calculated collisional detachment coefficient at 230°K is 4×10^{-20} cm^3/sec compared to values of 10^{-17} cm^3/sec or greater used in the analysis of ionospheric data.[2] Preliminary measurements in dry air show that, as expected, nitrogen has very little effect on the collisional detachment rate. Therefore, if the negative ions formed in the ionosphere are O_2^-, then the detachment observed at night must be due to an excited species, such as vibrationally excited O_2 resulting from the recombination of oxygen molecules, electronic excitation, etc. In addition, if the O_2^- ions in the photodetachment experiments of Burch, Smith, and Branscomb[1] are assumed to be in the same vibrational state as those described above, then the radiative attachment coefficient for 230°K electrons in molecular oxygen will be increased from about 3×10^{-21} cm^3/sec to as much as 2×10^{-18} cm^3/sec.

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NEW ISOTOPE OF CARBON: C^{16}

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Estimates of the neutron binding energies of a number of neutron-rich light nuclei have been made recently by Zel'dovich.[1] In particular, from these estimates the $C^{14}(t,p)C^{16}$ reaction was expected to have a Q value lying between -3 and -4 Mev. This reaction has now been observed and the measured Q value is -3.014 ± 0.016 Mev. In addition, the decay of C^{16} has been studied and the measured half-life is 0.74 ± 0.03 second.

A 6-Mev triton beam from the Aldermaston electrostatic generator was used to bombard a thin C^{14} target and the emitted protons were analyzed with a broad-range magnetic spectrograph.[2] The targets were prepared by polymerizing acetylene gas containing 33% C^{14} directly onto nickel backing foils. Several exposures were made with the spectrograph using different magnetic field strengths and at angles ranging from 15° to 65°. On five of these an intense proton group was observed which could not be accounted for by the known target impurities. Further analysis established that this group varied in energy characteristically of a mass-14 target nucleus and probably corresponded to the formation of C^{16} in its ground state. The kinematics of the reaction, however, do not allow the $C^{14}(t,p)C^{16}$ reaction to be distinguished from either the $C^{14}(He^3,p)N^{16}$ or the $N^{14}(t,p)N^{16}$ reactions. The He^3 contamination of the ion beam was measured to be less than 0.1% by observing the elastically scattered particles and was therefore unlikely to give rise to significant reaction groups. It was also noted that, although several intense groups were observed arising from the $C^{12}(t,p)C^{14}$ reaction, none could be attributed to the $C^{12}(He^3,p)N^{14}$ reaction. To eliminate the possibility of the $N^{14}(t,p)N^{16}$ reaction, two exposures were made with a target containing nitrogen. No group was observed with the same energy as the group ascribed to C^{16}. Also no proton groups were observed corresponding to the known lower excited states of N^{16} in the spectra obtained with the C^{14} target, and only a weak continuum of protons was observed from a typical nickel target backing.

The energy of the incident triton beam was determined in terms of the Q value of the $C^{12}(t,p)C^{14}$ reaction[3] and from this the Q value of the $C^{14}(t,p)C^{16}$ reaction was calculated to be -3.014 ± 0.016 Mev. This is consistent with a C^{16} mass excess of 13.694 ± 0.017 Mev and a mass of 16.014702 ± 0.000017 mass units, both referred to the scale on which the mass excess of C^{12} is zero.

An energy level diagram showing the possible modes of decay of C^{16} is shown in Fig. 1.[4-6] As a change of parity is required for the high-energy beta transitions, the beta decay of C^{16} was expected to leave N^{16} in neutron-unstable 1+ states. This expected delayed-neutron emission has been observed experimentally and used to determine the half-life of C^{16}.

A one-microampere triton beam from the electrostatic generator was interrupted by a mechanical shutter some 20 feet away from the neutron detector which was a block of polystyrene, 45 cm long by 45 cm in diameter, containing five BF_3 counters. A hole of 10-cm diameter through the polystyrene block allowed the C^{16} nuclei to be formed at the center of the assembly. The efficiency of the detector was between 1 and 2%. The pulses from the neutron detector and associated electronic equipment were fed into a circuit which converted their time of arrival into a pulse height. The time distribution of the pulses could then be displayed on a 100-channel pulse-amplitude analyzer immediately after the interruption of the beam. The time scale of the analyzer was calibrated using the 50-cps mains frequency.

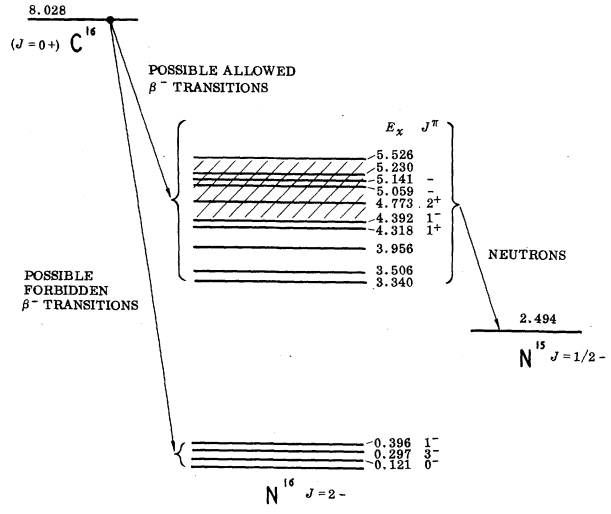

FIG. 1. An energy level diagram showing the possible modes of decay of C^{16}.

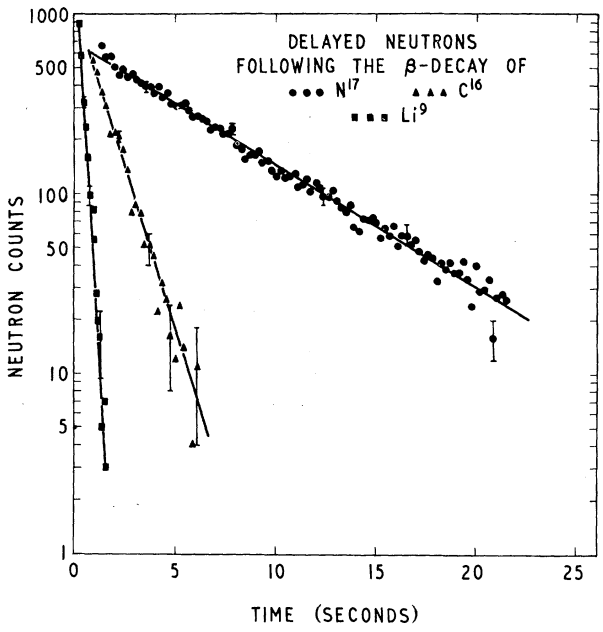

FIG. 2. A logarithmic plot of the decay of the delayed-neutron intensity from C^{16}. Also shown are the decay curves for the other two delayed-neutron emitters Li^9 and N^{17}.

Targets containing Li^7, C^{14}, and O^{18} were bombarded by the 6-Mev triton beam for periods between 2 and 10 seconds. The delayed neutrons from, respectively, Li^9, O^{16}, and N^{17} were displayed in the time-analyzer for periods ranging from 2 to 25 seconds. A fraction of a second delay between the end of each beam pulse and the start of the counting period was provided manually. No delayed neutrons were observed from the target backings though there was a very small background which was thought to arise from the triton beam striking the mechanical shutter. Figure 2 shows the decay of the delayed neutrons following the $Li^7(t,p)Li^9$, the $C^{14}(t,p)C^{16}$, and the $O^{18}(t,\alpha)N^{17}$ reactions. The half-lives of Li^9 and N^{17} were found to be 0.17 ± 0.01 and 4.20 ± 0.08 seconds, respectively, and these are in good agreement with the published values.[4] The half-life of C^{16} was found to be 0.74 ± 0.03 second.

The measured mass of C^{16} implies that the first $T = 2$ state in O^{16} is at approximately 23.0 Mev. In the future it would be interesting to determine the neutron-unstable states of N^{16} to which C^{16} decays and to determine the beta-ray branching ratio to the low-lying negative-parity states of N^{16}.

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MATRIX ELEMENTS IN THE FORBIDDEN BETA DECAY OF Ce^{141}

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We have performed measurements on oriented Ce^{141} in which the energy and angular distribution of the beta particles are determined with respect to the nuclear spin orientation. These measurements give information on the relative contribution of the various nuclear matrix elements contributing to the beta transitions.

The 33-day Ce^{141} undergoes beta decay to Pr^{141} via two beta groups according to the schemes

$$\tfrac{7}{2}- \xrightarrow{\beta_1} \tfrac{7}{2}+ \xrightarrow{\gamma} \tfrac{5}{2}+$$

and

$$\tfrac{7}{2}- \xrightarrow{\beta_2} \tfrac{5}{2}+.$$

The 70% abundant β_1 transition with a maximum energy of 435 kev and a $\Delta J=0$ will depend on all six first forbidden (real) matrix elements: $\mathfrak{M}(i\vec{\sigma}\cdot\vec{r})$, $\mathfrak{M}(\gamma_5)$, $\mathfrak{M}(i\vec{r})$, $\mathfrak{M}(\vec{\sigma}\times\vec{r})$, $\mathfrak{M}(\vec{\alpha})$, and $\mathfrak{M}(iB_{ij})$. The 30% abundant ground-state β_2 transition with a maximum energy of 580 kev and a $\Delta J=1$ will depend on only the last four matrix elements, i.e., those of tensor rank one and two.

The energy and angular distribution function, which has been calculated by Morita and Morita[1] and by Bincer,[2] has the form

$$W(\hat{p}\cdot\hat{J})=N_0(E)+N_1(E)\frac{p}{E}f_1P_1(\hat{p}\cdot\hat{J})+N_2(E)\frac{p^2}{E}f_2P_2(\hat{p}\cdot\hat{J})$$

$$+N_3(E)\frac{p^3}{E}f_3P_3(\hat{p}\cdot\hat{J}),$$

where $N_k(E)$ gives the energy dependence of the term of order k and contains products of the reduced matrix elements. The orientation parameter f_k describes the nuclear orientation, given in terms of an average over the population of the magnetic sublevels. The electron momentum and energy are p and E, respectively, and $P_k(\hat{p}\cdot\hat{J})$ is a Legendre polynomial. $N_0(E)$ gives the usual energy distribution for an unoriented beta emitter apart from the statistical factors.

The experimental apparatus and the procedure for the reduction of the data are similar to those used in earlier studies on the angular distribution of beta particles from oriented nuclei.[3] A single crystal of neodymium ethyl sulfate used for both cooling and orienting purposes is mounted with the c axis vertical in the demagnetization apparatus. On the uppermost surface of this crystal is grown a thin surface layer containing the Ce^{141} activity. Located about one centimeter above this is a thin anthracene scintillator which provides the input to a 100-channel pulse-height analyzer for the analysis of the beta spectra. Three 2-in. by 2-in. NaI gamma counters are located equatorially about 15 cm from the axis of the apparatus. These counters monitor the gamma-ray anisotropy which, combined with nuclear hyperfine splitting data for Ce^{141} neodymium ethyl sulfate, allows one to determine the nuclear orientation parameters f_k. The outputs of the gamma-ray counters are also compared for time coincidence with the output of the beta channel by