Experiments with $n\gg 1$ have the advantage[2] that then the circumstances can sometimes be such that the Coulomb barrier prevents appreciable overlap of the nuclei and all departures from the Rutherford scattering law must be attributed to the distortion of the deuteron by the electric field in scattering. On the other hand, under the conditions of the French and Goldberger[1] theory, the calculated departure from Rutherford scattering due to the deuteron structure occurs along with a large and unknown departure due to nuclear forces; the separation of the two effects experimentally would be very difficult. The importance of direct nuclear interaction is apparent from the fact that in their example of 14-Mev deuterons on aluminum the classical distance of closest approach of these nuclei considered as point charges is 1.34×10^{-13} cm which is much less than the radius of either the deuterium or the aluminum nucleus, so that large effects from nuclear forces should occur.

We have calculated the polarizability of the deuteron quantum mechanically, and we have interpreted the polarizability scattering by a classical approximation. The validity of the calculations are limited by the assumptions that the Coulomb field is adiabatically applied and that $n\gg 1$. In so far as these assumptions hold for the scattering of 8-Mev deuterons on bismuth, we find approximately a 3 percent departure from Rutherford scattering in the backward direction.

* This work was partially supported by the joint program of the U. S. Office of Naval Research and the U. S. Atomic Energy Commission.
[1] J. B. French and M. L. Goldberger, Phys. Rev. **87**, 899 (1952).
[2] N. F. Ramsey, Phys. Rev. **83**, 659 (1951).

Search for "*T*-Tracks" in Photographic Plates

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BLAU and Salant[1] have reported evidence for a type of event observed in photographic plates, which they called a *T*-track and tentatively interpreted as the break-up of a heavy particle at, or near, the end of its range into two fast, singly charged particles. Their evidence is based on the fact that *T*-tracks appeared to be more frequent than could be explained by the chance passing of a light track by the end of a black track.

In the last month we have scanned 112 cm² of 400 μ G-5 emulsion that was exposed vertically for about 10 hours at 90 000 ft and geomagnetic latitude of 41°N.

To find *T*-tracks, all stars with three or more prongs and with at least one prong longer than 100 μ were analyzed, and all the prongs ending in the emulsion were examined for minimum ionizing tracks passing at distances up to 5 μ. The minimum ionizing tracks were required not to scatter appreciably within 500 μ; this condition eliminates electrons of energy smaller than about 20 Mev.

A total number of 2191 stars were found, with 4246 prongs ending in the emulsion; of these, 335 had minimum ionizing tracks within 5 μ, subdivided as shown in Table I.

To determine the expected number of chance coincidences between the endings of the heavy tracks and tracks of minimum ionization, we have measured the number of minimum ionizing tracks crossing unit surfaces of developed emulsion, N_v in the vertical planes and N_h in the horizontal planes containing the shrunken coordinate.

It was found that $N_h\simeq N_v=1.0\times 10^{-3}\mu^{-2}$, which indicates an isotropic distribution of the minimum ionizing tracks. It follows that the expected number of chance *T*-tracks within a distance r is

$$n_{\text{ch}}=2\pi\times 0.86\times N_h\times r^2\times \text{No. of track endings observed.}$$

The factor 0.86 arises from taking into account that the emulsion has shrunk, after development, by a factor of about 2.5, so the sphere of developed emulsion was originally a prolate ellipsoid.

The estimated backgrounds are given in the lowest row of Table I. It seems that the observed number of *T*-tracks within 1 μ is well accounted for by chance coincidences.

TABLE I. Observed and expected track distributions.

Distances within which the minimum ionizing particles were found, in μ	0–1	1–2	2–3	3–4	4–5
No. of observed cases	19	47	86	87	96
Expected chance coincidences	22	66	110	156	198

The fact that the number of expected chance coincidences is higher than the observed coincidences at the larger distances is thought to be the result of a decrease in the efficiency of the scanner when looking at regions not very close to the end of the heavy track.

We did not try to subdivide further the 19 cases classified within 1 μ, as we felt very uncertain in determining the distances when they were smaller than this limit. One reason for this is that many of the minimum ionizing tracks are steep, and the distance from the end of the heavy track can be estimated by utilizing only a few of their grains. These are not enough to determine the trajectory of the fast particle within much less than 1 μ, as the grains may be displaced from the true trajectory by distances of the order of the dimension of a grain, i.e., by several tenths of a micron. Another reason is that it is often difficult to tell whether a grain is the last grain of the heavy track or a grain belonging to the light track. Finally, depths of field much less than the wavelength of the light (0.5 μ) cannot be realized, and this puts a limit on the precision of the depth measurements.

If we try to select among the 19 close cases the one which appear as "perfect *T*-tracks," three give unmeasurable distances. The value of r which corresponds to three chance coincidences is 0.37 μ, in reasonable agreement with the resolving power of the microscope.

We are thus led to the conclusion that, in order to explain the occurrence of the *T*-tracks observed in our plates, it is not necesto postulate the existence of any special particle.[2]

We wish to thank the Aero-Medical Field Laboratory, Holloman Air Force Base, New Mexico, for conducting the balloon flight and J. de Vesty, C. Lipetz, S. Perry, and C. Sienko for helping us scan the plates.

* H.T.I. Fellow.
[1] M. Blau and E. O. Salant, Phys. Rev. **88**, 945 (1952); we are grateful to Dr. Blau and Dr. Salant for communicating to us their results before publication.
[2] In a private communication, Dr. Salant has stated to us that the number of *T*-tracks they observe within 1 μ is four times the calculated random background. Since in our plates the background of light particles is larger by about a factor four than that quoted by Blau and Salant, the detection of *T*-particles would be more difficult in our case.

The Lattice Expansion of Quartz Due to Fast Neutron Bombardment

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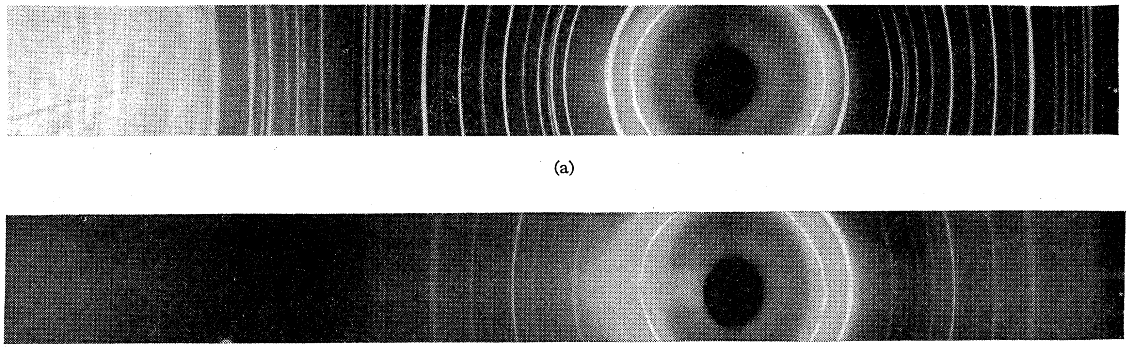
THE progressive anisotropic expansion of α-quartz irradiated with increasing dosages of fast neutron flux has been observed and measured by x-ray and density methods of analysis. Bombardment produced by a neutron source that gave a total integrated neutron flux of 6.6×10^{19} *nvt* resulted in a density change of $(\Delta\rho/\rho)\times 100=3.5\pm 0.1$ as measured by the hydrostatic weighing method. The density change measured by the x-ray method gave $(\Delta\rho/\rho)\times 100=4.8\pm 1.5$. The crystal temperature was approximately 100°C during irradiation.

X-ray diffraction data taken from Debye-Scherrer, Laue, and precession photographs show that the expanded lattice belongs to the trigonal system. In addition, it appears likely that this lattice has the same space group, D_3^4 or D_3^6, as the nonirradiated crystal. The expanded lattice constants are $a_0=5.01\pm 0.01$A and $c_0=5.41\pm 0.02$A, as compared with the nonirradiated quartz $a_0=4.903$A and $c_0=5.393$A.

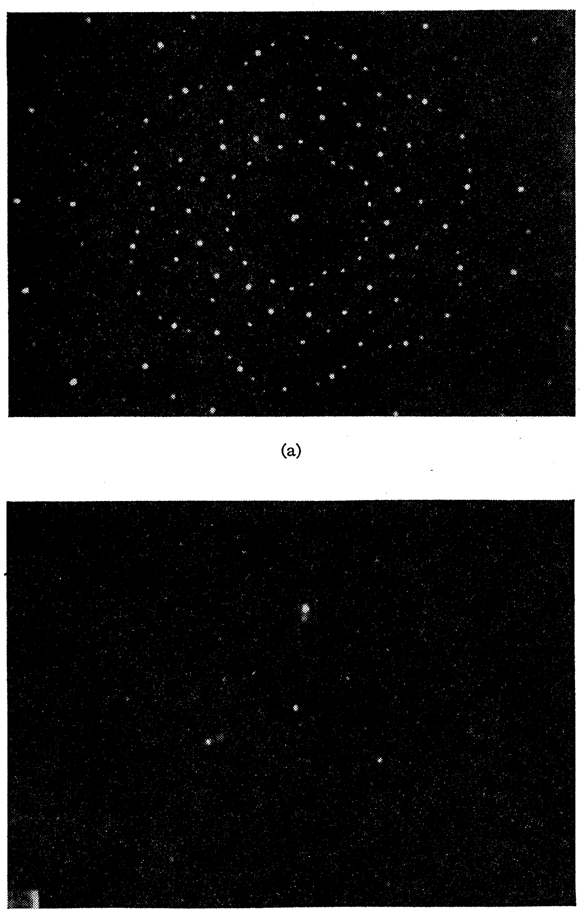


(a)

(b)

FIG. 1. Debye-Scherrer diffraction patterns of α-quartz (a) before irradiation; (b) after irradiation.

The strain imposed on the lattice by this expansion is evidenced in the back-reflection region of the Debye-Scherrer diffraction pattern (Fig. 1b). All reflections at $2\theta > 90°$ have been "smeared out" so that they are indistinguishable above background level. The inaccuracies in determining precise lattice constants and x-ray densities are due to the absence of these reflections at large Bragg angles.



(a)

(b)

FIG. 2. Laue transmission photographs of α-quartz parallel to Z (a) before irradiation; (b) after irradiation.

The pseudo-hexagonal symmetry inherent in the Laue pattern of Z-cut quartz (Fig. 2a) is barely visible in the same pattern (Fig. 2b) of the irradiated crystal which shows its true trigonal symmetry. In addition, the apparent absence of many reflections in this latter pattern also indicates strain in the expanded lattice.

The thermal stability of this expanded lattice is of considerable magnitude. Annealing at 485°C for two hours produced no detectable relief from lattice strain, and no lattice contraction. Four hours of annealing at 650°C produced no lattice contraction, but the (33.1) and (23.4) reflections reappeared as broad, very weak peaks in the back-reflection diffraction pattern. The interest here lies in the fact that this annealing temperature is 77°C higher than the normal inversion temperature of $\alpha \rightarrow \beta$ quartz. Heating at 900°C for twelve hours relieved the lattice strain completely and contracted the lattice to normal parameters.

A model of the packing of atoms in α-quartz indicates that the largest interstitial spaces in the lattice form long irregular channels parallel to the principal axis. It seems likely that these sites are the most probable positions in which the dislocated atoms could be trapped. On the basis of this premise, the anisotropic expansion in the a direction is explained.

The writer is indebted to F. A. Sherrill, B. S. Borie, Jr., and G. E. Klein for valuable assistance during the course of the investigation.

The Thermal Neutron Absorption Cross Section of Scandium

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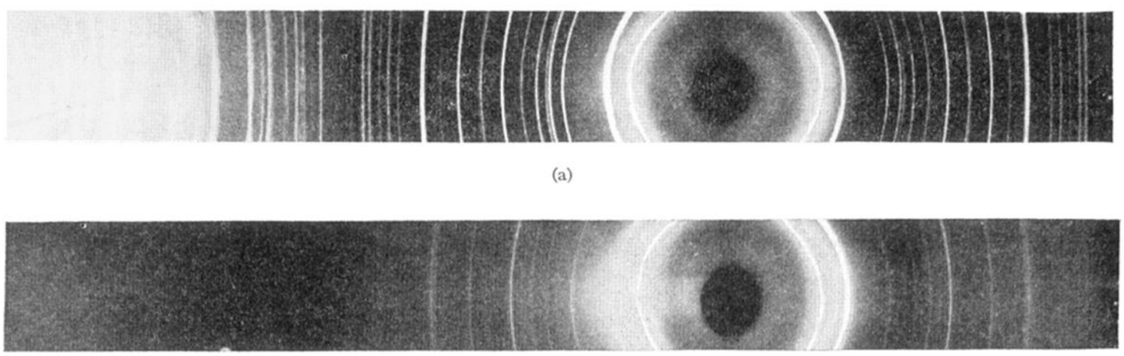
WE have made a measurement of the thermal neutron absorption cross section of scandium in an attempt to resolve the inconsistencies in the published literature on the cross section of this element.

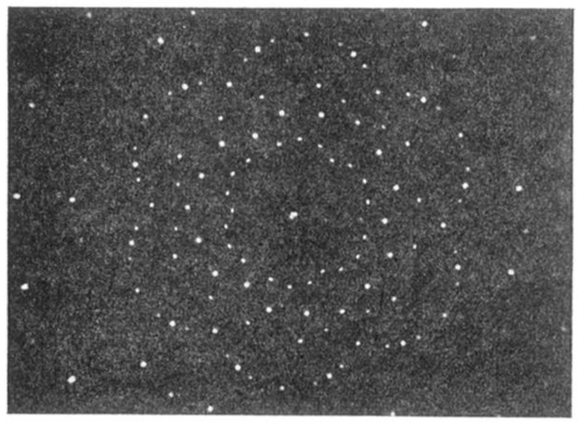
The thermal neutron cross section is quoted by Pomerance[1] as 11.8 barns, and the pile neutron cross section by Harris *et al.*[2] as 31.8 barns. Sc^{45} is 100 percent abundant in natural scandium, and neutron capture in it leads to 85-day Sc^{46}, partly directly, and partly via a 20-second isomer of Sc^{46}.[3] The pile activation cross section for the production of 85-day Sc^{46} is, therefore, also the pile absorption cross section of scandium. Seren, Friedlander, and Turkel[4] have measured this activation cross section as 22 barns ($\pm$20 percent).



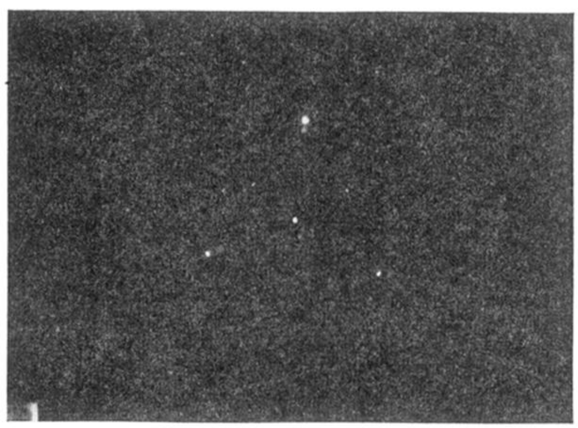
(a)

(b)

Fig. 1. Debye-Scherrer diffraction patterns of α-quartz (a) before irradiation; (b) after irradiation.



(a)



(b)

FIG. 2. Laue transmission photographs of α-quartz parallel to Z (a) before irradiation; (b) after irradiation.