Summary. — The alpha-decay of $^{147}$Sm has been investigated in the Gran Sasso Underground Laboratory by using plates of CR-39 as detector in close contact with thin layers of natural samarium. The half-life of the decay process, measured for the first time under conditions free from cosmic-ray neutrons, is found to be $T_{1/2} = (1.23 \pm 0.04) \cdot 10^{11}$ y. The present result is compared with the half-life values reported in the literature and interpreted on the basis of a simple formalism for alpha-decay developed in the framework of penetration through a Coulomb-plus-centrifugal potential barrier.

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1. – Introduction.

The determination of the accurate value of half-life of the $\alpha$-decay of elements in the rare-earth region of the periodic table is a problem still far from being solved, owing to difficulties experienced in measuring half-lives greater than $10^{10}$ y.

When dealing with such low $\alpha$-activity one indeed faces the problem of employing an experimental technique characterized not only by a high registration efficiency for alpha-particle detection, but also by the ability of discriminating spontaneous emission events against background events due to the alpha-particle emission induced eventually by cosmic rays impinging on the sample under analysis.

A study on alpha-activity of $^{144}$Nd, $^{152}$Gd and $^{162}$Er by means of loaded nuclear-track emulsion [1] showed that the number of background tracks registered in the

(*) The authors of this paper have agreed to not receive the proofs for correction.
emulsion could be markedly reduced if the samples were stored under conditions of lower environmental radioactivity. Reference [1] was intended as a proof of principle for an experimental method of measuring long-term alpha-decay by nuclear track detectors in an underground laboratory.

Owing to the opportunity of performing experiments in the Gran Sasso Underground Laboratory, which is highly protected against cosmic radiation [2], we felt it worthwhile to undertake a study of alpha-decay of rare-earth elements making use of solid-state nuclear-track detectors.

We chose to use the CR-39 plastic, employed here for the first time as detector for decay time measurements, in view of its high sensitivity to light-charged particles such as the 2.23 MeV \( \alpha \)-particles emitted from \( ^{147}\text{Sm} \).

The present research deals with a measurement of the \( \alpha \)-decay half-life of \( ^{147}\text{Sm} \), and it was motivated by the observation of remarkable discrepancies among \( T_{1/2} \) values reported in the literature [3-16].

Along with the experimental \( T_{1/2} \) value measured in the present experiment, we report the result of a theoretical estimate of \( T_{1/2} \) obtained following the formalism proposed in ref. [17], which gives a closed formula deduced within the framework of penetration through a Coulomb-plus-centrifugal potential barrier.

2. - Experimental procedure and result.

A solution containing 20 mg of natural samarium (15% of \( ^{147}\text{Sm} \)) in the form of \( \text{Sm(NO}_3\text{)}_3 \), and 1% of photographic collodion in equal volumes of alcohol and ether has been carefully deposited on a glass plate \((5.8 \times 5.8) \text{cm}^2\) and evaporated at low temperature. The resulting coated sample was placed in a muffle and gradually heated up to \( T = 600 \degree \text{C} \).

After cooling a residual stable thin film of natural samarium oxide \( \text{Sm}_2 \text{O}_3 \) with an overall uniform thickness of \((0.207 \pm 0.005) \text{mg/cm}^2\) and good adherence to the substrate has been obtained. This method enables one to control accurately, within the limits of volumetric error, the quantity of the samarium deposited on the glass substrate.

The thin layer of natural samarium prepared as described above was contacted with a CR-39 plate for registration of spontaneous alpha-particle emission, and the resulting stack was stored for \( t = 30 \text{d} \) in the Hall C of the Gran Sasso Laboratory.

At the end of the exposure the CR-39 plate was processed by immersing into a 6.25 N NaOH solution kept at \((60 \pm 2) \degree \text{C}\) during 6 hours, then rinsed in distilled water and dried.

Etched tracks were counted to yield track density by using a Leitz Wetzlar microscope equipped with \( 45 \times \) objective and \( 10 \times \) ocular. One of the eyepieces fitted with a calibration square grid enabled to accurately define 496 scanning areas uniformly distributed on the detector surface and thus to achieve the number of tracks per unit area.

A possible contribution to the number of etched tracks arising from the possible presence of U and Th atoms has been excluded in view of the \( \gamma \)-spectroscopy carried out on the samarium-oxide film by means of a surface barrier detector. This analysis did not reveal any alpha-particle of energy between 3 and 5 MeV emitted within 24 hours.