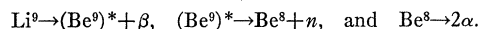


linear roll paper by a fast recorder. All circuits are left on continuously. The target is irradiated, the cyclotron is turned off, and the excitation is observed immediately.

With this arrangement measurements were taken using a one-sixteenth-inch thick carbon plate as a target. Runs were made at twelve different proton energies chosen in the range between 20 and 110 Mev by varying the distance of the target from the center of the cyclotron tank. Owing to the occurrence of simple and spallation reactions, a variety of modes of disintegration was observed. By pulse-height analysis and varying the time of irradiation, additional discrimination was obtained. Previously known lifetimes as well as some new ones appeared with great consistency over various bombarding energies.

The first part of our investigation was aimed at the detection of the Li^9 isotope. The activity has been first tentatively reported by Gardner *et al.* on the basis of the detection of delayed neutrons produced according to the following scheme:¹



The half-life obtained was 168 ± 4 msec.

By this first direct detection of the beta-decay particles a half-life of 170 ± 5 msec has been obtained, thereby corroborating the California results. The spallation reaction leading to Li^9 is $\text{C}^{12}(p, 4p)\text{Li}^9$, with a threshold energy of about 47.5 Mev in the laboratory system.

We wish to thank Mr. R. Brown and Mr. M. Hurley for their help in evaluating the large number of decay curves.

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† Now at the Scientific Specialties Corporation, Cambridge, Massachusetts.

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Atomic Beam Resonance Method for Excited States

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THUS far, only long-lived or metastable states of atoms or molecules have been studied by molecular beam resonance methods. The purpose of this letter is to indicate that excited atomic or molecular levels are accessible to experimental methods quite similar to those which have been used for the ground states.¹ There is the inevitable loss in precision which arises from the fact that excited states have lifetimes of the order of 10^{-8} sec, which brings with it an inevitable line width of approximately 10 megacycles. It will, therefore, be difficult to measure hyperfine structure intervals to a higher accuracy than a fraction of a megacycle.

In essence, this new method is similar to the original investigations. However, in addition to the radio frequency field, the region of the "C" field is also illuminated with radiation of the principal series of the atoms under investigation. This resonance radiation brings a substantial fraction of the atoms into an upper level in which they have a lifetime of about 10^{-8} sec. When they return to the lower state by radiation there is a preference for the original hyperfine structure state from which they started, as can be shown by a simple calculation. The application of an rf field of sufficient amplitude and of appropriate resonance frequency causes transitions among the upper hyperfine structure or magnetic levels and "scrambles" the population in the upper state. Since the atoms are essentially "tagged" atoms by the deflection which they have suffered in the "A" field this scrambling will cause a change in refocused intensity at the detection.

To reduce background, the "A" and "B" fields are so arranged as to produce equal deflections and of the same sign at the detector. In this way only very few atoms reach the detector. However, when the beam is illuminated with the optical radiation, some of the atoms which have absorbed this radiation come down to the ground state with moments pointing in a direction opposite to the original and are, therefore, focused onto the detector by the "B" field. When the rf is resonant, this beam intensity is changed.

By the interposition of slits or obstacles right after the "A" or after the "B" field, or both, one can select certain specific states which are to be subjected to the optical excitation, or shut out atoms which have undergone specific transitions, procedures which should prove to be helpful in the interpretation of results, or in the resolution of overlapping lines.

These general methods are capable of wide extension. To mention a few, it should be possible to study isotope shifts by these methods by illuminating with the line of one isotope and, by means of magnetic or electric fields, moving the line of the other isotope into a frequency region which can absorb this radiation; it should be possible to produce atomic states which are too high for temperature excitation by illuminating the ground state with appropriate radiation and studying the atoms which fall into this upper state; double optical excitation can make accessible states other than those which can be reached by absorption of the series alone.

The method here suggested is related to the methods which use the depolarization of resonance radiation.² Our present method, however, has the general advantages which atomic and molecular beam methods have of greater simplicity and control of the details of the complicated processes which are involved when a multiplicity of states exists as in hyperfine structure, as well as a better ratio of signal to noise.

This method is being applied to the study of the alkalis, particularly Rb in the first *P* level. It has already been found quite easy to cause 20 percent of the atoms to make transitions by optical excitation with a very simple source of resonant radiation.

Further details will be published in a later paper.

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The Directional Correlation of the Ni^{60} γ - γ Cascade

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THE directional correlation of the γ - γ cascade of Ni^{60} was first investigated by Brady and Deutsch,¹ who report their measurements to be consistent with the correlation function $W(\theta)$ for the cascade $4(E2)2(E2)0$: $W(\theta) = 1 + \frac{1}{3} \cos^2\theta + (1/24) \cos^4\theta$; anisotropy $A \equiv [W(180^\circ)/W(90^\circ)] - 1 = 0.167$. The assignment of the radiation type, *E2*, stems from the measurement of the direction-polarization correlation² and from the determination of the internal conversion coefficients.³ The conclusions of Brady and Deutsch were confirmed by several other investigators.⁴⁻⁷

Using the apparatus described in a forthcoming paper,⁸ we remeasured the directional correlation of the Ni^{60} -cascade. The scintillation counters were shielded with lead (0.5 cm in front, 1.0 cm laterally) against scattered quanta and annihilation radiation from internal pair production. The scattering correction for the anisotropy, calculated and tested experimentally with Fe^{59} γ -rays,⁹ amounts to less than 0.003.

The measurements made with the radioactive source consisting of a spherical piece of pile-irradiated metallic cobalt (diameter ~ 0.02 cm) yield an anisotropy $A = 0.148 \pm 0.003$. Additional measurements with sources prepared chemically [CoSO_4 , solid and in solutions; $\text{K}_4\text{Co}(\text{CN})_6$], with the double stream method (imbedding materials Ag and Ni), and by electrolysis on a thin Ag wire, are all consistent with this value of the anisotropy. The weighted mean value of the anisotropy, taking into account all measurements, is $A = 0.148 \pm 0.002$. (Inspection of the investiga-

tions^{4,5,7} shows that the values and curves reported there are also consistent with this value of the anisotropy.)

Our experimental value for the anisotropy differs from the theoretical value for the cascade $4(2)2(2)0$: $A_{\text{theor}}=0.167$. To explain the discrepancy, we considered two possibilities:

1. The assignment $4(E2)2(E2)0$ is wrong. We tried to fit all experimental data together with our value of A by assuming other spin- and parity-assignments and by taking into account mixtures of different multipole radiations. No other assignment, however, seems compatible with all known facts.

2. The directional correlation is influenced by the electron shell.^{10,11} To test this assumption, we applied an external magnetic field H in the direction of the fixed counter. According to Goertzel,¹² such a field should restore the undisturbed correlation if the field strength H satisfies the relation $\mu H \gg \hbar\omega$, where μ and $\Delta\nu = \omega/2\pi c$ are the magnetic moment and the hyperfine splitting of the atom if the nucleus is in the intermediate level. (Goertzel's statement is only valid for magnetic interactions. We assume, however, that other interactions are too weak to have an appreciable effect.) The directional correlation of Ni^{60} remains, however, unchanged for field strengths H up to 8000 oersted (corresponding to inner fields of $\sim 15,000$ gauss in the metallic source). This allows an estimate of the lifetime T of the intermediate nuclear state. The existence of an attenuation by the shell implies $\omega T \sim 1$. The failure of the external magnetic field H to restore the directional correlation means $\hbar\omega \gtrsim \mu H$. These two conditions (with $\mu \sim \mu_{\text{Bohr}}$) give an upper limit for T : $T \lesssim 10^{-11}$ sec. If one assumes further an upper limit for the magnitude of the hyperfine splitting, $\Delta\nu < 1 \text{ cm}^{-1}$, one gets $T \sim 10^{-11}$ sec. This value for the lifetime of the first excited state of Ni^{60} is in essential agreement with the value calculated from the Weisskopf formula¹³ for an electric quadrupole transition.

From the present experiments it is, however, impossible to decide if the discrepancy between theoretical and experimental anisotropy is caused by the influence of the electron shell or if other effects have to be considered. Before definite conclusions can be drawn, the measurements have to be repeated with stronger external magnetic fields. The precise determination of the directional correlation of other $4(E2)2(E2)0$ cascades would perhaps also give more information.

We wish to thank Professor P. Scherrer for his continued interest, Dr. M. R. Schafroth and Mr. K. Alder for many valuable discussions, and Mr. R. Hiltbrunner for his assistance during the measurements.

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Superconductivity in the Cobalt-Silicon System

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A COBALT-SILICON melt with 75 atomic percent Si has been found to become superconducting at 1.33°K. This was determined both by measuring the magnetic flux change and by observing the Meissner effect. The bulk properties thus obtained indicate that about half of the sample becomes superconducting. X-ray analysis¹ shows two phases: pure silicon and CoSi_2 in roughly equal proportions.

Whereas it has been impossible to detect superconductivity at temperatures above 1.27°K in pure CoSi_2 , measurements on melts with more than 75 atomic percent Si indicate, from the volume of the sample which becomes superconducting, that CoSi_2 is the superconducting phase. This suggests that the transition temperature in CoSi_2 has been slightly raised in our samples by the strain resulting from its rapid crystallization into the CoSi_2 in an excess of silicon. This suggestion is further supported by the fact that annealing a melt with 75 atomic percent Si lowered the transition temperature.

As cobalt is ferromagnetic and silicon is a semiconductor at best, the probability is low that either element is a superconductor, even at the lowest temperatures. Superconducting compounds of nonsuperconducting elements have thus far been limited to some borides, carbides, nitrides of molybdenum and tungsten, CuS, and a large number of Bi-compounds. In the periodic system, however, Mo, W, Cu, and Bi are very close to the two groups of superconducting elements. This has given rise to the hypothesis² that superconducting elements or compounds are essentially confined to these two regions in the periodic table. The present example indicates that this hypothesis is not reliable.

¹ I want to thank Dr. E. A. Wood and Professor W. H. Zachariasen for their help and advice in this analysis.

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A Quantitative Determination of the Abundance of Telluric CO above Columbus, Ohio*

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LINES of the 0-1 absorption band of CO at 4.7μ have been observed in solar spectra recorded at Columbus, Ohio,^{1,2} and at the Jungfrauoch, Switzerland,^{3,4} and it has been shown that the absorption is of telluric origin. However, recent measurements made by Goldberg, McMath, Mohler, and Pierce^{5,6} at Lake Angelus, Michigan, and Mt. Wilson, California, who have studied the solar spectrum in the CO overtone region at 2.3μ , have so far failed to reveal any absorption which can be ascribed to telluric CO. Thus, estimates of the average amount of telluric CO above these various geographic locations vary very widely, and in addition daily variations in the amount of CO present has also been reported.^{4,4}

In order to make an accurate measurement of the amount of atmospheric CO above Columbus, Ohio, observations on the line $R(2)$ of the fundamental band of CO in the solar spectrum were made on several days during January and February, 1952. The region of the solar spectrum studied is shown in Fig. 1, and it is seen that the $R(2)$ line, marked with an arrow, appears to be free of other strong interfering lines. Measurements of the total absorption of this line for various solar altitudes are shown in Fig. 2.

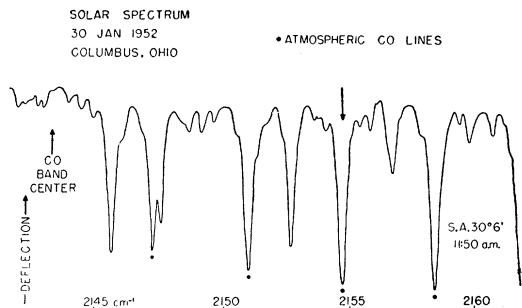


FIG. 1. The solar spectrum near 4.7μ .