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REGISTRATION OF α - PARTICLE "STARS" PRODUCED BY RADIOACTIVE NUCLEI AND TIME DISCRIMINATION OF α - PARTICLE TRACKS IN NUCLEAR EMULSIONS

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As already known, the radioactive nuclei subjected to α- decay are registered and identified by the energy spectra of α- particles. Nuclear emulsions are used for this purpose side by side with other α- particle detectors. If the radioactive nuclei are synthetized on accelerators, the collector with accumulated nuclei is usually transferred to an inactive zone, where it is brought into contact with nuclear emulsions (1). The energy spectrum of α - particles is determined by measuring the length of their tracks. In the present paper we try to develop a technique which would allow us not only to register α - particles emmitted by radioactive nuclei on the collector, but also to introduce the nuclei themselves directly into the emulsion. We were in this case attracted by the fact, that when the nuclei introduced into the emulsion are decaying, they leave behind not only information on their own α- decay but also on the decay of the whole radioactive family. The chain of nuclear α-decays is registered by the emulsion us one, two, three etc. tracks of α- particles, originating from one point, which has an appearance of α- particle "star" (Fig.1). It also seemed interesting to investigate the possibility of time discrimination of separate

α - particle tracks in α - particle "stars". In our early experiments (2, 3) we used gelatine film as a collector of radioactive nuclei. After accumulating radioactive nuclei on this film, it was sticked on both sides on 50 and 100 μ thick sensitive emulsion layers of ya - 2 and NIKFI-P types. In these experiments Ra^{224} and Ra^{223} nuclei being daughter nuclei of Th^{228} and Th^{227}, were accumulated on the gelatine film. The recoil nuclei (Ra^{224} and Ra^{223}) were collected in vaccum at a pressure $\approx 10^{-2}$ mm of Hg column. A three-layer sandwich registered 4-rayed α -particle "stars", which represented visible pictures of α-decay chains for Ra^{224} and Ra^{223}. In case of sticking to NYKFY-R emulsion layers, tracks of β -decay electrons, present in these chains were observed in 4-rayed α -particle "stars" (Fig.2). Standard NIKFI technique for 200μ -layers was used for developing the sandwich stacks. When chosing the glue for the stack we found, that if this glue is diluted in a larger volume of water, a considerable quantity of nuclei diffuse from the gelatine film into the emulsion layers, sinking from its surface for some 5 to 10μ We made use of this phenomena in our recent experiments on introducing radioactive nuclei into the photographic emulsion (4). Plates made of stainless steel, aluminum, nickel, molybdenum and other metals, were used as collectors for nuclei. Nuclei which gave rise to α - and β -decay chains were collected on the plate surfaces. Nuclei of rare-earth elements, synthetized on ion accelerators and other radioactive nuclei were accumulated on the collectors side by side with Ra^{224} and Ra^{223} nuclei. A collector with accumulated nuclei was brought into contact with a 100 μ thick nuclear photographic plate of the NIKFI-R type, pre-swelled in destilled water. The collector came into contact with the surface of the photographic layer either directly or through thin paper fail. Prior to wet contact the collector -, as a check - , was brought into contact with a dry photographic plate. After exposure, the wet photographic plates were dried (in usual conditions and in vacuum). The plates were developed after a period t, equal to half-life period of the nuclei accumulated on the collector surface.

The treatment of data on diffusion into the depth of the emulsion layer for nuclei of Ra^{223}, Ra^{224} and some other elements is already completed now. To find out the relation between rate of diffusion and time, we made successive 5-minutes contacts between nuclear collectors (with accumulated nuclei) and wet emulsion layers. Wet contact was carried out through paper foils about 10 μ thick. The quantity of diffused nuclei was determined by counting the number of α-particle "stars". Data on the rate of diffusion for Ra^{223} nuclei from stainless steel collector are given in Fig.3. As seen from the hystograph in Fig.3, over 70% of all the diffused nuclei have diffused during the first 5 minutes of the wet contact. Diffusion of nuclei of Ra^{224} and of other elements from a stainless steel collector into the emulsion layer shows similar results. But the nuclei diffusion into the emulsion layer from a molybdenum collector is quite different. In this case 90% of all the nuclei diffuse in the first 2 minutes. To investigate the distribution of diffused nuclei through out the depth of emulsion layer we counted the number of α-particle"stars" in three parts of emulsion layer (0 to 15 μ deep at the glass, 15 to 30 μ and 30 to 45 μ deep). From a total number of 10100 nuclei of Ra^{223} 3100 nuclei diffused into the layer 0-15 μ deep, 3275 - into that 15-30 μ deep, and 3725 nuclei into the layer 30-45 μ deep. The experimental results for other nuclei show more or less uniform distribution of diffused nuclei through all the depth of the emulsion layer. Measurements of α-tracks (tracks of α-particle with given energy) show that α-particle tracks generated by nuclear decay in the wet emulsion are less dense and their length exceeds that of similar α-particle tracks in dry emulsion (Fig.4). Therefore α-particle tracks in wet emulsion are easily discriminated from those registered in dry emulsion. This effect can be used for time discrimination of α-particle tracks. We made also an attempt to use the phenomenon of accelerated regression in H_2O_2 vapours for time discrimination of α-particle tracks in nuclear emulsions. Our preliminary results were reported at a conference in Dubna (December 1963). As shown by our experiments, if photographic plates are exposed to H_2O_2 vapours, the number of α-particle tracks remains practically constant for a certain time τ. The phenomenon of regression within the time τ is manifested by the decrease of diameter of developed grains, the appearance of gaps between grains and decreased density of the image. The track characteristics (as, for instance, mean half-width of the track, as measured by a microscope) are significantly changed if the plates are stored for a time t, which satisfies the condition $\tau_0 < t$ where τ_0=time for which the track half-width remains practically unchanged. The results indicate a possibility of discriminating α-particle tracks, being registered with 5-minutes intervals.

An interesting phenomenon is observed when analyzing the α-particle "stars": when a radioactive nucleus undergoing a successive α-decay diffuses into the emulsion layer, the diffusion ends after the first stage of decay.

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FIGURES

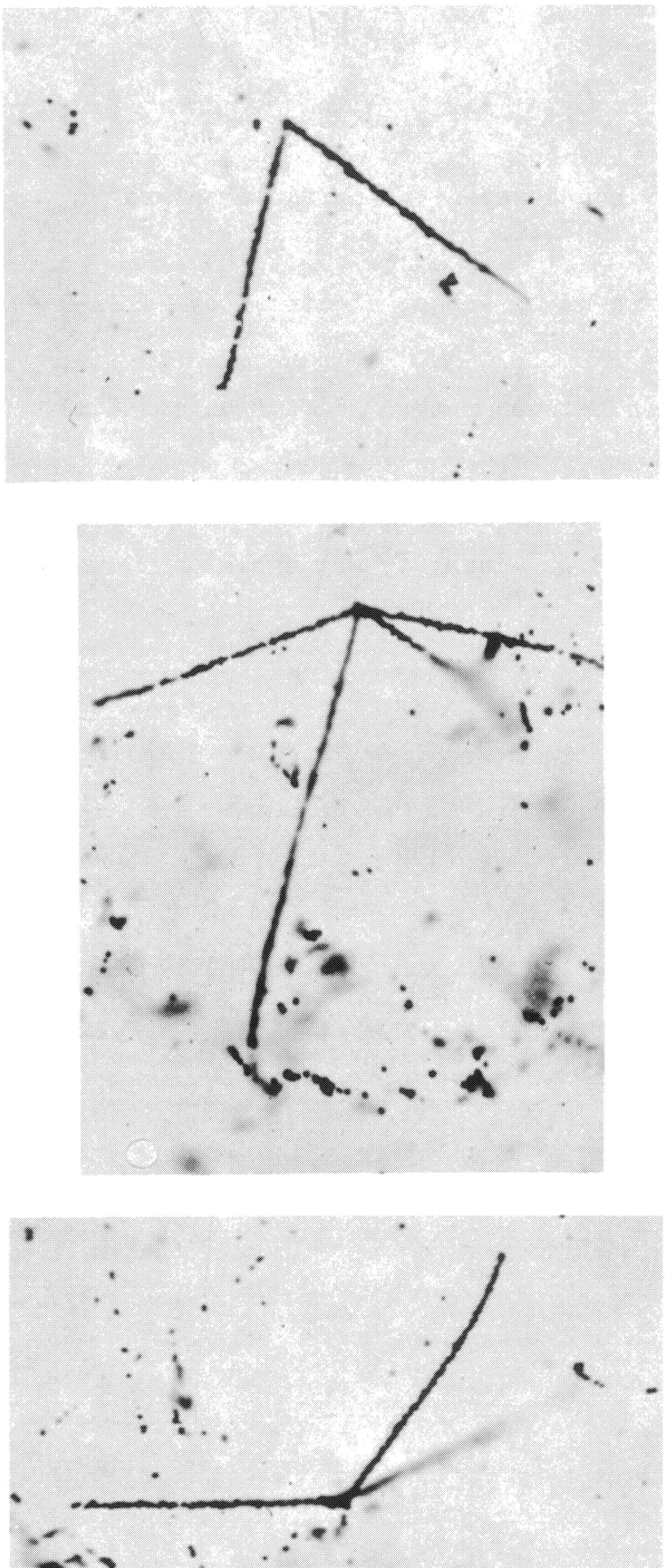

Fig. 4

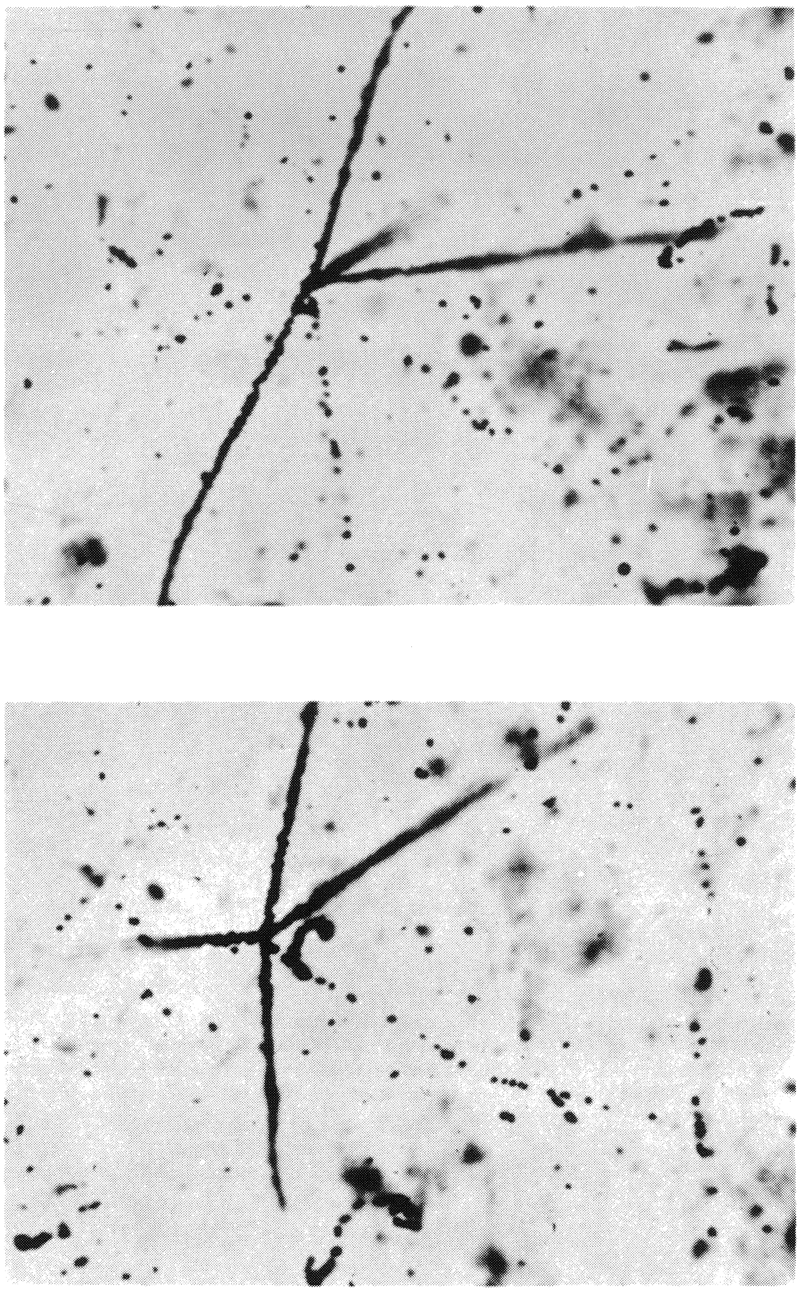

Fig. 2

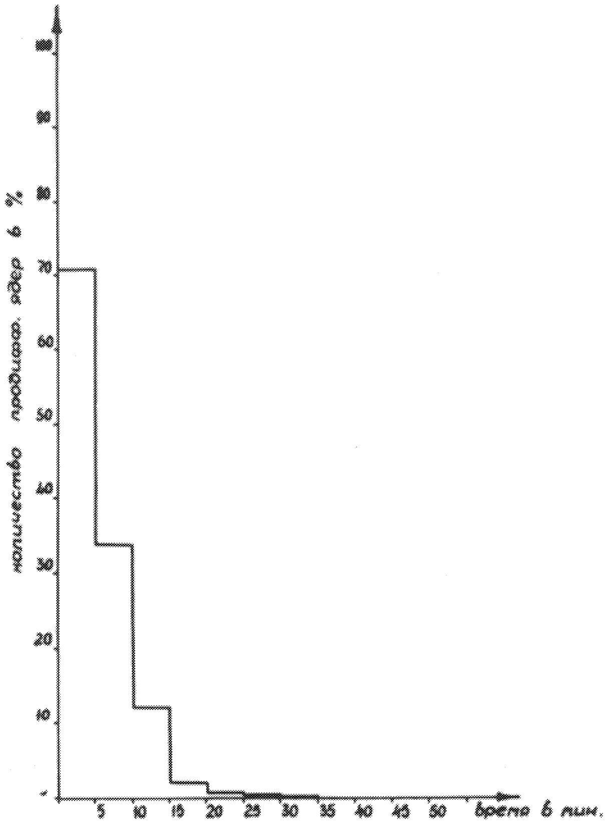

Fig. 3

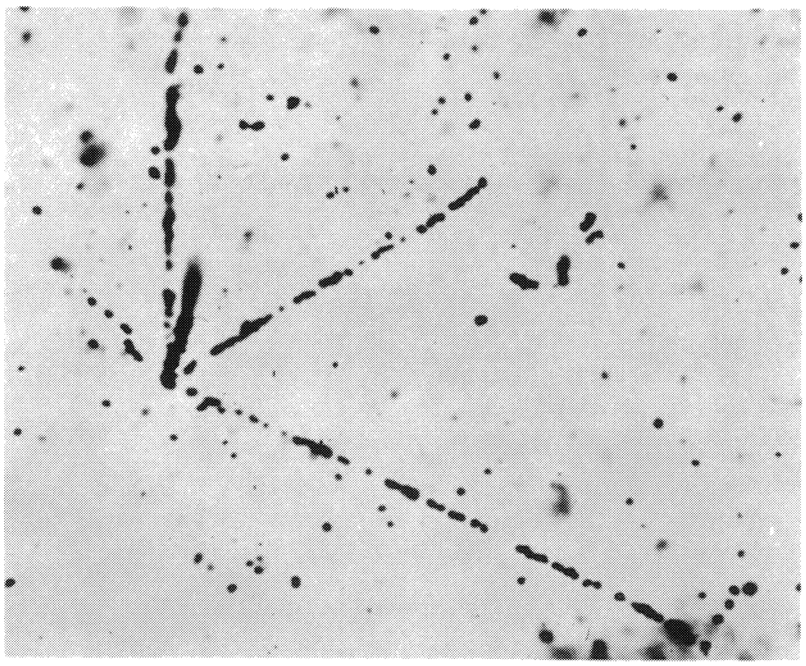

Fig. 4