evaporation from a hot filament coated with lithium salts. A 90° electrostatic analyzer selects a beam homogeneous in energy within 1.0% and the lithium isotopes are then separated by a 22.5° magnetic deflection. The experiments were conducted at a beam energy of 1.61 ± 0.02 Mev, and beam currents in the range 0.5 to 1 microampere.

Observation of the particles emitted at 90° to the beam when the Li^7 beam impinged on a LiF target disclosed a group of particles of approximately 50-cm range in air. Using other targets of separated lithium isotopes, a study of the numerous reactions produced by either the Li^6 or the Li^7 beam showed that the group arose from the Li^7-Li^7 combination. The detector was a CsI(Tl) scintillating crystal 0.5 mm thick attached to a photomultiplier tube, and ranges were studied by inserting aluminum foils between target chamber window and crystal detector. Pulse heights were recorded on a 6-channel analyzer. The yield of these protons was about 28 per unit solid angle at 90° in the laboratory system, per microcoulomb of Li^7 ions on a thick target of LiF.

The entire target chamber and its rigidly attached crystal-photomultiplier assembly could be removed and attached to our Cockcroft-Walton accelerator. Thus the new group was compared with a 58-cm proton group from $B^{10}(d,p)B^{11*}$, whose energy, at 90° from a 400-kev deuteron beam, is known[5] to be 6.802 ± 0.008 Mev. Portions of the range-energy curves for both proton groups were constructed by plotting pulse height *versus* mg/cm² of aluminum inserted. The identity in slope of the new curve with that of the known protons from boron shows that the new particles from Li are protons. The two curves were displaced by 12.35 ± 0.4 mg/cm² of Al, or 8.35 ± 0.3 cm air, and using the slope of the proton range—energy curve in this region we find 6.23 ± 0.03 Mev for the energy of the new proton group.

Using published mass values,[6] it results that the Q-value of the new $Li^7(Li^7,p)B^{13}$ reaction is 5.97 ± 0.03 Mev, giving B^{13}, presumably in its ground state, a value of $(M-A)$ equal to 20.39 ± 0.03 Mev, or a physical atomic weight of 13.02190 ± 0.00003. This agrees with the value of 19 ± 2 Mev for $(M-A)$ predicted by Barkas.[2]

A search for the β activity and possible delayed neutrons will be made. Thanks are due Walter Mankawich for careful construction of the electrostatic analyzer and I. S. Iwaoka for operation of the Van de Graaff accelerator.

---

* This work supported in part by the U. S. Atomic Energy Commission.

[1] W. H. Barkas, Phys. Rev. **55**, 691 (1939).

[2] A. H. Snell, Science **108**, 172 (1948).

[3] Hubbard, Ruby, and Stebbins, Phys. Rev. **92**, 1494 (1953).

[4] R. K. Sheline, Phys. Rev. **87**, 557 (1952).

[5] Energy analysis by magnetic deviation has shown that the Q of this group is 7.097 ± 0.009 Mev. Van Patter, Buechner, and Sperduto, Phys. Rev. **82**, 248 (1951).

[6] F. Ajzenberg and T. Lauritsen, Revs. Modern Phys. **27**, 77 (1955).

Ultrasonic Saturation of Nuclear Magnetic Energy Levels*

W. G. Proctor† and W. A. Robinson
Department of Physics, University of Washington, Seattle, Washington

(Received February 23, 1956)

RECENTLY, Proctor and Tanttila have described an experiment in which pure nuclear electric quadrupole energy levels were saturated by ultrasonic excitation at the pure quadrupole transition frequency.[1] In a similar experiment we have observed a change in the population of the nuclear magnetic energy levels of Na^{23} in a single crystal of NaCl as a result of ultrasonic excitation. The cubic symmetry of the NaCl crystal is removed by the sound, causing time varying electric field gradients at the Na^{23} nuclei which interact with their quadrupole moment. This may induce transitions corresponding to m changes of both ±1 and ±2. In our experiment, the sound frequency was twice the magnetic resonance transition frequency, which corresponds to $\Delta m=\pm2$. Our experiment was performed in a steady magnetic field of 4220 oersteds, under which conditions the nuclear magnetic resonance occurred at a frequency of 4.75 Mc/sec. We measured the thermal relaxation time to be 8 seconds at room temperature.

In a magnetic field, Na^{23} has four nuclear magnetic energy levels corresponding to m values of $-\frac{3}{2}$, $-\frac{1}{2}$, $+\frac{1}{2}$, and $+\frac{3}{2}$. There are 3 transitions between these and they are at identical frequencies in ideal NaCl crystals. In this experiment the population difference between the $m=+\frac{3}{2}$ and $m=-\frac{3}{2}$ levels was measured by the amplitude of the nuclear induction signal that followed a short pulse of radio-frequency magnetic field at the Larmor frequency.[2] The nuclear signal was induced in a receiver coil oriented perpendicular to the transmitter coil and containing the NaCl crystal sample. The sample was a cylinder of halite 1.5 cm in diameter and 3 cm long. It was cemented to an identical crystal which in turn was cemented to an X-cut quartz transducer. The quartz had a broad resonance centered at 9.5 Mc/sec when loaded and was driven by a variable frequency oscillator. This oscillator was turned on for a period of 8 seconds; then after a delay of 0.03 sec the $+\frac{3}{2}$, $-\frac{3}{2}$ population difference was measured. This cycle was repeated every 17 seconds. We assume that the sound generated by the quartz was scattered into an isotropic distribution at the free end of the halite sample since this end had been made irregular. The magnetic fields generated by currents in the ultrasonic system, a possible source of difficulty in the experiment of Proctor and Tanttila, could not affect the population since they were at twice the Larmor frequency.

We observed a decrease in the $m=+\frac{3}{2}$, $m=-\frac{3}{2}$ population difference for a small range of ultrasonic frequencies centered exactly at twice the nuclear frequency. With 1.2 watts of radio-frequency power delivered to the quartz transducer the population difference could be reduced to 26% of its equilibrium value. The difference of frequency values for which the population decrease was $\frac{1}{2}$ of the maximum decrease was found to be 4 kc/sec. The 4-kc/sec width of this effect is to be compared to the nuclear magnetic resonance line width of 2.3 kc/sec.[3] The difference in these widths can be explained in terms of imperfections in the crystal lattice giving rise to random but permanent electric field gradients. These gradients cause the $\Delta m = \pm 2$ transitions to be spread by the quadrupole interaction.[4] In nuclear magnetic resonance two transitions are of the type $m=\frac{1}{2}$ to $m=\frac{3}{2}$ and these will be spread by the same amount as the $\Delta m = \pm 2$ transitions. The $m=\frac{1}{2}$ to $m=-\frac{1}{2}$ transition, however, will have only dipolar broadening and will weight the nuclear magnetic resonance line toward the center frequency.

Measurements are now under way to examine the quantitative and directional properties of this phenomenon. It is hoped that the thermal relaxation mechanism proposed by van Kranendonk[5] can be studied in this way.

---

[*] This research was supported by the U. S. Air Force, through the Office of Scientific Research of the Air Research and Development Command.

[†] On leave at the University of Basel, Basel, Switzerland.

[1] W. G. Proctor and W. H. Tanttila, Phys. Rev. **98**, 1854 (1955).

[2] E. L. Hahn, Phys. Rev. **77**, 297 (1949).

[3] R. Schumacher, private communications.

[4] G. D. Watkins and R. V. Pound, Phys. Rev. **89**, 658 (1953).

[5] J. van Kranendonk, Physica **20**, 781 (1954).

Associated Production and the Lifetimes of the Λ^0 and θ^0 Particles[*]

H. Blumenfeld, E. T. Booth, and L. M. Lederman,
Columbia University, New York, New York

and

W. Chinowsky, *Brookhaven National Laboratory, Upton, New York*

(Received March 22, 1956)

A PRELIMINARY report is presented here of the observations on heavy unstable particles in the Columbia 36-in. diameter magnet cloud chamber at the Brookhaven Cosmotron.[1] The particles are produced by 1.9-Bev negative pions incident upon $\frac{1}{4}$-in. thick lead and $\frac{1}{2}$-in. thick carbon plates inside the chamber. A total of 95 Λ^0 and 29 θ^0 decays has been analyzed. The particles are identified by Q-values determined from the measured momenta and included angle of the decay tracks. Confirmation of these identifications is provided by ionization estimates and the observed angles of the decay tracks with the lines of flight of the neutral unstable particle. The mean Q-value of the Λ^0 events is 36 ± 1 Mev with an average error in a single determination of ±6 Mev. The mean θ^0 Q-value is 200 ± 10 Mev, with a mean individual error of ±60 Mev.

We have collected 65 Λ^0's satisfying criteria of (1) vertex >2 mm from the nearest plate and (2) positive prong ionization $\geq 2\times$minimum. For these events the decay times and the potential times of flight are determined, using fiducial planes parallel to and located 1.0 cm from vertical bounding surfaces and 2.5 cm from horizontal boundaries. These planes insure sufficient track length to establish identification, since the vertical surfaces are thin plates which rarely stop decay products. Following the procedure of Bartlett,[2] we obtain, for the mean life,

$$\tau_{\Lambda^0} = (2.8_{-0.4}{}^{+0.5})\times10^{-10}\ \text{sec.}$$

To eliminate possible errors of misidentification of the origins of events, each region between successive plates is treated as a separate chamber. The mean potential time of flight is 12×10^{-10} sec and the potential time correction to the mean life amounted to 18%. The stated error includes a small contribution due to average momentum uncertainties. This result is somewhat lower than, but not in disagreement with, most of the earlier cosmic-ray determinations.[3] It should be noted that this measurement differs from those previously made in that observations are made closer to the birthplace, the mean "dead time" being only $\sim6\times10^{-11}$ sec.

A similar analysis of the θ^0 decays, excluding four possible cases of anomalous V^0 events, yields

$$\tau_{\theta^0} = (0.8_{-0.2}{}^{+0.3})\times10^{-10}\ \text{sec.}$$

Inclusion of the events with low Q-values does not alter this result. Here the potential path correction is $\sim$20%. Since the identification of θ^0's is less certain than that of Λ^0's, and the errors in individual Q-values are rather large, we consider this determination more subject to the inclusion of wrong particles.

We have selected a set of events out of the data such that (i) a Λ^0 is associated with an incoming pion that stops in a plate, and (ii) either no charged particle emerges from the production point or only very heavily ionizing, straight tracks emerge. We believe these criteria exclude, with high probability, the possibility of associated K^+ mesons or of θ^0-meson decays, inside the plate, into charged pions. Twenty-eight such events have been observed. These include only seven events which have an observed, associated θ^0 decay. Any observational inefficiency in this number involves failure to detect a θ^0 after having found a Λ^0 decay and should be very small.

The known lifetime and distribution of potential paths permit an evaluation of the number of associated $\theta^0\rightarrow\pi^++\pi^-$ events which take place outside the chamber. This is $1_{-1}{}^{+2}$, where the errors are limiting uncer-