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]

$$Li^9 \rightarrow (Be^9)^* + \beta, \quad (Be^9)^* \rightarrow Be^8 + n, \quad \text{and} \quad Be^8 \rightarrow 2\alpha.$$

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 $C^{12}(p, 4p)Li^9$, 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.

* This work has been supported by the ONR.

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

[1] Gardner, Knable, and Moyer, Phys. Rev. **83**, 1054 (1951).

Atomic Beam Resonance Method for Excited States

I. I. RABI
Columbia University, New York, New York
(Received June 4, 1952)

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.

[1] Kellog, Rabi, and Zacharias, Phys. Rev. **50**, 472 (1936); Rabi, Millman, Kusch, and Zacharias, Phys. Rev. **55**, 526 (1939); Kusch, Millman, and Rabi, Phys. Rev. **57**, 765 (1940).
[2] E. Fermi and F. Rasetti, Nature **115**, 764 (1925); Z. Physik **33**, 246 (1925); F. Bitter, Phys. Rev. **76**, 833 (1949); J. Brossel and A. Kastler, Compt. rend. **229**, 1213 (1949); M. L. Pryce, Phys. Rev. **77**, 136 (1949); Brossel, Sagalyn, and Bitter, Phys. Rev. **79**, 196, 225 (1950); F. Bitter and J. Brossel, Phys. Rev. **85**, 1051 (1952); J. Brossel and F. Bitter, Phys. Rev. **86**, 308 (1952).

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

H. AEPPLI, H. FRAUENFELDER,* E. HEER, AND R. RÜETSCHI
Swiss Federal Institute of Technology, Zürich, Switzerland
(Received May 26, 1952)

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 $4(E2)2(E2)0$: $W(\theta)=1+\frac{1}{8}\cos^2\theta+(1/24)\cos^4\theta$; anisotropy $A\equiv[W(180°)/W(90°)]-1=0.167$. The assignment of the radiation type, *E*2, stems from the measurement of the direction-polarization correlation[2] 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 $A=0.148\pm0.003$. Additional measurements with sources prepared chemically [$CoSO_4$, solid and in solutions; $K_4Co(CN)_6$], 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 $A=0.148\pm0.002$. (Inspection of the investiga-