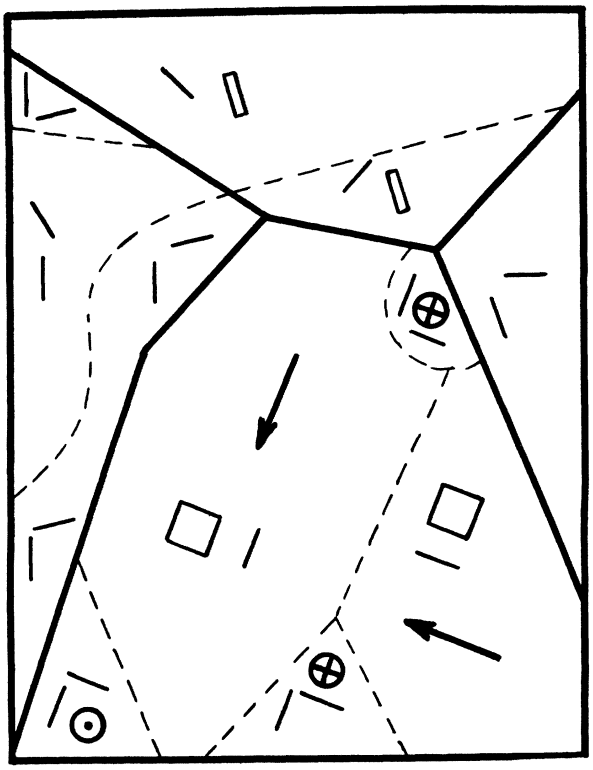

FIG. 3. Tracing of Fig. 2 showing crystal boundaries as heavy lines, approximate domain boundaries as broken lines, the traces of precipitate particles, and field direction in each domain of the largest crystal.

particles exhibited plates on (010) and (100) planes but none on (001) planes.[3] An elaboration of the author's theory that the magnetostriction energy of the matrix supplies part of the strain energy for nucleation of the favored orientations of the precipitate is included in the latter report.

Goldman and Smoluchowski[4] propose that the preferred orientations are those in which the direction of minimum strain energy due to magnetostriction is closely parallel to the field direction. From work on single crystals of Fe-Co alloys they show that the minimum magnetostriction in the precipitate would be expected to occur in ⟨100⟩ directions.

When an applied field is capable of influencing the precipitation process one would expect that the field due to spontaneous magnetization of the magnetic domains would promote a similar effect. The micrograph in Fig. 2 is presented as evidence for this effect. The micrograph is for Alnico 5 which had been oil quenched from the solution heat treating temperature and then aged for 300 hr at 800°C to grow the particles to a microscopically resolvable size. No external field had been applied during any part of the treatment. The micrograph shows that within each of the four crystals there are domains in which two of the three possible orientations of the precipitate predominate. The extent of the domains and the traces of the precipitate plates are sketched in Fig. 3. The direction of spontaneous magnetization in the domains can be determined by the criterion that the direction of the field must have been parallel to the two different orientations of precipitate plates. These directions have been designated in Fig. 3 for the largest crystal which has been sectioned with a (100) type plane approximately parallel to the plane of polish.

The non-uniform distribution of the precipitate in Fig. 2 is thus a manifestation of the magnetic domain structure of the matrix which has been revealed also by the usual powder technique.[5] In the presence of an applied field each crystal would be a single domain and those favored orientations of the precipitate would be nucleated throughout the crystal. In contrast to the macro-domain structure of the parent matrix, the micro-domain structure of the individual precipitate particles and the cooperative interaction between particles in the less ferromagnetic matrix are the more important considerations in producing the magnetic hardening. The increased residual induction provided by preferred nucleation most likely originates in the enhancement of particles in orientations of minimum demagnetization energy.

The main contribution of this note is the observation that the internal spontaneous fields in the domain structure of the matrix exert an important influence on the precipitation process in Alnico 5. Thus, the requirement of a high external field considered in theoretical treatments of the phenomenon is not necessary. The absence of preferential precipitation in Alnico 2 (Fig. 1) is in accordance with the observation that cooling in a magnetic field has little effect on the properties of this alloy. The author's theory would attribute the difference in behavior of these two alloys mainly to differences in the anisotropy of strain energy associated with the precipitation process as modified by matrix magnetostriction, whereas others[4] attribute it to differences in magnetic properties of the precipitate. Both alloys contain precipitate particles of a plate-like shape necessary for anisotropy of demagnetization energy; however, the spontaneous field in the Alnico 2 sample would be expected to be low, for the 800°C aging temperature is only 25° below the Curie temperature of Alnico 2 while 90° below that of Alnico 5. Metallographic studies of the effect of domain structure on the precipitation process at lower temperatures is now in progress, and they should provide additional information to permit further evaluation of the three theories.

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Gamma-Alpha-Reaction in Rb^{87}

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USING 100-Mev betatron x-rays, Baldwin and Klaiber[1] have obtained multiple photo-nuclear disintegrations in which alpha-particles were observed in cloud-chamber photographs to be ejected from nuclei. Gaerttner and Yeater[2] have also observed disintegrations in N and O which they believe may be due to (γ, α) reactions. To date the most extensive examination of (γ, α) processes has been carried out by the use of photographic emulsion techniques.[3–5] This letter describes a study of the (γ, α) processes by an entirely different method; namely, by the study of the activity in an unstable product nuclide.

Samples of $RbNO_3$ of 10 g were irradiated in the University of Saskatchewan betatron at peak energies ranging from 15 to 27.4 Mev. The samples were placed very close to the donut target for high dosage rates. Irradiation times ranged from a few minutes to several hours. Tantalum strips were used to monitor the dosage rate. The reaction $Ta^{181}(\gamma, n)Ta^{180}$ gives a pure 8.2-hr activity which has a low threshold and whose activation curve has been measured carefully in this laboratory.[6] After irradiation the active Br was extracted from $RbNO_3$ by precipitation with $AgNO_3$, and the resulting activity counted in standard geometry. For irradiation energies up to 27 Mev a pure 140-min activity, arising from Br^{83}, was observed. After appropriate corrections for geometry, self-absorption, back-scattering, etc., the activation curve of Fig. 1 was obtained. This shows the number of active atoms formed per minute per $100r$ per minute per Rb^{87} atom bombarded, as a function of maximum betatron energy. Here 100 percent efficiency of chemical separation has been assumed.

Analysis of the activation curve by a method described pre-

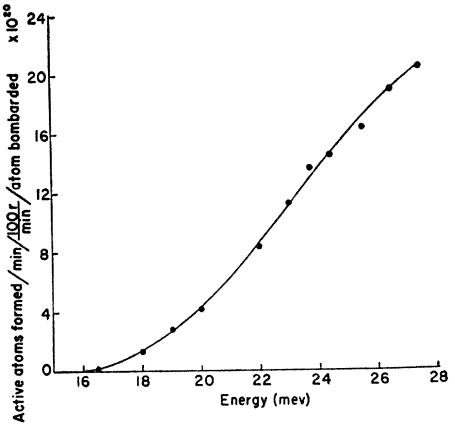

FIG. 1. Activation curve, $Rb^{87}(\gamma, \alpha)Br^{83}$.

viously[6] yields the cross-section curve reproduced in Fig. 2. This curve has a maximum at 22.5 Mev, a half-width of 6.6 Mev, and the integrated cross section is 4×10^{-4} Mev-barn. Presumably the reason that the cross section starts at a finite value is that a threshold has been assumed which is actually too high and consequently, near the threshold, activity which is actually due to photons of lower energy has been credited to photons of energy in the immediate vicinity of the apparent threshold. The observed threshold (16 Mev) may be considerably higher than the actual threshold. The experimental point at 16.5 Mev corresponds to a measured activity of only 1.5 counts/min above background of 32 counts/min over a two-hour counting period. The length of irradiation was 1.5 hr. To obtain points at lower betatron energies would have necessitated much longer irradiations than were thought feasible. The binding energy of the alpha-particle in Rb^{87} calculated from the Feenberg formula[7] in the form given by Stern[8] (with the obvious corrections) is only 5.3 Mev. The discrepancy between this value and the observed value is very large but it may be explained partially by the barrier effect. It should be expected that in order to compete with de-excitation by gamma-emission the half-life for alpha-emission must be of the order of 10^{-13} sec at the most. According to calculations based on the simple one-body theory of Bethe[9] the half-life for alpha-emission from Rb^{87} as a function of alpha-energy is as follows:

α-particle energy (Mev)	4	5	6	8
Half-life (sec)	3.8×10^{-10}	4.8×10^{-13}	2.8×10^{-15}	4.3×10^{-18}

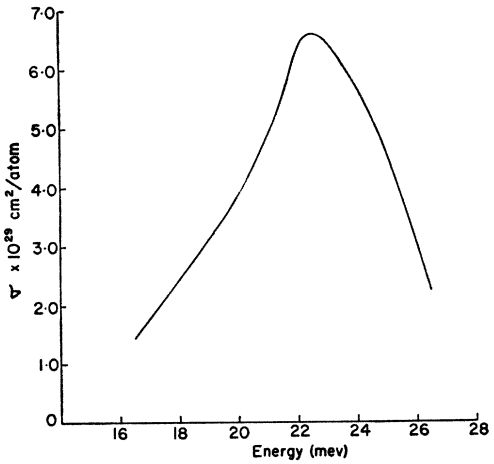

FIG. 2. Cross-section curve for the reaction $Rb^{87}(\gamma, \alpha)Br^{83}$.

It follows on this picture that a threshold energy of the order of 10 rather than 5 Mev would be expected. This is still considerably lower than the observed value. Further, the observation by Cameron and Millar[10] of α-particles ejected by γ-rays from Ag or Br, having an energy distribution which exhibits a peak at about 4 Mev, casts doubt on this simple interpretation.

The falling-off in cross section following the peak may be due to the influence of competing reactions. However, it should be noted that cross-section curves for (γ, n) reactions observed in this laboratory exhibit a similar course. In this case, however, an explanation in terms of competing reactions does not seem feasible and thus some other explanation must be sought.

The observed activity might be due to the reaction $Rb^{85}(\gamma, 2p)Br^{83}$. This is thought to be unlikely for several reasons. The calculated threshold energy (apart from the barrier effect) is 17.7 Mev which is 12.4 Mev higher than the calculated alpha-particle binding energy. Further, it seems unlikely that the $(\gamma, 2p)$ reaction would occur to any appreciable extent for energies near the threshold, since the first proton emitted might be expected, for a large percentage of potential $(\gamma, 2p)$ occurrences to have more than one-half the available energy and thus the second proton not enough energy to escape. An attempt was made to detect the corresponding reaction in the neighboring isotope, $Rb^{87}(\gamma, 2p)Br^{85}$. Evidence of a possible 3-min Br^{85} activity after a rapid chemical separation was obtained first at 27.4 Mev. Thus it seems unlikely that Br^{83} would be produced by a $(\gamma, 2p)$ reaction in Rb^{85} with a threshold at 16 Mev.

Work on (γ, α) reactions leading to unstable product nuclides is continuing.

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The First Excited State of Be^7 from the $Li^7(p, n)Be^7$ Reaction*

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THE existence of an excited state in Be^7 at about 430 kev has been confirmed by several methods: (a) the reaction[1-3] $B^{10}(p, \alpha)Be^7$, (b) the reaction[1] $Li^6(d, n)Be^7$, (c) scattering of neutrons from a $Li^7(p, n)Be^7$ source[4] by He, (d) photographic plate analysis of recoil protons from a $Li^7(p, n)Be^7$ neutron source.[5-8] Of these methods, (a) and (b) are the most accurate, the results[1] being 429 ± 5 kev from γ-ray measurements, and from magnetic analysis of α-particles,[2,3] 434 ± 5 and 431 ± 5 kev. Method (d) has shown the presence of a low energy neutron group with about ten percent of the total neutron intensity at bombarding energies $E_p = 2.7$ to 4.0 Mev (well above the expected threshold for the second group at 2.38 Mev).

With a thin target and a neutron counter subtending a small angle on the beam axis, the yield curve just above threshold shows a "geometrical peak"[9] due to forward concentration of neutrons in the laboratory reference frame. By taking advantage also of the greater sensitivity of a bare BF_3 counter for the low energy second group neutrons, it should be possible to detect the group at its threshold unless its relative intensity is very small. We are not aware that this has been done previously.[10]