Calculations are being carried out for high energy proton-proton scattering and will be published elsewhere.

[1] J. Leite Lopes, Phys. Rev. **70**, 5 (1946).
[2] G. Wentzel, Helv. Phys. Acta **18**, 430 (1945).
[3] F. Villars, Helv. Phys. Acta **19**, 323 (1946).
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[6] L. Hulthén, Arkiv. Mat. Astr. Fysik **31A** [15] (1944).

Quantitative Alpha-Particle Counting by the Emulsion Technique

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EXPERIMENTS with weighed thin films of radiochemically pure U_3O_8 exposed to fine grained emulsions[1] show that the rate of disintegration δ can be computed accurately by microscopic evaluation of the number of alpha-particle tracks n_r recorded by the emulsion. For films having an equivalent air thickness τ emitting alpha-particles of average range $\bar{R}$;

$$\delta = 2n_r/[1-(\tau+2l)/2(\bar{R}-e)] = n_r k_w.$$

When the distance between the source and the emulsion l is less than 0.05 cm, about 98 percent of the tracks are confined to an area on the emulsion equal to that of the source, and n_r can be evaluated by counting tracks in sampled portions of this area with a precision of 2 percent. At magnifications exceeding 500×, employing dark field illumination, the tracks of alpha-particles striking the emulsion at normal incidence are readily discernible from the background fog (Fig. 1). Measurements with a collimated source of polonium alpha-particles reveal that the minimum residual air range e recorded in the emulsion as a distinct track is 0.84 air cm. The equivalent air thickness of the source τ is computed from its atomic composition with the aid of the Bragg-Kleeman stopping power law. For films of U_3O_8, $\tau = 0.2288w$, where w is the film thickness in mg per sq. cm. The track-disintegration conversion factor

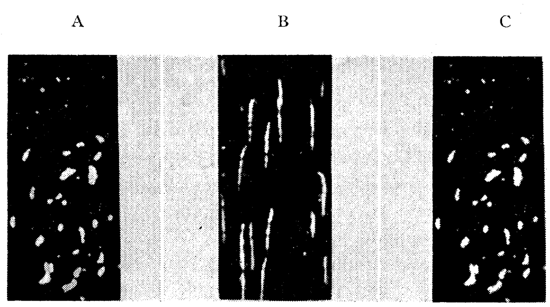

FIG. 1. Dark-field photomicrographs (44× obj.+15× ocular) of tracks from collimated monoenergetic alpha-particles (RaF) at varying obliquities.
A: Perpendicular Incidence. Geometric considerations indicate that these tracks should be dimensionless. After fixation the residual gelatin dries to a very thin layer and the vertical tracks may be tilted slightly. Their visibility is also enhanced by the light scattered from the compressed column of silver grains.
B: 45° Incidence. Using sources weighing less than 1 mg./sq. cm., over 90 percent of the tracks have obliquities typical of visibility class *B*.
C: Oblique tracks of minimum discernibility (e = 0.84 air cm.) produced by alpha particles which spent 80 percent of their energy in traversing the source and air gap.

TABLE I. Rate of disintegration in U_3O_8 films.*

Film	w	k_w	Track count	δ per g of U per sec.
A	0.61	2.12	6604	2.51×10^4
B	0.75	2.14	11,600	2.48
C	1.43	2.23	13,500	2.37
D	2.32	2.36	13,874	2.34
			average:	$2.43\pm.07\times10^4$
Comparative determinations:				
Geiger and Rutherford,** from scintillations				2.37×10^4
Kovarik and Adams,*** alpha-pulses				2.48
Schiedt,† alpha-pulses				2.53
Kovarik and Adams,†† alpha-pulses				2.50

* The U_3O_8 was isolated and purified from a sample of Great Bear Lake pitchblende containing 51.0 percent U, 0.005 percent Th and 10.1 percent Pb. The Pb/U ratio of 0.198 indicates that the specimen (U. S. Nat. Mus. R6736) is probably of the same age (1.3×10^9 yr) as found in the investigations of Marble[5] and Nier.[3] The measurements of Rutherford and Kovarik were made on uranium oxide isolated by Boltwood from Norwegian uraninite of similar geologic age,[3] 1.1×10^9 yr.
** H. Geiger and E. Rutherford, Phil. Mag. (6) **20**, 691 (1910).
*** A. F. Kovarik and N. I. Adams, Jr., Phys. Rev. **40**, 718 (1932).
† R. Schiedt, Sitz. Akad. Wiss. Wien, Math.-naturw. Kl. Abt IIa **144**, 175–211 (1935).
†† A. F. Kovarik and N. I. Adams, Jr., J. App. Phys. **12**, 296 (1941).

k_w was evaluated for an air gap of 0.05 cm, using 2.93 cm for $\bar{R}$ (the weighted average of the mean ranges of the alpha-particles emitted by U*I*, U*II* and AcU based on the measurements of Rayton and Wilkins[2] and the activity ratios of Nier).[3]

Preliminary results on sources of varying thickness prepared by the ether-sedimentation method are recorded in Table I. The average on the four films corresponds to a disintegration rate of $2.43\pm0.07\times10^4$ alpha-particles per sec. per g of U. This is in good agreement with other experimental determinations of this constant and indicates the general validity of the method as a quantitative tool. Track counts from electrolytically deposited extra-thin films of uranium may lead to a more precise determination of the value of this fundamental constant.

The principal applications of the method reside in the estimation of low levels of alpha-ray activity, the track population increasing linearly on extended exposure until the fading of the latent image[4] of the older tracks becomes pronounced. Preliminary experiments on an exposure identical with *B* of Table I, but whose development was delayed for 10 days, gave a track count 9.2 percent lower than that of the undelayed control. With the brief exposures of 25 to 10 minutes employed in conjunction with sources *A* to *D* this factor is entirely negligible. However, in the analysis of a radiochemically purified carrier containing only 0.01 percent uranium, a 10 day exposure is desirable, and the track count would be about 5 percent low as a result of partial fading of the older tracks. Experiments on the mechanism and rate of fading in progress at present are expected to yield data on the fading factors covering exposures of 100 days duration for alpha-particles of diverse energy. A comprehensive report covering the technical details of the method is in preparation.

[1] Eastman fine grain alpha-particle emulsion No. 340,388 was employed. Our analyses indicate a composition of 84 percent silver halide and 16 percent gelatin. Their stopping power relative to air is 1680 for alpha-particles of 4.7 to 6.9 Mev. The value of e is dependent on the emulsion composition and must be determined for each lot of plates.

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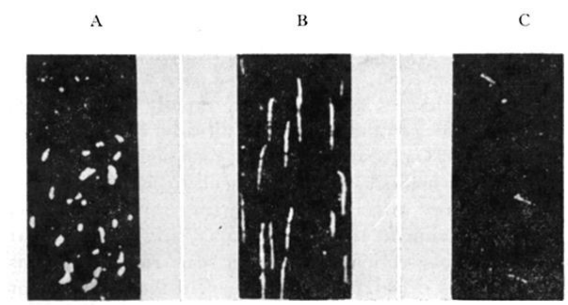
[3] A. O. Nier, Phys. Rev. **55**, 150–163 (1938).
[4] H. Yagoda and N. Kaplan, Phys. Rev. **71**, 910 (1947).
[5] J. P. Marble, J. Am. Chem. Soc. **58**, 434 (1936).



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