

Experiments with $n \gg 1$ have the advantage² 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 Goldberger¹ 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.

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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 Salant¹ 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 $N_h \approx N_v = 1.0 \times 10^{-3} \mu^{-2}$, 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

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

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 necessary to postulate the existence of any special particle.²

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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} *not* 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 $a_0 = 5.01 \pm 0.01$ Å and $c_0 = 5.41 \pm 0.02$ Å, as compared with the nonirradiated quartz $a_0 = 4.903$ Å and $c_0 = 5.393$ Å.