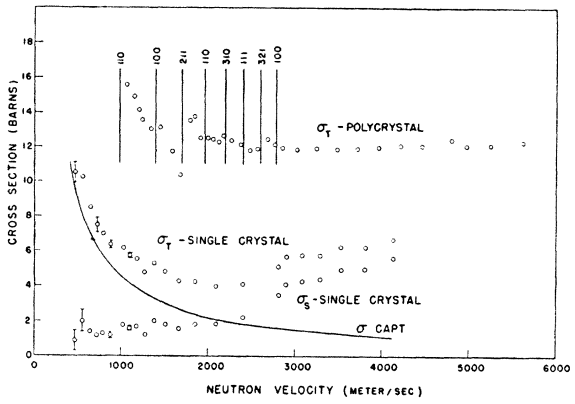

FIG. 1. Measured total cross sections of an iron polycrystal and a single crystal of iron-silicon. The scattering cross section of the single crystal, σ_S, obtained by subtraction of capture, is also shown. The vertical lines are the limiting velocities for reflection by lattice planes, marked with the appropriate Miller indices.

sample. The single crystal cross section is much smaller than that of the polycrystal, especially in the region just above the "cut-off" velocity (980 meters per sec., below which velocity the polycrystal exhibits no coherent scattering). The points marked σ_S are those for the single crystal after subtraction of the capture cross section, taken as 1/v and equal to 2.45 b at 2200 m/s for iron. (The single crystal cross sections of Fig. 1 all refer to the "average atom" in the crystal, containing 18 percent silicon atoms.) After an additional 0.40 b is subtracted from the single crystal points, to take account of the incoherent scattering caused by the assumed random location of the silicon atoms, the remaining scattering, shown in Fig. 2, represents the incoherent scattering of the

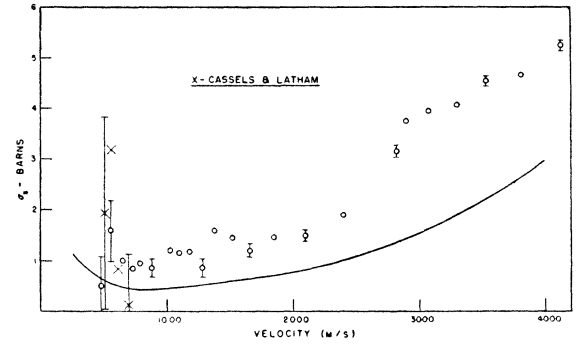

FIG. 2. The incoherent scattering of the iron-silicon single crystal after subtraction of the calculated scattering resulting from the assumed random location of the silicon atoms. Results of Cassels and Latham and the calculated inelastic scattering (Weinstock) are shown for comparison.

crystal. Some points obtained by Cassels and Latham[7] are also shown (we have re-analyzed their data, using 2.45 b for capture instead of their 2.2 b), as well as the inelastic scattering calculated by Cassels and Latham from the theory developed by Weinstock.[8] The variation of the incoherent scattering with velocity suggests that the scattering is mainly inelastic and about twice the calculated value. Both spin-dependent and isotope disorder scattering, in contrast to the inelastic scattering, would show no change with neutron velocity.

The polarization, which would result from inelastic scattering but not from other incoherent scattering, was next sought and found by magnetizing the crystal in a field of 11,000 oersteds and measuring the single[1,6] transmission effect, E_s. E_s is the fractional increase in transmitted neutron intensity resulting from magnetization to saturation. The measured points for an iron thickness of 2.97 cm are compared in Fig. 3 with the effect calculated from

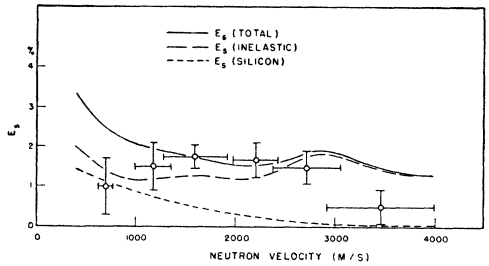

FIG. 3. Observed single transmission effect, E_s, in a 2.97-cm single crystal of iron-silicon compared with the calculated value.

the observed incoherent scattering assuming it to be entirely inelastic and isotropic. The form factor for the magnetic scattering used in the calculation is that given by Steinberger and Wick.[9] The silicon atoms constitute irregularities in the magnetic scattering of the magnetized single crystal, and there will be corresponding production of neutron polarization from the resulting incoherence, in addition to that arising from inelastic scattering. The calculation of the polarization caused by silicon atoms is complicated by the unknown amount of order in the silicon location. The silicon effect shown in Fig. 3 is based on the assumption of random location; if order were present the silicon effect would be smaller but the inelastic effect larger by a comparable amount, leaving the total almost unchanged.

Considering the results mainly above 1200 m/s where the silicon effect is small, it is seen that the observed E_s is consistent with the assumption that the incoherent scattering in iron is largely inelastic. In fact, as the calculated E_s varies with the square of the inelastic scattering cross section, the presence of only 0.25 b of spin-dependent or isotope disorder scattering would change E_s by about 50 percent at 1500 m/s and destroy the agreement exhibited by Fig. 3. The present results support the recent calculation of polarization in polycrystalline iron by Steinberger and Wick[9] in which it was assumed that most of the total scattering (coherent plus incoherent) produces polarization. We wish to express our gratitude to Dr. M. Hamermesh for his generous help in the analysis of these measurements.

* Research carried out under contract with the AEC.
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A 3×10^{-9} Sec. Isomeric State in $_{63}Eu^{153}$

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AN excited state in Eu^{153} with a half-life $(3.0\pm0.3)\times10^{-9}$ sec. has been observed with a delayed coincidence scintillation spectrometer. The position of the metastable state in the disintegration scheme has been determined.

The delayed coincidence scintillation spectrometer employing anthracene with Type 5819 multiplier tubes as detectors is similar to that described in a previous letter.[1] The video amplifier sections have been replaced with Hewlett Packard 460A wide-band amplifiers. With this apparatus the existence of the short-lived isomeric state[2] of Yb^{170} (1.6×10^{-9} sec.) was confirmed.

Sm^{153} (47 hr.) is known to decay by a 0.78-Mev beta-ray branch leading to an excited state of Eu^{153}. This state is de-excited by γ-ray transitions in cascade[3] corresponding to 69 and 103 kev

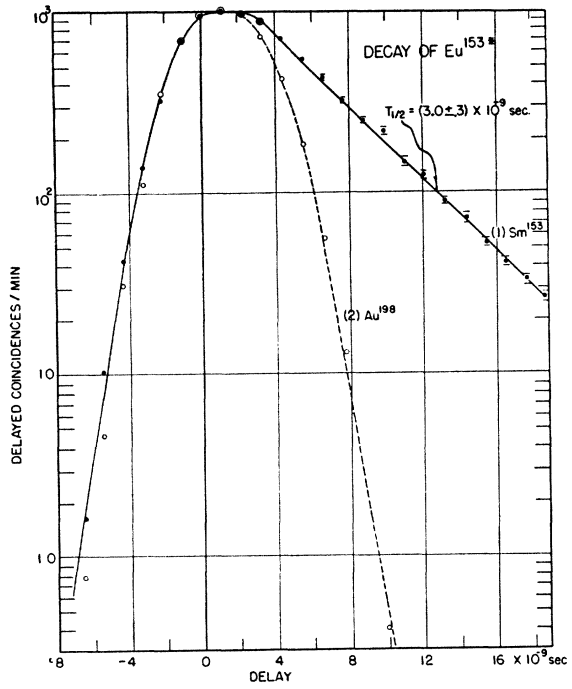

FIG. 1. Delayed coincidences as a function of delay time.

which are strongly converted.[4] In Fig. 1, curve (1), the number of coincidences are plotted as a function of delay time obtained with a source of Sm^{153}. This delayed coincidence resolution curve was recorded by exciting one channel of the delayed coincidence apparatus by the nuclear beta-rays and the other channel by the L, M, or N internal conversion electrons of the 103-kev γ-rays. Without a change in the apparatus, a resolution curve for prompt coincidences was obtained between the 411-kev γ-rays or internal conversion electrons and 85- to 110-kev nuclear beta-rays with a source of Au^{198}. Curve (2) shows the result of such a measurement. Thus, for delay $T \geqslant 8\times10^{-9}$ sec. the half-life of Eu^{153*} may be determined from the slope of curve (1).

The spectrum of the radiation announcing the formation of the metastable state appears to be a simple beta-ray distribution unaccompanied by γ-rays. This information plus the fact that the decay curve for Eu^{153*} was obtained selecting coincidences between the nuclear beta-rays and the L, M, or N internal conversion electrons of the 103-kev γ-ray fixes the position of the metastable state at 172 kev above the ground state of Eu.

Measurements of the internal conversion electron spectrum of the delayed radiation indicate the presence of the 69- and 103-kev γ-rays. The relative heights of the K conversion peak of the 103-kev γ-ray (superimposed on the L, M, and N conversion lines of the 69-kev γ-ray) and the $L+M+N$ conversion peak of the 103-kev γ-ray indicates that the amount of internal conversion in the L shell is comparable to that in the K shell. Also, the spectrum of the unconverted and delayed electromagnetic radiation shows the presence of two peaks which are attributed to the K x-ray of Eu and the 69-kev γ-ray. These observations favor the idea that the isomeric transition is the 103-kev transition.

From the energy and half-life of this isomeric state the transition is probably electric quadrupole or a combination of electric quadrupole and magnetic dipole radiation.

* This document is based on work performed for the Atomic Energy Project at Oak Ridge National Laboratory.

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Radiofrequency Spectrum of D_2 in a Magnetic Field*

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THE radiofrequency spectrum of D_2 in a magnetic field of about 1616 gauss has been investigated by means of a molecular beam apparatus[1] of improved resolution. The molecules of the beam are cooled to the temperature of liquid N_2, so that most of them are in the zeroth and first rotational states. They traverse a path of total length 269 cm. Experimental evaluation of the frequency separations of the six first rotational state resonances permits more accurate determination of D_2 molecular and nuclear constants. In the customary notation,[2] the results are

$$H' = 13.43\pm0.06 \text{ gauss},$$
$$S_D = \tfrac{1}{3}(H''+H''') = 19.301\pm0.015 \text{ gauss},$$
$$H''' = -5e^2qQ/4\mu_D = 86.11\pm0.08 \text{ gauss},$$
$$-qQ = (1.2931\pm0.0012)\times10^3 \text{ cm}^{-1},$$
$$Q = (2.739\pm0.016)\times10^{-27} \text{ cm}^2.$$

The error in the above value of the quadrupole moment of the deuteron is largely the consequence of error in the newly calculated value[3] of q.

Improved accuracy of the present results is to be attributed chiefly to three factors: (a) increased length of the apparatus, (b) variation of frequency instead of magnetic field, (c) use of a recently developed technique[4] of applying the radiofrequency current in two separated sections near the ends of the homogeneous magnetic field. The latter method, involving only the average effect of the field along the molecular path, minimizes the results of field inhomogeneities, which otherwise are found in the present apparatus to be rather serious. Line widths in the new method are very close to theoretical. Instead of turning the oscillator on and off, as in customary operation, we found it advantageous to change the phase of one r-f end section 180° relative to the other. By recording the sense as well as the magnitude of the resulting signal, one can obtain a resonance curve of the same shape (near resonance) as the customary one[1,4] but having double the effective amplitude. Experimental curves of this type are shown in Fig. 1. Moreover, the phase-shifting method greatly reduces r-f pick-up changes in the detector circuit by eliminating r-f current amplitude changes.

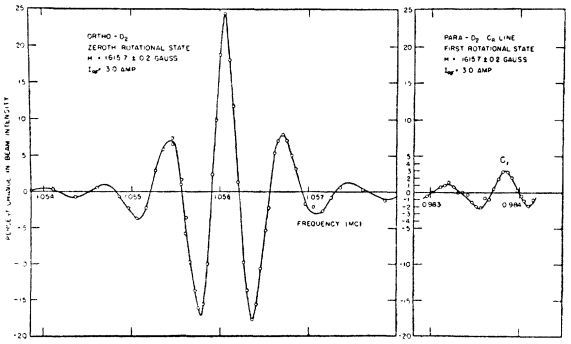

FIG. 1. Experimental resonance curves for D_2 in zeroth and first rotational states, obtained by reversing relative phases of separated r-f sections. Relative intensities are in approximate agreement with theory.

Acknowledgment is made to the Isotopes Division of the AEC for D_2 and D_2O used in the current investigations. These are continuing, and will be more fully reported later.

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‡ NRC Fellow.
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