

than the radiofrequency itself, with the result that these local fields fluctuate rapidly and very nearly average out. The residual mean-square components of these internal fields, in a frequency band $\Delta\nu$, should be inversely proportional to the collision frequency, and the line width hence *inversely* proportional to pressure. A rough calculation of the line width on this basis yields the value 0.04 gauss, considerably smaller than the upper limit found experimentally.

On the other hand the process described is a potent one for thermal relaxation. It should lead to a relaxation time proportional to the pressure. We have measured the relaxation time by observing the onset of saturation as the r-f voltage is increased and find that the relaxation time does in fact *increase* with *increasing* pressure, and in a proportional manner within the accuracy of our measurement, which is not great. At 10 atmospheres the relaxation time is of the order of 10^{-2} sec., which is in fact the order of magnitude to be expected as a result of the process described.

We suggest that a related process may be important in liquids, and perhaps also in non-crystalline solids. The unexpectedly short relaxation time of protons in paraffin, for example, is well established.^{3,4} If this view is correct, the rate of local rearrangements and rotations of the molecule and its neighbors may control the relaxation time in such substances, and in such a way that a slow rate, so long as it is greater than the radiofrequency, leads to a short relaxation time.

In any case the extreme sharpness of the H_2 resonance is of interest in connection with precise g value determinations. As was suggested by J. S. Schwinger at the beginning of this investigation, the H_2 absorption might be useful in measuring orthohydrogen concentration. We are interested in the eventual application of the method to He^3 ; in that case, however, thermal relaxation will presumably have to be brought about by other means, e.g., by admixture of oxygen.

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Long-Life Radio-Iodine *

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A Te target bombarded for 40 hr. with 14.5-Mev deuterons by the MIT cyclotron was received. The radio-iodine was separated in substantially quantitative yield without addition of carrier by oxidizing (heating to

200°C) the target with excess chromic and sulfuric acids, adding water, and reducing to free iodine by heating with phosphorous acid. Addition of a small amount of oxalic acid after the reduction by phosphorous acid served to complete the reduction, but without the usual frothing experienced when oxalic acid is used alone in large quantity. During the reduction, the iodine was distilled in a brisk stream of air into a dilute solution of sodium carbonate and sodium sulfite.

An aliquot of the solution showed considerable activity 6 months later, which was incompatible with the known radio-isotopes.

On addition of iodide as carrier, the bulk of the activity was found to precipitate with silver iodide, and was extractable into carbon tetrachloride after oxidation with iodate. Upon injection into rats, large fractions of the carrier free material injected could be found in the excised thyroid glands.

The emission of material freshly re-separated by CCl_4 extraction was studied using a mica-window Geiger-counter tube. Aluminum, copper, and silver foils were used to determine absorption characteristics, with corrections made for obliquity of the paths through the foils. An x-ray with $\mu = 22.7$ cm²/g Ag, 15.1 cm²/g Cu, and 1.51 cm²/g Al was found. This is equivalent to an energy of 27.0 kev and corresponds to the $K\alpha$ -radiation from tellurium, indicating K -electron capture by iodine.

A particle emission of weak energy having an absorption coefficient of about 270 cm²/g Al, corresponding to a maximum energy of *ca.* 0.1 Mev occurred once to about every forty K -electron captures. No γ -ray was found.

A half-life of about 56 days was found for the I_2 . The total long-life iodine activity of the target 235 days after bombardment was about 930 μ Curies. That would amount to the order of 10 milliCuries at bombardment end.

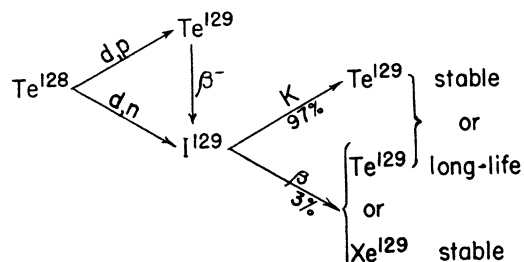
Another activity was found in the iodine solution. It was not removable by boiling. Sodium tellurite was added as a carrier to the mixture, and the tellurium precipitated with SO_2 . This was redissolved in KCN, a sample made and counted. The foreign activity was found to have quantitatively followed the tellurium. It decayed with a long half-life (>200 days) by particle emission (no γ -rays observed) with an absorption coefficient of 5.1 cm²/g Al (*ca.* 1.6 Mev). Its maximum activity was only about 1 disintegration per 1000 K -electron captures.

Two other targets we have examined have furnished radio-iodine with the same properties. It seems probable that the new iodine is the missing I^{129} formed by a (d, n) reaction on the abundant Te^{128} (32.8 percent)³ or by β -decay of a (d, p) produced Te^{129} . If the I^{129} is the isotope produced as a decay product of the 72-minute half-life Te^{129} , there is present the unique case of isomeric transition through β -decay and subsequent K -electron capture.

The position of the Te^* in the scheme is not clear. It may be an impurity; however no such long-lived Te isotope is listed in Seaborg's table.⁴ If it were a daughter of the I^* which had been building up after the last I_2 separation, it would then have a half-life of about 10 or 400 years depending on the channel responsible for its production. With the activities available, no estimation as to

whether growth was occurring could be made in the time of observation.

A possible transformation scheme would be



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Resonance Absorption by Nuclear Magnetic Moments in a Single Crystal of CaF_2

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THE magnetic dipole-dipole interaction between nuclei arranged on a cubic lattice in the presence of a strong external field H_0 depends markedly on the direction of H_0 with respect to the lattice axes. If the width of the radiofrequency absorption¹ line at $\nu = \mu H_0 / h$ arises mainly from this interaction, the width and also the peak intensity of the resonance absorption observed in a suitable single crystal should vary as the crystal is rotated in the field H_0 . We have observed such an effect in a single crystal of fluorite, CaF_2 , in which the magnetic nuclei (F^{19}) occupy a simple cubic lattice.

A cylindrical specimen, 6-mm diam. by 15 mm long, was cut from a fluorite crystal, the axis of the cylinder lying in the 110 -direction. The axis of the r-f coil into which the specimen was inserted was perpendicular to the strong field H_0 , and the specimen could be rotated within the coil to align any vector in the 110 -plane with H_0 . The fluorine resonance was observed at 29.1 mc/sec. by our modulation method.² Quantities related to line width and peak intensity were measured as functions of crystal orientation. The "line width" measured (expressed in gauss) is the width between points of maximum slope of

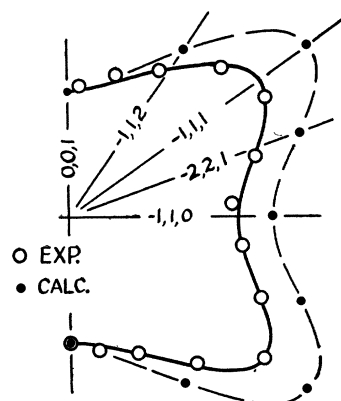


FIG. 1. Polar plot of the dependence of the intensity of magnetic resonance absorption in CaF_2 with the direction of H_0 with respect to the crystal. Absorption is maximum, for example, when H_0 lies along the $(-1, 1, 1)$ direction.

the curve of absorption vs. H_0 at constant frequency. The maximum slope multiplied by this line width is taken as a measure of the peak intensity; it would be strictly that for lines of similar shape, for which in addition, the product of line width and peak intensity should be constant in our experiment.

The variation of the product of measured width and measured intensity was in fact no more than ± 5 percent, while each of these quantities individually displayed a pronounced anisotropy of the expected type. Figure 1 is a polar plot of the relative intensity observed with H_0 in various directions. The solid points are located on radii inversely proportional to the r.m.s. line width from dipole-dipole interaction, calculated for certain crystal directions. That the observed anisotropy is somewhat less pronounced than that calculated may be ascribable to variation of line shape with orientation or to broadening influences other than the dipole-dipole interaction.

In absolute magnitude, the measured line width for the 001 -direction was 8.5 gauss. The theoretical r.m.s. width, computed from a rigorous formula kindly provided by Professor Van Vleck, is 5.4 gauss in this case. The quantities are not strictly comparable, but one would expect rough agreement.

The spin-lattice relaxation time was of the order of 5 sec., and no variation with crystal orientation was found. All line width measurements were made at low signal power to avoid saturation. In all these experiments, moreover, the r-f field is so weak ($< 10^{-2}$ gauss) as to have no direct influence on the line width.

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