corrections have been introduced for the slight shift of the high energy part of the spectrum owing to the absorption in the emitting layer.

Inelastic Scattering of Neutrons

J. M. CASSELS AND R. LATHAM
Cavendish Laboratory, Cambridge, England
May 13, 1948

A THEORETICAL paper by Weinstock[1] discusses the scattering of neutrons by polycrystalline materials, taking into account the lattice vibrations. The scattering is inelastic when the neutron gains or loses energy to the lattice, and the cross section for this process is obtained by assuming the Debye approximation to describe the frequency spectrum of the thermal oscillators.

We have made use of his work to calculate the inelastic scattering cross section (E_{in}) of iron at five temperatures, for incident neutron wave-lengths (λ) ranging from 1.79 to 20A (Fig. 1). Since iron has four stable isotopes, one of which possesses a spin, we have examined the theory to see which scattering cross section is relevant. At these energies, it seems that the inelastic scattering is a function only of the cooperative cross section $S=4\pi(\Sigma_r p_r a_r)^2$, where a_r is the bound scattering length and p_r the effective abundance of the rth nuclear state; p_r contains spin-dependent factors if the nucleus concerned has a spin.

The theoretical results are, accordingly, expressed as percentages of S. At 1.79A they agree closely with those already computed by Weinstock. We have, following him, retained only the K_1 term in Eq. (52); a trial for 10A and 800°K showed that the K_2 and K_3 terms were each about 5 percent of the K_1 term and of opposite sign to each other, so that this approximation is probably well justified throughout. For $\lambda>4.1$A, the inelastic scattering is entirely due to processes in which the neutron gains energy; at very long wave-lengths the K's decrease linearly so that E_{in} becomes proportional to λ.

We have attempted to test the theory by measuring at two temperatures the total cross section of iron in the 5–8A region, with the aid of the Cavendish Laboratory velocity selector. These wave-lengths are more than 4.1A, or twice the maximum Bragg spacing, so that there is no ordered elastic scattering.

There remain nuclear capture, nuclear disorder scattering, and inelastic scattering processes. The capture cross section has been taken[2] as 1.22λ barn. The disorder scattering cross section ($s=4\pi\{\Sigma_r p_r a_r^2-(\Sigma_r p_r a_r)^2\}$) we have found to be about 0.8 barn by another type of experiment[3] which measures, for $\lambda>4.1$A, the scattered rather than the transmitted neutrons. In such an experiment, the effect of the inelastically scattered neutrons is much reduced, because they have gained energy in the collision and are hence less efficiently detected by a "thin" BF_3 counter.

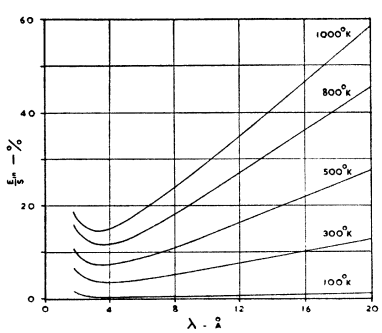

FIG. 1. Theoretical inelastic scattering of iron.

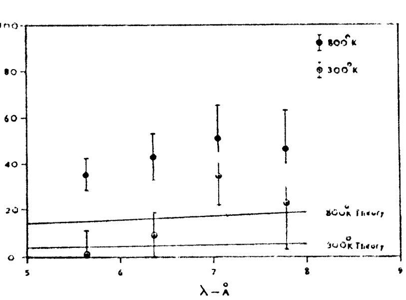

FIG. 2. Comparison of theoretical and experimental inelastic scattering.

The disorder scattering arising from magnetic effects would be negligible even if the atomic spins were oriented at random, and this is, of course, not the case since both temperatures are below the Curie point.

We accordingly obtain the inelastic scattering by subtracting the other two contributions to the total cross section; it is shown in Fig. 2 as a percentage of $S=10.2$ barns. The value of S is determined from the amorphous scattering cross section ($\sigma=4\pi\Sigma_r p_r a_r^2$) by means of the relation $\sigma=S+s$, taking[2] σ as 11.0 barns.

The rather large nuclear capture (approximately $\frac{3}{4}$ of the total cross section) makes it difficult to obtain really accurate values, but the experiment so far shows that the inelastic scattering is rather more than the theory predicts, and perhaps has a different energy dependence in this region.

The discrepancies are probably caused by departures from the Debye spectrum, which are, of course, to be expected.[4-6] More accurate experimental data should indicate quantitatively the modifications required, since by varying the temperature and neutron wave-length it is possible to weight the contributions from different parts of the spectrum.

[1] R. Weinstock, Phys. Rev. **65**, 1 (1944).
[2] L. J. Rainwater, W. W. Havens, Jr., and C. S. Wu, Phys. Rev. **73**, 1265 (1948).
[3] R. Latham and J. M. Cassels, Nature **161**, 282 (1948).
[4] M. Blackman, *Reports on Progress in Physics* (Physical Society, London, 1941), Vol. 8, p. 11.
[5] W. V. Houston, Rev. Mod. Phys. **20**, 161 (1948).
[6] R. B. Leighton, Rev. Mod. Phys. **20**, 165 (1948).

Fading of the Latent Image in Nuclear Emulsions

W. A. Lamb and F. W. Brown III
Naval Radiological Defense Laboratory, San Francisco, California
May 21, 1948

Recently Yagoda and Kaplan[1] reported that the latent image produced by alpha-particles in an emulsion with a high percentage of silver halide fades with time. Qualitatively, our results confirm this work, and it seems appropriate we publish this confirmation of the phenomena because a different technique was employed.

Eastman NTA plates (emulsion No. 359938) were irradiated identically with Po^{210} alpha-particles. Some of these were developed immediately as controls and the remainder were stored at 0°C, 20°C, and 40°C. Plates were developed after delays of 5, 12, 20, 29, and 46 days; these were examined after development with a microscope using normal illumination and the number of tracks (about 200 per plate) counted. The fractional loss in numbers of tracks was computed

$$(N\text{ control}-N\text{ counted})/N\text{ control},$$

and Fig. 1 is a plot of this as a function of the period of delayed development. It is believed this increase is due to the fading of the tracks. Only the longer period trends are deemed to be real, and the deviation from these trends may be accounted for by the inherent subjective errors of visual counting.

Experiments are under way to see if there is a significant difference between the rate of fading of the tracks of other highly ionizing particles and that of images produced by visible light.

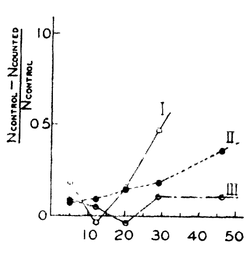

FIG. 1. Period of delayed development in days.

[1] H. Yagoda and N. Kaplan, Phys. Rev. **71**, 910 (1947).

Wide Range Frequency Modulation*

K. R. MacKenzie
*University of California at Los Angeles***
and
Radiation Laboratory, Department of Physics, University of California, Berkeley, California
May 21, 1948

The cyclotron frequency-modulation systems, so far proposed, utilize mechanical variation of capacity. This capacity is most effective when placed at the leading edge of the dee. In this position, however, many difficulties are introduced. A system has been developed at the Radiation Laboratory, in which the variable capacitor is outside the magnetic field.[1] Tests made with a one-half scale model of the proposed system for the 184-inch cyclotron show that a frequency range of 2.4 to 1 can be covered continuously. This range can be shifted approximately 10 percent by addition of fixed inductance or capacity. Since the frequency ranges required for protons and deuterons in the 184-inch magnetic field are 22.9 to 15.8 megacycles, and 11.5 to 9.8 megacycles, respectively, it seems that the cyclotron can accelerate either type of ion by making minor adjustments, or possibly both ions at once if so desired. Recent measurements on the 184-inch cyclotron indicate that the required frequency range need be only a few percent greater than the theoretical range, and also the shape of the frequency time curve is not critical.

A schematic diagram is shown in Fig. 1(a). It resembles the arrangement used on the Berkeley 37-inch and 184-inch cyclotrons in which the dee and rotary capacitor are joined by a transmission line and form an electrical half-wave system.[2] In the new system the capacitor is grounded, not directly, but through a large rectangular cross-section line, somewhat less than a $\frac{1}{4}$ wave-length at the upper frequency limit. The lower frequency limit is now greatly extended, since the capacitor and transmission line eventually pass through series resonance. The voltage distributions corresponding to f, $\frac{3}{4}f$, $\frac{1}{2}f$, and $\frac{2}{5}f$ are shown in Fig. 1(b) for the expected condition where the minimum ca-