Classification
Physics Abstracts
23.60

On the evidence of high-energy alpha emitters ($E \geq 10.6$ MeV) in monazite

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(Reçu le 7 décembre 1978, accepté le 12 janvier 1979)

Résumé. — La radioactivité alpha d'échantillons de monazite de Madagascar a été étudiée dans le but de trouver des particules alpha de grande énergie. Un télescope conventionnel de détecteurs ΔE - E a été utilisé. Aucun événement d'énergie $E \geq 10,6$ MeV, et 32 événements d'énergie $8,8$ MeV $< E < 10,6$ MeV (particules alpha dites de *Long parcours*) ont été détectés, sur un total de $1,6 \times 10^6$ particules alpha mesurées.

Abstract. — Monazite mineral samples from Madagascar were investigated for high-energy alpha radioactivity. Using a conventional ΔE - E counter telescope we detected zero events with $E \geq 10.6$ MeV and 32 events with 8.8 MeV $< E < 10.6$ MeV (so-called *long range alpha particles*) in a total spectrum containing 1.6×10^6 alpha particles.

1. Introduction. — Recently, Chevallier *et al.* [1, 2] published evidence for the existence of a so far unknown high-energy alpha particle emitter in monazite minerals from Madagascar containing a high concentration of thorium and uranium. These monazite minerals have already aroused some interest [3-5]. These authors [1, 2] detected high-energy alpha particles ($E \geq 10.6$ MeV) with Si(Au) surface barrier detectors, as well as by means of nuclear emulsion techniques.

When a surface barrier detector is employed, two or more particles coincident within the rise time of the electronic pulse are detected *via* electronic pile-up as one high-energy particle. An unambiguous determination of an high-energy alpha particle, however, is achieved with a conventional ΔE - E counter telescope. Here we report the study of high-energy alpha particles emitted from monazite using such a counter telescope.

2. Experimental. — We have obtained some monazite minerals from Ambatofotsikely in Madagascar. A small amount was crushed and placed as a thin layer of fine powder (approx. 2 mg.cm^{-2}) in front of two different detectors for alpha spectroscopy.

At first, an energy measurement was carried out with a single Si(Au) surface barrier detector (200 mm^2 area, $100 \text{ }\mu\text{m}$ sensitive thickness). We acquired during 10.6 d. an alpha spectrum as shown in figure 1. All alpha energies are well-known, originating from the natural decay series. Among the 5.1×10^6 total events we observe twelve events with an energy of

Fig. 1. — Alpha spectrum obtained from a monazite sample (approx. 2 mg.cm^{-2} powder) using a Si(Au) surface barrier detector. It shows the natural decay series of Th and U. Above an energy of 10.6 MeV we observe twelve events in a total of 5.1×10^6 events. In such a single detector experiment we cannot distinguish genuine high energy alpha particles from pile-up effects.

$10.6 \text{ MeV} \leq E(\alpha) \leq 15.4 \text{ MeV}$, similar to the results reported previously [1, 2].

Considering the rise time, count rate and acquisition time, all these events should be due to electronic pile-up.

The same sample was then placed in front of a counter telescope (E -detector : 200 mm^2 , $300 \text{ }\mu\text{m}$; ΔE -detector : 50 mm^2 , $15 \text{ }\mu\text{m}$). The coincidence spectrum accumulated within 73 d. is shown in figure 2. In a total of 1.6×10^6 counts we detected zero events with an energy $E \geq 10.6$ MeV. Since the detection efficiency of the telescope was twenty times smaller than in our previous registration, the pile-up proba-

Fig. 2. — Upper part : Coincidence matrix obtained from a residual energy E versus energy loss ΔE measurement with the same sample as in figure 1. This plot provides a distinction of genuine alpha particles from pile-up events by the energy loss.

Lower part : Residual energy E distribution of all coincident data. The ^{212}Po long range alpha particles ($E + \Delta E = 10.54$ MeV) appear in the energy window $8 \text{ MeV} < E < 9.2 \text{ MeV}$. Above a total energy $E + \Delta E \geq 10.6$ MeV we observed neither genuine alpha particles nor pile-up events in the matrix containing totally 1.6×10^6 events. Due to the detection efficiency the count rate was twenty times smaller than in the previous measurement. Therefore pile-up effects can be neglected in this measurement.

bility was reduced by a factor of 400. As expected, we see events with energy

$$8.8 \text{ MeV} < E(\alpha) < 10.6 \text{ MeV}$$

due to so-called *long range alpha particles*, known for a long time in the natural decay series.

3. Conclusions. — If the twelve high-energy alpha particles observed in figure 1 (single energy determination) were due to genuine high-energy alpha particle emission, we should have observed about four such events in figure 2 (coincident registration). As there are none, we cannot confirm the observation of high-energy alphas in monazite [1-3]. However, we cannot rule out the possibility that our disagreement with reference [2] might be due to a difference between the monazite samples investigated.

Concerning the evidence based on loaded nuclear emulsion [1, 2], we have not reproduced such work. However, looking at the photographic pictures in reference [2], we cannot exclude the possibility that the $93 \mu\text{m}$ long track ($E(\alpha) = 13.3$ MeV) is due to two alpha particles with approx. $45 \mu\text{m}$ track length each, emitted at an angle of 174° in the observation plane. It appears to us that the counter technique is the more sensitive method.

Acknowledgments. — Stimulating discussions with Drs. A. Chevallier and M. Debeauvais are acknowledged, as well as financial support from the Bundesministerium für Forschung und Technologie, Bonn, and GSI, Darmstadt.

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