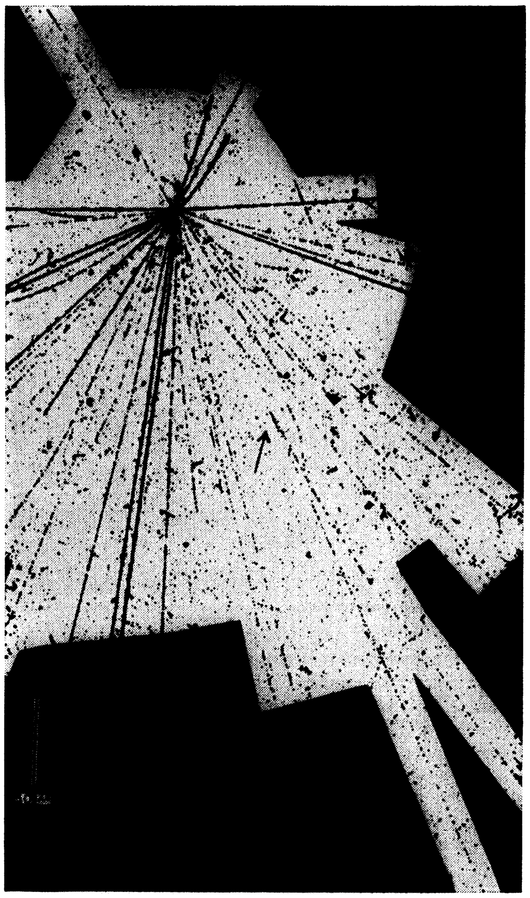

FIG. 1. Mosaic of photo-micrographs of 43-pronged star with wide angle shower. An electron pair probably associated with the star is indicated by the arrow.

scattering measurements, their energies being 65±10 and 8±2 Mev, giving 73±12 Mev as the energy of the initiating γ-ray. The direction of the more energetic electron, when projected back, passed within one or two microns of the star center, both in the horizontal and vertical planes.

Recent Berkeley experiments[3–5] have indicated the probable emission in high energy events of a neutral meson, decaying into two photons with a very short lifetime. Kaplon *et al.*[6] have described a large cosmic star with multiple pair production inside a narrow shower cone, suggesting an explanation in terms of the emission of neutral mesons, the lifetime being $\lesssim 10^{-13}$ sec.

While the present event does not in itself give direct evidence for a neutral meson, the pair is compatible with its being produced by a lower energy photon of a coincident photon pair from a neutral meson decaying somewhere in the shower cone, and within a few microns of the star center, i.e., within a time $\lesssim 10^{-14}$ sec., if we assumed a fairly low energy neutral meson ($E \sim$ a few times mc^2).

Assuming that approximately equal numbers of charged and neutral mesons are emitted in a shower,[6,7] that most of the charged shower particles are mesons, and that the neutral meson decays almost immediately into γ-rays with a radiation length in the emulsion, $\lambda = 2.9$ cm, the probability of an electron pair starting within 120μ of the star in Fig. 1 is ~ 0.12. This is much greater than the chance of a random pair pointing to the star center. In a systematic search of 1.6 cm² of emulsion in the center of the stack of plates, 41 random electron pairs were found projected mostly into the lower hemisphere, giving a probability ~ 0.005 of a pair starting in any 120μ sphere. If this contained a star then the chance of a random pair pointing to the star center would, of course, be much less.

The above density of random pairs would indicate about 12.5 neutral mesons/cm², assuming equilibrium inside the emulsion stack (15 vertical×7.5×5 cm), mostly glass ($\lambda \sim 12$ cm), and neglecting pair multiplication. The density of neutral mesons can also be estimated from the observed number of charged shower particles. A rough count of shower particles from stars[8] indicated about 6 charged mesons/cm² in the emulsion. The agreement between this value and that given above for neutral mesons would indicate that the numbers of neutral and charged mesons emitted in cosmic-ray stars are the same, at least in order of magnitude. Further data on random, and also on associated pairs should confirm this, and give more detailed information on the production of neutral mesons.

These emulsions were carried aloft through a collaborative program of cosmic-ray investigations by the Bartol Research Foundation, and the National Research Council of Canada, with the cooperation of the ONR project, "Skyhook."

1 We find them in emulsions both at airplane and balloon altitudes.
2 See mention of work of Bristol group in report on Edinburgh Conference, Nature **165**, 54 (1950).
3 Bjorklund, Crandall, Moyer, and York, Phys. Rev. **77**, 213 (1950).
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6 Kaplon, Peters, and Bradt, Phys. Rev. **76**, 1735 (1949). Bradt, Kaplon, and Peters, Helv. Phys. Acta **23**, 24 (1950).
7 Lewis, Oppenheimer, and Wouthuysen, Phys. Rev. **73**, 127 (1948) indicate approximately equal numbers of neutral and charged mesons for pseudoscalar theory.
8 Star density $\sim 6/\text{cm}^2$ on these plates, flown in high altitude balloon flights. About one-sixth had showers.

Magnetic Analysis of the $B^{10}(p,\alpha)Be^7$ Reaction*

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An excited level in Be^7 at 434±5 kev was first reported by Brown *et al.*[1] from the $B^{10}(p,\alpha)Be^7$ reaction. This level was soon confirmed by other investigators,[2–6] of whom only Grosskreutz and Mather[3] reported additional levels at 205±70 and 470±70 kev using the $Li^7(p,n)Be^7$ reaction.

The purpose of the investigation reported here was to search for alpha-groups from the reaction $B^{10}(p,\alpha)Be^{7*}$ corresponding to the 205- and 745-kev levels reported by Grosskreutz and Mather. The alpha-particles emitted at 90° to the incident beam were analyzed by a high resolution magnetic spectrometer employing 180-degree focusing and detected by means of nuclear track emulsions. The target used for most of the work was a layer of 96 percent enriched B^{10} evaporated onto a thin film of Formvar.

In the range of energies investigated, both alpha-particles and elastically scattered protons are found, the latter being considerably more intense. While both types of particles are recorded simultaneously on the plates, they are plotted separately in Fig. 1. As shown in the top curve at 1.790-Mev bombarding energy, two alpha-groups were found, corresponding to the ground state of Be^7 and an excited state at 431 kev. The regions A and B indicate where alpha-groups would be expected if levels existed in Be^7 at 205±70 and 745±70 kev. In the region B, no alpha-group was found with an intensity greater than one percent of the ground-state alpha-group. At this bombarding energy, it was not possible to count alpha-particles in the region A because of the intense groups of protons elastically scattered from C^{12} and O^{16}. The spectrum of elastically scattered protons at 1.790-Mev bombarding energy is shown in the middle curve of Fig. 1, the scale of ordinates being reduced by a factor of 100 compared to the scale for the top curve. Proton groups scattered from B^{10}, C^{12}, O^{16}, and Si^{28}

were identified, in addition to a group X, scattered from an unknown contaminant of high atomic number which amounted to less than one percent of the target material.

In order to look for an alpha-group corresponding to a level in Be^7 at 205 kev, the bombarding energy was decreased to 1.600 Mev, and the results are shown in the lowest curve of Fig. 1. At region A, corresponding to a level at 205 ± 70 kev, no alpha-group was detected with an intensity greater than 3 percent of the intensity of the ground-state alpha-group. The entire region B, corresponding to a 745-kev level in Be^7, was not surveyed because the target was destroyed before the completion of the results; however, in the region surveyed, no alpha-group was found of intensity greater than 2 percent of the ground-state alpha-group. The position of the elastically scattered proton groups is shown. No attempt was made at this lower bombarding voltage to detect the alpha-group corresponding to the 430-kev level because of the presence of protons elastically scattered from B^{10} and C^{12}.

Using fresh targets of B^{10} evaporated onto platinum, the Q-values of the two alpha-groups were determined to be 1.152 ± 0.004 and 0.721 ± 0.006 Mev, corresponding to the ground state of Be^7 and an excited state at 431 ± 5 kev. After a correction of 18 kev for surface contamination was added to the Q-values measured from the B^{10} Formvar target, these values agreed with those from the fresh targets. This correction was made by a comparison of the energies of the proton groups elastically scattered from B^{10} and C^{12}. The errors given on the Q-values do not include any estimate of the effect of surface contamination; however, it is

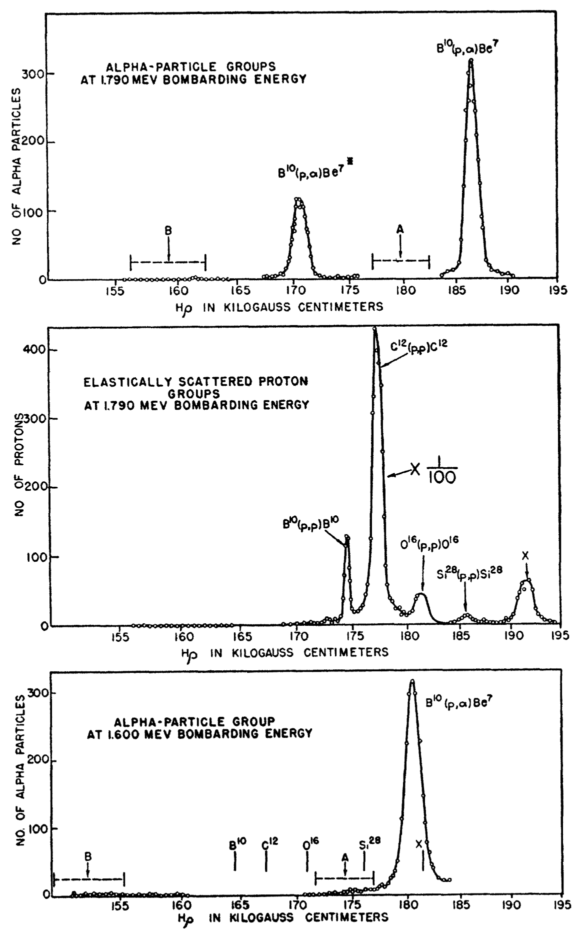

FIG. 1. Proton and alpha-particle groups from a thin target of enriched B^{10} on Formvar bombarded by protons.

believed that this is less than the stated errors. The results are in agreement with the Q-values reported by Brown *et al.*[1] of 1.148 ± 0.006 and 0.714 ± 0.008 Mev. The position of the excited state of Be^7 agrees with the two most accurate published values of[1] 435 ± 5 and[2] 429 ± 5 kev.

The observation of the proton group elastically scattered from the B^{10} on Formvar at 1.790-Mev bombarding energy permits the estimation of the relative yields of the $B^{10}(p,\alpha)Be^7$, $B^{10}(p,\alpha)Be^{7*}$, and $B^{10}(p,p)B^{10}$ groups which were in the ratio 1.0:0.4:10. Since the $B^{10}(p,p)B^{10}$ and $B^{10}(p,\alpha)Be^{7*}$ groups occurred at the same field setting, the relative intensity of these groups is considered to be the most accurate, reliable to 30 percent. In addition, if Rutherford scattering is assumed at 90 degrees for the 1.790-Mev protons from B^{10}, it is possible to estimate the absolute differential cross sections for the $B^{10}(p,\alpha)Be^7$, $B^{10}(p,\alpha)Be^{7*}$ alpha-groups to be 4.1 and 1.8 millibarns/atom/steradian. The accuracy of the differential cross sections calculated by this method cannot be stated since the validity of assuming Rutherford scattering is not known. This assumption leads to an estimate of 4 percent of Si^{28} in the enriched B^{10} material instead of less than 2 percent, as given by the Oak Ridge analysis. This indicates that the scattering of 1.790-Mev protons at 90 degrees from boron may be at least a factor of 2 lower than predicted by Rutherford scattering.

From these results, it may be concluded that there is no indication that levels in Be^7 at 205 and 745 kev are excited by the $B^{10}(p,\alpha)Be^7$ reaction at the bombarding energies used.

* This work was assisted by the joint program of the ONR and AEC.

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Radiations of Krypton^{85}

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A LONG-LIVED krypton activity was found among the products of uranium fission by Hoagland and Sugarman.[1] From aluminum absorption measurements they concluded that this krypton emitted beta-radiation with a maximum energy of 0.74 Mev and no gamma-radiation. Later Thode[2] using mass spectrometer measurements assigned this krypton to mass 85 and gave 9.4 yr. as the half-life.

In the course of work in which gaseous activities were separated by elution with helium from a charcoal column, gamma-radiation was found associated with the long-lived krypton activity after extensive purification. A more detailed study of the beta- and gamma-radiations of Kr^{85} was therefore made and is reported below.

In measurements of beta-spectra of gaseous activities a major problem is the source container which should have a low mass in order to reduce distortion of the spectra from absorbed and scattered radiation. In this work the gas was contained in a 6-mm diameter bulb with a thickness of 0.7 mg/cm² which was blown on the end of a quartz capillary tube 0.8 mm o.d. and 0.4 mm i.d. Experimental data obtained with gaseous activities contained in this bulb indicated that there was very little distortion of beta-spectra at energies above 150 kev.

The experimental beta-energy distribution of Kr^{85} obtained with a thin lens spectrometer is shown in Fig. 1 as a Kurie plot for an allowed transition. Because of the curvature shown in Fig. 1, the data have been replotted in Fig. 2 on the assumption that the transition is first forbidden with a spin change of two and a parity change. The fact that Fig. 2 is a straight line indicates the validity of the above assumption, which is consistent with the Mayer[3] theory of nuclear shell structure. Extrapolation of the