the domain is consistent with the simple notion of generation at a plane of acoustic flux with a single velocity, the same cannot be said of the spatial extent of the domain. It is too large to be explained by the extended rise time of the applied pulse itself. It remains to be studied whether the generation occurs over a more extended region than the end contact (e.g., due to such accidental factors as narrowing of the sample near the contacts in the etching procedure), or whether many modes are generated with a dispersion in velocities. We have also noted evidence of weaker bulk generation, manifesting itself in the appearance of very diffusely excess resistance ahead of the moving domain itself. This is observed particularly in very long samples in the case of constant-current mode of operation, and may be due to homogeneous amplification of phonons from the thermal background.

[18]In photoconducting semiconductors, such as CdS, nonuniform optical generation of excess carriers due either to nonuniform illumination or to nonuniformities in the material itself may give rise to multiple ultrasonic generation sites when high-voltage pulses are applied. Such effects may account for some of the complicated photocurrent oscillation patterns which have been recently reported. See, e.g., M. Kikuchi, J. Appl. Phys. (Japan) 3, 448 (1964); J. Okada and H. Matino, J. Appl. Phys. (Japan) 3, 698 (1964).

DECAY OF CARBON-9

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This Letter reports the results of recent measurements on delayed protons following the β^+ decay of ^9C. These measurements were undertaken as part of a systematic investigation carried out at this Laboratory on the $A=(4n+1)$, $T_z=-\frac{3}{2}$ series of delayed proton precursors.[1] Carbon-9 was of particular interest not only because it was the lightest member of the series, but also because it was the lightest nuclide whose existence (i.e., particle stability) was expected, and whose decay had not been definitely detected. A few years ago, Swami, Schneps, and Fry[2] interpreted a single event in a nuclear emulsion as an example of the decay of ^9C, and more recently Wilkinson[3] and Jaenecke[4] estimated that ^9C should be stable against proton emission by about 1 MeV. While the present experiment was in progress, Cerny et al.[5] verified Wilkinson's estimate by measuring the energy balance in the reaction $^{12}C(^3He, {}^6He)^9C$ leading to the ground state of ^9C.

Bombardments were carried out in the internal beam of the McGill synchrocyclotron using targets of carbon and natural boron; ^9C was produced by the reactions $(p, d2n)$ on ^{12}C, and $(p, 2n)$ and $(p, 3n)$ on ^{10}B and ^{11}B, respectively.

Two alternative detection systems were used. The first was a solid-state counter telescope comprised of a 50μ totally depleted surface-barrier silicon detector (dE/dx) and a 3-mm (22-MeV for protons) lithium-drifted detector (E). The second detection system was a surface-barrier silicon detector of 500μ depletion depth (8-MeV for protons) with absorbers to reduce the incident-proton energy. The detector system and target foil were mounted 5 cm apart on a radial probe which was inserted into the internal cyclotron beam. Counting was performed between repeated 30-msec bursts of normal cyclotron operation. The recording of pulses was interrupted during the beam burst and for 100 msec afterwards, this delay being long enough to allow the dissipation of beam-storage effects in the cyclotron. As well as proton energy spectra, time spectra could be obtained by using a 400-channel pulse-height analyzer in its scaling mode, or by sequentially directing the proton spectrum into the four quarters of the analyzer.

For the telescope system, the dE/dx and the E pulses were added, and the sum was recorded only if the dE/dx pulses fell within predetermined limits. These limits were set so as to make it possible to record protons with energies from 0.3 to 14 MeV and to exclude all α particles in this range. The β- and γ-ray background, however, was not completely rejected. Figure 1 shows the spectrum obtained from a carbon target (2.4 mg/cm^2 polyethylene); the threshold for production of this spectrum was found to be 52 ± 3 MeV. Similar peaks were obtained from a boron target (3.6 mg/cm^2 H_3BO_3 sprayed on thin gold foil) bombarded at 45 MeV. No sign of a similar activity was observed in energy spectra and decay curves from thick beryllium and lithium targets. These findings

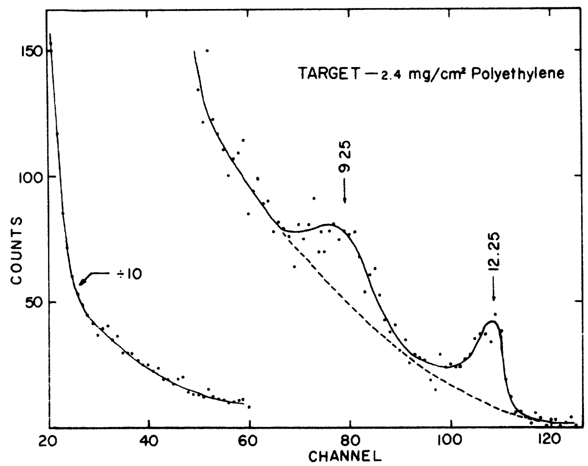

FIG. 1. Spectrum of delayed protons following the decay of ^9C. The continuum contains an unknown but probably small number of β and γ counts. The peaks have been marked with their center-of-mass energies. The target was bombarded with $\sim 10^{16}$ 85-MeV protons, and the over-all detection efficiency was about 0.25 %.

identify the activity as being due to ^9C, whose calculated laboratory production threshold is 55.1 ± 0.2 MeV for the reaction $^{12}C(p,d2n)^9C$ and 28.4 ± 0.2 MeV for the reaction $^{10}B(p,2n)^9C$.

The two peaks in Fig. 1 were brought in turn within the range of the 8-MeV-thick detector by appropriate aluminum absorbers. This again identifies the peaks as due to protons, and gives another measure of their energies. The energies measured by the 22-MeV-thick detector involve a long extrapolation from the 5.305-MeV α-particle calibration, while those measured by the 8-MeV-thick detector involve a large absorption correction; the peaks also have substantial widths. Nevertheless, the two methods of energy measurement disagreed by only about 0.3 MeV, and we will quote average figures with appropriate error estimates. The peaks of Fig. 1 are both much wider than the resolution width (~0.25 MeV) of the target-detector system. We finally quote the measured peak energies and widths in Table I.

Table I. Peak energies corrected to center of mass, with corresponding observed widths (full width at half-maximum) corrected for resolution.

Energy (MeV)	Width (keV)	Relative intensity
12.25 ± 0.20	800 ± 100	1
9.25 ± 0.25	1400 ± 200	~1.5

The time decay of the spectrum was observed in many runs, all of which gave consistent results for the half-life. Separate multiscaling runs were performed on pulses corresponding to the 12.25-MeV peak, and on those pulses in the range of 4 to 10 MeV. In the latter case a weak 800-msec component due to a mixture of ^8B and ^8Li had to be subtracted. The result for the half-life of ^9C is 127 ± 3 msec.

Figure 2 shows a level scheme embodying the present results on ^9C. The two peaks of Fig. 1 are attributed to proton decay from a level of ^9B to the familiar ground and first excited states of ^8Be. The separation of the observed peaks is 3.0 ± 0.3 MeV in agreement with the known 2.90-MeV separation of these levels. The energy of the proton-emitting level of ^9B is calculated to be 12.05 ± 0.2 MeV and its width to be 800 ± 100 keV. This is presumably the state which Dietrich and Davies[6] observed at 12.3 ± 0.3 MeV with a width of 800 ± 200 keV.

These authors also observed a level at 14.67 MeV to which they assigned $T=\frac{3}{2}$. Although β^+ decay to this level from ^9C would be superallowed, the decay energy is small, and reasonable estimates for the logft values lead one to expect an unobservably small number of delayed protons from this level.

With three odd particles, ^9C is taken to have spin-parity $\frac{3}{2}^-$, and its allowed β^+ decay to the

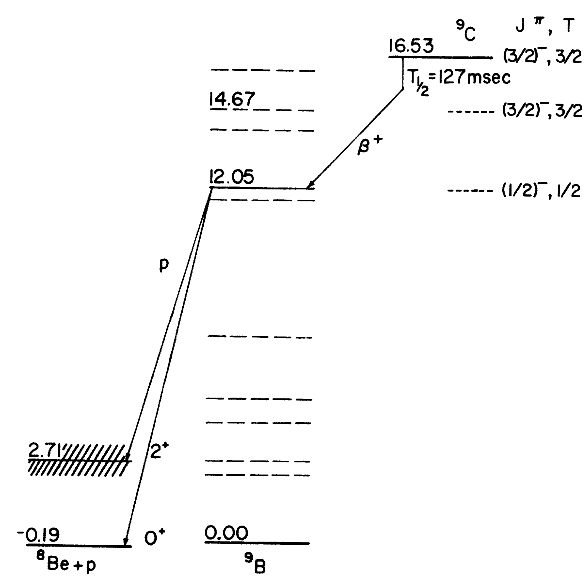

FIG. 2. Partial decay scheme of ^9C showing the branch identified in this experiment. All of the indicated levels for ^9B have been observed by previous workers.

12.05-MeV state of ^{9}B restricts that state to $\frac{1}{2}^-$, $\frac{3}{2}^-$, or $\frac{5}{2}^-$. The nearly equal proton intensities to the 0^+ and 2^+ states of ^{8}Be favor the assignment of $\frac{1}{2}^-$.

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DECAY OF BARYON RESONANCES IN THE SPIN AND UNITARY-SPIN INDEPENDENCE MODEL

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There is a relation[1-3] between decay widths of the $N^*(1238)$, $Y_1^*(1385)$, and $\Xi^*(1530)$ in the SU(3) model in which a symmetry-breaking interaction is taken into account. In this note, we present relations between these decay widths in the spin and unitary-spin independence model.[4-6]

Following our previous works,[7,8] we use the traceless tensors $M_\mu{}^\nu$ and the totally symmetric tensors $B^{\lambda\mu\nu}(\lambda, \mu, \nu = 1, 2 \cdots 6)$, for the field operators of the 35-plet meson and 56-plet baryon, respectively. It is possible to write the part of the S matrix for these processes invariantly by the introduction of spurions. The property of these spurions can be determined from the following consideration: As these resonances are of spin $\frac{3}{2}$ and parity +, the decays occur in P wave. From this and the conservation of isobaric spin and hypercharge, we find that the quantum numbers of the spurions should be $|I| = 0$, $Y = 0$, and $|S| = 1$. In the SU(3)$\otimes$SU(2) submultiplet of SU(6) these spurions can appear in the representation $(\underline{1}, \underline{3})$, $(\underline{8}, \underline{3})$, $(\underline{27}, \underline{3})$, etc. The $(\underline{1}, \underline{3})$-type spurion corresponds to the completely symmetric interaction in SU(3), and the $(\underline{8}, \underline{3})$ type to the symmetry-breaking interaction $T_3{}^3$ first introduced by Gell-Mann[9] and Okubo.[10]

Now we assume that the spurions have the same transformation properties as certain appropriate elements of the adjoint representation $(\underline{35})$ of SU(6). In that case, the $(\underline{1}, \underline{3})$-type spurion, Φ^1, has the same characteristics as the φ meson [SU(3) singlet particle] while the $(\underline{8}, \underline{3})$ type spurion, Φ^8, has those of the ω meson [a member of the SU(3) octet]. In other words, if we make a product of the tensors which represent these spurions with $\bar{M}_\nu{}^\mu$ which stands for the 35-plet meson operator, we have

$$\Phi_\mu{}^{1\nu} \bar{M}_\nu{}^\mu = \phi_1{}^1 \bar{\varphi}_1 + \phi_0{}^1 \bar{\varphi}_0 + \phi_{-1}{}^1 \bar{\varphi}_{-1}$$

and

$$\Phi_\mu{}^{8\nu} \bar{M}_\nu{}^\mu = \phi_1{}^8 \bar{\omega}_1 + \phi_0{}^8 \bar{\omega}_0 + \phi_{-1}{}^8 \bar{\omega}_{-1}, \tag{1}$$

where $\phi_i{}^1$ and $\phi_i{}^8$ represent the ith component of a vector in ordinary space.

The part of the S matrix which is relevant to the decay of these resonances in yielding a baryon and pion can be written in the form[11]

$$S = S^1 + S^8,$$

$$S^j = \Phi_\mu{}^{j\nu}[a^j \bar{M}_\alpha{}^\beta \bar{B}_{\nu\beta\gamma} B^{\mu\alpha\gamma} + b^j \bar{M}_\alpha{}^\mu \bar{B}_{\nu\beta\gamma} B^{\alpha\beta\gamma} + c^j \bar{M}_\nu{}^\alpha \bar{B}_{\alpha\beta\gamma} B^{\mu\beta\gamma} + d^j \bar{M}_\nu{}^\mu \bar{B}_{\alpha\beta\gamma} B^{\alpha\beta\gamma}] \tag{2}$$

$$(j = 1, 8)$$

in the first-order perturbation of the $(\underline{8}, \underline{3})$ interaction, where a^j, b^j, c^j, and d^j are invariant amplitudes. Calculating the matrix elements, we have the decay amplitudes in terms of a^j,