

Multiple resonances were found in several fluorocarbons containing fluorine atoms in differing structural positions. 2,3,5-trifluorobenzotrifluoride, $C_6H_2F_3-CF_3$, has a double resonance, one with shielding of 0.0115 percent and the other of 0.0047 percent, which in itself is rather broad and may be double. The perfluorolube oil (du Pont) resonance is a triplet with a strong center line at 0.0055 percent and shoulders at 0.0098 and 0.0002 percent. The resonance in $n-C_3F_7CO_2H$ is a doublet at 0.0053 and 0.0095 percent. Several binary mixtures were examined, including $CF_3-CCl=CCl_2$ with 1,4-difluorobenzene, 1,3,5-trifluorobenzene, and 1,2,4,5-tetrafluorobenzene. In these mixtures two resonances appeared at field values identical with those of the separate compounds.

The temperature independence of magnetic shielding was observed in perfluorolube oil from 240 to 400°K, in BF_3 etherate from 175 to 375°K, in CF_3CO_2H from 235 to 370°K, and in a mixture of 1,2,4,5-tetrafluorobenzene and $CF_3-CCl=CCl_2$ from 225 to 400°K. In the mixture only the separation of the resonance lines was followed.

Measurements are in progress on additional simple fluorides to provide more adequate information for detailed theoretical consideration. Also, we wish to report preliminary observations on the magnetic shielding of the proton resonance which in mineral oil apparently occurs at a field 0.02 to 0.05 gauss higher than in benzene, CF_3CO_2H , HBF_4 , $CHCl_3$, concentrated HCl and HNO_3 .

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¹ W. D. Knight, *Phys. Rev.* **76**, 1259 (1949). This report, while mainly concerned with resonance shifts attributed to conduction electrons in metals, mentions observed chemical effects in phosphorus compounds.

² W. C. Dickinson, *Phys. Rev.* **77**, 736 (1950).

³ W. C. Proctor and F. C. Yu, *Phys. Rev.* **77**, 717 (1950).

⁴ J. E. Mack, *Rev. Mod. Phys.* **22**, 64 (1950), Section IIIC2.

⁵ N. F. Ramsey, *Phys. Rev.* **78**, 699 (1950). E. Hylleraas and S. Skavlem, *Phys. Rev.* **79**, 117 (1950).

⁶ Bloembergen, Purcell, and Pound, *Phys. Rev.* **73**, 679 (1948).

⁷ W. C. Dickinson, private communication; we have confirmed his values for PCl_3 , PBr_3 , and H_3PO_4 and also observed PI_3 and P_4 .

The β -Spectrum of C^{14}

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TWO of the most striking contradictions¹ of the predictions of the nuclear shell model are given by the β -spectra of C^{14} and P^{32} . Therefore, although both of these spectra have been extensively investigated, the results are of sufficient interest—and in sufficient doubt—to warrant verification. This communication and one to be published shortly will present a careful repetition of some of these investigations.

Three previous determinations² of the C^{14} spectrum have indicated that the shape is allowed. Two other measurements³ made at about the same time as the former set show at least an indication of a non-linear Fermi plot. Most of these observations had in common the use of an insoluble $BaCO_3$ source, which made the preparation of thin, uniform sources rather difficult. Feldman and Wu (using a helical focusing spectrometer) had probably the best source, since they used an aggregate thickness of only 0.015 mg/cm², and special precautions were taken to ensure that the particle size in the precipitate was small and uniform. However, Cook *et al.* (using a shaped field spectrometer) varied the source thickness from 0.13 to 0.97 mg/cm² and concluded that, since the

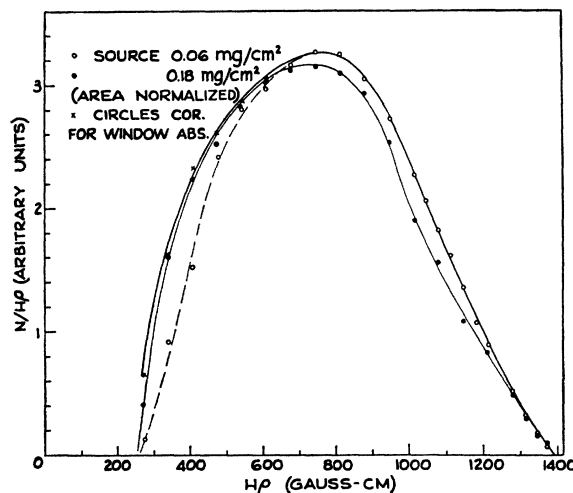
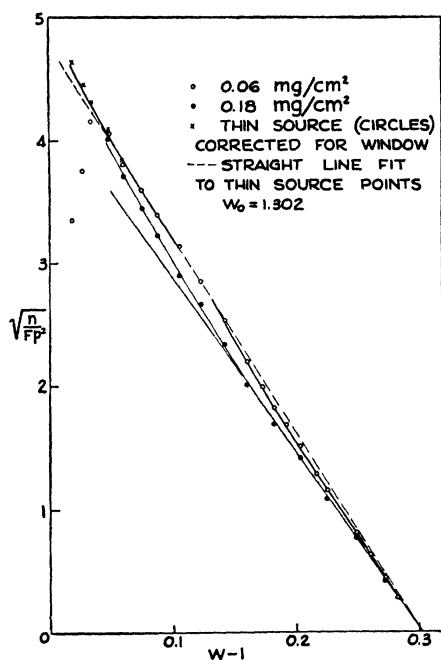


FIG. 1. Momentum distribution for C^{14} .

shape of the spectrum did not depend strongly on the thickness, their observed curvature of the Fermi plot was a real characteristic, rather than an instrumental distortion. Possibly, however, the variation in the *effective* source thickness was less than they supposed; i.e., that much of the distortion was produced not in the source aggregate but rather in the individual grains of the material. However, their result was essentially corroborated by Angus, Cockroft, and Curran, who used a proportional counter technique. In the present investigation, a double thin lens spectrometer was used, with the resolution set at 2.1 percent. Previous work with this instrument⁴ has confirmed the negligible amount of purely instrumental distortions. The source material was $NaHCO_3$, converted from the 40 percent enriched $BaCO_3$ obtained from the Isotopes Division at Oak Ridge. It was felt that the danger of losing a small amount of the activity by exchange with CO_2 in the atmosphere⁵ would be compensated by the increased accuracy made possible by the ease of deposition of a soluble source material.

Thin, uniform sources were deposited on 0.01-mg/cm² Nylon loaded with Aquadag, and immediately placed in the vacuum system to prevent further loss of activity. Figure 1 shows momentum distributions for two of the sources used (0.06, 0.18 mg/cm² approximately) with both curves normalized to the same area. These represent a graphic illustration of the thick source distortion. A window correction (for a 0.05-mg/cm² Nylon window) has been applied to the thin source curve. Figure 2 shows the Fermi plots for these two curves. The thicker source apparently results in a straight line to 80 keV where the curve deviates upward. A still thicker source (0.24 mg/cm², not shown in Fig. 2) was straight only for the last 30 keV of the range. A dashed straight line has been drawn through the thin source points; here, however, there is a distinct indication that the upper solid curve (fitted to the experimental points) is convex to the energy axis, in agreement with reference 3. Below this region the curve is linear to 25 keV, while below this point the (corrected) curve rises. Assuming that the window correction is good, this rise probably is due to source thickness. The maximum (in Fig. 1) occurs at 45 keV, agreeing with Angus *et al.*³ and the end-point energy is 155 ± 1 keV, in agreement with the previous work.

While, therefore, it would seem that the shape is not quite allowed, this result is not very helpful in explaining the β -transition. The empirical classification is second-forbidden and the spin change is unity. Assuming that the transition is really second-forbidden the only possibility (with no parity change) is the Fermi interaction with the correction factor A_{-} in Konopinski's notation. This factor however was not applied successfully to the observed plot. Primakoff⁶ has suggested that the ground state of N^{14} is an accidental mixture of states in such proportions that the

FIG. 2. Fermi plot for C^{14} .

shape may appear to be nearly allowed while the classification is still forbidden. However, Gerjuoy⁷ has argued that this explanation is implausible. If the transition is really first-forbidden (unfavored) with a parity change,⁷ a much wider latitude in fitting the theory to the observed spectrum shape would be permitted. This would require a modification of the shell model prediction.

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³ Cook, Langer, and Price, *Phys. Rev.* **74**, 548 (1949); Angus, Cockroft, and Curran, *Phil. Mag.* **40**, 522 (1949).

⁴ Van Atta, Warshaw, Chen, and Taimuty, *Rev. Sci. Inst.* (to be published).

⁵ M. Calvin *et al.*, *Isotopic Carbon* (John Wiley and Sons, Inc., New York, 1949), p. 123.

⁶ Quoted in reference 1.

⁷ E. Gerjuoy (to be published).

A Thermal Mechanism for Residual Latent Image Fading in Nuclear Emulsions

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EXPERIMENTS by Mather¹ on fading rates in nuclear emulsions indicate a reduction of approximately 90 percent in the fading of proton tracks when stored prior to development in a vacuum, indicating that at least that proportion of the fading phenomena is chemical in nature, with some constituent of the atmosphere the agent involved. However, it is proposed that some or all of the residual 10 percent of the fading can be explained on the basis of the thermal ejection of electrons from the silver specks of the latent image.

This mechanism would consist in the acquisition by these electrons of sufficient energy to re-enter the conductance band of the crystal, causing an electrolytic current of silver ions to flow from the latent image into the grain. The electrons will recombine with

the ions in the interior of the grain where the resulting Ag atoms cannot function as nuclei for development, a redistribution of the latent image similar to that occurring in the Herschel effect. The dissociation energy required to remove an electron from the silver specks comprising the latent image will equal the difference between the work function ϕ of the specks and the energy of the lowest state of the conductance band. The most recent value for this energy has been given² as 0.77 eV, and is great enough to assure the comparative stability of such images with respect to thermal decomposition at ordinary room temperatures, corresponding to an energy of approximately 0.7 eV. However, a relatively slight change in one of the factors governing the magnitude of the dissociation energy would be sufficient to alter the rate of thermal regression of a latent image at room temperature. This latter condition is fulfilled in nuclear emulsions to a certain degree, since the size of the silver specks after particle irradiation is much smaller than of those in optical emulsions, leading to a lower value for ϕ and hence to a lower value for the energy needed to release a trapped electron. The smaller size will be due to the rapidity with which a radiation particle traverses the halide grains (about $2 \cdot 10^{-14}$ sec. for 5 MeV alpha-particles). Since the migration of the silver ions through the crystal is considerably slower than that of the electrons, the sensitivity specks will acquire negative charges faster than they can be neutralized and further electrons will be repelled until sufficient silver ions have reached the specks. By that time, however, no further electrons will be available and the repelled electrons will have combined with silver ions in the interior of the crystal. Thus, in a very rapid transfer of energy to the emulsion, the latent image will tend to contain unusually small silver specks, which is generally the case. The small size also may be expected to contribute to the atmospheric instability of the latent image.

¹ K. B. Mather, *Phys. Rev.* **76**, 486 (1949).

² J. H. Webb, *J. Opt. Soc. Am.* **40**, 3 (1950).

Mechanism of Magnetization in Alnico V

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USING magnetic powder pattern technique,¹ new information has been obtained on the mechanism of magnetization in the alloy containing 14 percent Ni, 8 percent Al, 24 percent Co, 51 percent Fe, and 3 percent Cu (Alnico V). This permanent magnet alloy is unique in that it responds to heat treatment in a magnetic field, and the work here reported has been done to try to explain this action.

Figure 1 shows photographs of magnetic powder patterns of polycrystalline Alnico V cooled from 1300°C at 2° to 5°C per second to 810°C and then oil-quenched, a field being present from 900°C to room temperature. Figures 1(a-c) show photographs in which the specimen was magnetized vertically during heat treatment and horizontally during observation. In (a), domains are seen to lie in a vertical direction and as the field is increased from zero to successively higher values (b, c) the domain boundaries either disappear or the domains contract in width and the horizontal lines (splotches), which indicate the direction of magnetization,¹ gradually rotate toward a vertical position. When the specimen is near saturation, the boundaries of the domains disappear and the originally horizontal lines have become vertical. It is evident, therefore, that in this case the mechanism of magnetization is mainly one of rotation and not of boundary displacement.

Figure 2 shows the magnetization curve for the specimen shown in Figs. 1(a-c). The coercive force of this specimen was only 17 oersteds and yet the knee of the magnetization curve occurs in the neighborhood of 450 oersteds. This indicates that the material has a high anisotropy caused by heat treatment in a field. If this material could be divided into fine particles² (e.g., by precipitation