mechanism for the observed bend is clear. Assuming the nucleus to be a heavy one, like silver or bromine, one finds that a proton of 10 MeV. kinetic energy moving in a suitable direction in the nucleus could absorb the required amount of energy and momentum to explain the observed tracks. The extra energy acquired by the proton would be immediately divided among the other particles in the nucleus. If the track be due to a π -meson with a mass of 300 m , then a corresponding calculation shows that the track can also not be explained by an elastic collision. In this case the recoiling nucleus would be excited to the extent of about 2.7 MeV.

There is, however, another possible explanation of the track which we have to consider, namely, that at the point b a heavy particle decays *while in motion* into a lighter one, with the emission of a neutral particle, as, for example, a π -meson decaying into a μ -meson. Assuming different values for the mass m_l of the light meson and mass m_h of the heavy meson, the mass m_n of the neutral particle can be calculated. The result is shown in Table 2.

TABLE 2

m_h	m_h/m_l	m_h	m_n/m
170	1.5	255	79.5 ± 14.7
170	1.7	289	114.8 ± 21.2
200	1.5	300	93.6 ± 17.3
200	1.7	340	135.0 ± 24.9
300	1.5	450	140.4 ± 22.4
300	1.7	510	202.5 ± 32.4
300	3.33	1000	695.5 ± 111.2

Thus assuming the mass of the light meson to be 170 m and the ratio of the masses of the heavy and light mesons to be 1.7, as in the case of the π - and μ -mesons of Lattes, Powell and Occhialini¹, we find the mass of the neutral particle to be 0.68 ± 0.08 times that of the μ -meson, giving it a mass of $115 \pm 21 m$. Although this agrees within the limits of error with the mass of the neutral particle required by these authors, our calculated energy release would be 2.5 MeV., whereas they find an energy release of about 10 MeV. We are therefore inclined to believe that if our track is to be explained as a decay process at all, it would have to be the decay of a heavier particle into a π -meson. The only evidence for preferring such an interpretation to that of simple inelastic scattering is that the part of the track after the bend b shows noticeably greater scattering than before the bend. Some support for this visual impression can be obtained by a more quantitative measurement of the scattering along the track. The mean square of the scattering angle $\bar{\theta}^2$ in a length l of track varies inversely as the square of the kinetic energy E . Thus $E^2\bar{\theta}^2$ should depend only on the properties of the material for a particle of given mass. We have worked out the mean value of $E^2\bar{\theta}^2$ for eight intervals of length 15μ each before the bend, and twenty similar intervals after the bend, and obtained 9.2 and 2.5 respectively in arbitrary units, assuming the mass of the particle to be 300 m throughout. On the other hand, if the mass of the particle before the bend were twice that after the bend, the values of $E^2\bar{\theta}^2$ would become more equal. This argument has, of course, to be taken with extreme caution, since the statistics are small and the fluctuations large. If the track observed by us is really to be interpreted as the decay of a heavier particle into a π -meson, then it cannot be identified with the process suggested by Rochester and Butler², as

the last line of Table 2 shows. The mass of the neutral particle would have to be quite different.

We may summarize the above discussion by saying that the track reported by us is due to the scattering of a meson by a nucleus in which the nucleus is not disrupted but simply excited. Although we should expect such a process to occur, this is the first time that experimental evidence appears to have been obtained showing it.

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¹ Lattes, Powell and Occhialini, *Nature*, **160**, 453 and 486 (1947).

² Rochester and Butler, *Nature*, **160**, 856 (1947).

Investigation of the Radioactivity of Rocks by the Photographic Method

MADAME IRENE CURIE has pointed out¹ the feasibility of estimating the total uranium and thorium content of rocks by using the photographic method. H. Yagoda and N. Kaplan have more recently employed the method for determining the disintegration constant of U^{238} , getting values in concordance with previous results². We have now tried the method on various rock specimens and the results obtained have been definitely encouraging. The method employed is to place an Ilford Nuclear Research plate at a distance of about 0.1 mm. from a flat surface of the specimen cut with a diamond saw, and expose it for one to three weeks, depending on the probable activity of the specimen. In more recent experiments the plate has been placed in contact with the cut surface, as this makes easier the identification of α -ray tracks, which all originate from one nucleus. Theoretically, from the frequencies of two-, three-, four- and five-ray stars, it should be possible to estimate the separate amounts of uranium and thorium present. Enough data have not yet been obtained to determine whether this method will prove possible.

As might be expected, the plates show that the distribution of the radioactive elements in rocks is sporadic. This specially applies to coarse-grained rocks such as granites: Fig. 1 is a photomicrograph of a very active spot obtained from a Finnish granite. More than two hundred tracks can be counted in the area shown, an area of about 7×10^{-4} cm.².

The average number of tracks for the same area taken over a gross area of 0.1 cm.² was only about five. It will be seen that the tracks show a very definite tendency to be radial, and that the tracks increase in apparent length as they recede from the centre. The plate was separated from the rock surface by an air space of about 0.1 mm., so both observations agree with the view that the radioactive source is concentrated in a small volume of rock nearly opposite the centre of the photograph. This would agree with the usual hypothesis of the method of formation of pleochroic halos. The fact that for some rocks such large local concentration of activity occurs renders the quantitative estimation of the average radioactivity of these rocks more laborious.

100 μ
Fig. 1

It must be remembered that some of the α -tracks observed may be due to radioactive elements present either in the glass of the plate or possibly even the emulsion. This question has been investigated by developing some of the plates without exposure to any rock, and as might be expected, a fair number of tracks, most of which originate in the glass, were found. Two-, three-, four- and one five-ray star were observed: Fig. 2 is a photomicrograph of a four-rayed star which apparently actually originates in the emulsion, but such stars are rare. A rough estimate gives the number of these tracks as about 0.1 track per cm.² per hour. Fortunately, as the great majority of these tracks originate in the glass, it is fairly easy to distinguish them from the α -tracks from the rock. Alternatively, the tracks on a part of the plate which has not been exposed to the rock can be counted, and the necessary correction applied to the figure obtained for the portion exposed to the rock.

The presence of these α -ray stars in our plates would seem to cast some doubt on H. E. Huntley's hypothesis that similar stars observed in plates exposed at 11,000 ft. are due to cosmic rays³. Our plates have been kept at sea-level, and hence their exposure to cosmic rays has been small. To date, only one undoubted cosmic ray disintegration of an atom has been found, and yet the frequency of the stars observed is at least as high as that found in Huntley's plates. It would, as a matter of fact, be surprising if the glass of the plates were so free from radioactive materials that the small number of stars observed was not present. Probably the main source of the radioactive elements is the optical sand used in the manufacture of the glass, and it would not be

100 μ
Fig. 2

expected that the radioactive elements present in the sand would be nearly totally eliminated during the process of manufacture.

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¹Joliot-Curie, I., *J. Phys. et le Rad.*, 7, 313 (Nov. 1946).

²Yagoda, H., and Kaplan, N., *Phys. Rev.*, 72, 356 (1947).

³Huntley, H. E., *Nature*, 161, 356 (1948).

Lightning Arrester Discharge Currents

DURING the last five years an investigation has been made of the discharge currents of a number of 38,000-volt lightning arresters. The transmission system on which these arresters were installed is operated with its neutral point earthed through Peterson coils; the lines are not equipped with overhead ground wires. The earth lead of each single-phase arrester was equipped with a pair of magnetic links. In addition, paper-puncturing recorders were used to indicate when arresters had operated.

Among the results obtained last season were two of particular interest. The pairs of links involved were evaluated by the new step-method put forward by Prof. H. Norinder¹. From the results it was apparent that the links had not been magnetized by a unidirectional current discharge. Reversals of direction of current flow were clearly indicated and could be evaluated. The magnitudes of the discharges were also evaluated by the older method² of comparing the relative magnetizations of the inner and outer links, assuming the presence of a single reversal. The values obtained were as follows:

Result No.	Norinder method		Value derived from relative magnetization of inner and outer links (amp.)
	Inner link evaluation (amp.)	Outer link evaluation (amp.)	
36 S	+1150, -390, +80	+1130, -370	+1220, -400
36 T	+1570, -250, +530	+1650, * - ?	+1590, -210

* Further evaluation of this link spoiled by a laboratory accident.

The characteristic curve obtained for the inner link of result No. 36 T is shown in the accompanying graph.