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Ne EMISSION BY SPONTANEOUS DECAY OF ^{231}Pa

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The first experimental results concerning a new type of decay of ^{231}Pa by Ne emission are reported. The detection of Ne nuclei was performed by using track detectors of polyethyleneterephthalate sensitive to energetic Ne nuclei but not to alpha particles.

The investigation has been performed at the Laboratory of Nuclear Reactions, JINR.

Спонтанный распад ^{231}Pa с испусканием ядер неона

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Сообщаются первые экспериментальные результаты по обнаружению нового вида распада ^{231}Pa с испусканием ядер неона. Регистрация неона на фоне большого числа α-частиц производилась трековым детектором из лавсана.

Работа выполнена в Лаборатории ядерных реакций ОИЯИ.

Recently, Rose and Jones/1/ reported the first experimental evidence for the earlier predicted/2/ new type of decay of the heavy nuclei, in which heavy clusters are emitted leading to residual (daughter) nuclei close to the double magic ^{208}Pb. The decay of ^{223}Ra by ^{14}C emission observed by Rose and Jones was later confirmed by experiments performed in Moscow /3/ and in Orsay /4/. Afterwards, the emission of the ^{14}C cluster was observed for the neighbouring isotopes ^{222}Ra and ^{224}Ra /5/.

In the context of these results it is interesting to provide more experimental evidence for the existence of new types of decay particularly the emission of Ne, a process for which theoretical estimations indicate the largest branching ratios relative to the alpha decay.

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In the present paper the first experimental evidence for the spontaneous decay of ^{231}Pa by the emission of neon nuclei is reported.

According to the theoretical estimations [6] the most probable decay mode of ^{231}Pa is its decay into ^{207}Tl and ^{24}Ne with the branching ratio relative to alpha decay of $10^{-10.7}$ and the kinetic energy E_{Ne} = 60.4 MeV.* The next most probable decay mode of ^{231}Pa leads to ^{208}Pb and ^{23}F. For this process the Q-value is lower and the branching ratio relative to alpha decay is two orders of magnitude smaller, i.e., $10^{-12.7}$, the kinetic energy being E_F = = 51.8 MeV.

Because of the tremendous background due to the alpha particles the method chosen for the registration of the decay products was based on track detectors of polyethyleneterephthalate sensitive to energetic neon but not to alpha particles. ^{20}Ne ions of 48 and 64 MeV delivered by the U-300 cyclotron of the JINR, fission fragments of ^{232}Th obtained at the JINR microtron and an intense source of alpha particles were used for the calibration of the detectors. These control experiments show that polyethyleneterephthalate can be used as a good track detector because it allows to register neon ions in the presence of a background of $\sim 10^{12}$ alpha particles on cm^2 and also to separate Ne- tracks from fission fragments by using the length and the shape of the tracks.

The experiment was performed with a ^{231}Pa source of 7 mg, separated from the decay products and deposited on a tantalum backing as a layer of 0.4 mg/cm^2 thickness. The 170 microns thickness trace detector was put on the ^{231}Pa source, at a distance of 0.1 mm. The registration of tracks in polyethyleneterephthalate was done within the angles of 20° and 70° relative to the plane of the detectors. This geometry of the experiment allowed the registration of 30% of the tracks due to ^{231}Pa decay by neon emission. In order to decrease the background due to the cosmic rays, during the exposure the detectors were screened by a shield, the thickness of which was equivalent to 7 m of concrete. A blank measurement was performed by placing the detector on the tantalum without source in the same conditions.

After exposure times of 142 and 168 hours respectively the detectors were etched during 4 and correspondingly

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* By typing error this decay mode was not included in Table 2 of ref. [6].

3 hours with a 6 normal NaOH solution at 60°C. 12 and 13 respectively tracks of the decay products were registered. No tracks were detected in the blank measurement. The track length and the corresponding etching rate along the track were measured in order to identify the decay products. The experimental mean value of the range is $R = 30 \pm 3\ \mu m$, while the expected range based on the calibration experiment for ^{24}Ne of 60.4 MeV energy in our polyethyleneterephthalate is $R \approx 32-33\ \mu m$. The good agreement of the range value and the etching rate with the ones obtained in the calibration experiment gives a reasonable support for the identification of the decay product of ^{231}Pa as ^{24}Ne.

On the basis of the number of the registered tracks one can determine the branching ratio relative to alpha decay of the new discovered decay mode of ^{231}Pa as being equal to $6 \cdot 10^{-12}$ and the partial half-life equal to $5 \cdot 10^{15}$ y. These experimental data are in quite good agreement with the theoretical results. At the same time the absence of the fission fragments among the decay products allows to increase the lower limit of the lifetime for spontaneous fission of ^{231}Pa from 10^{16} y /7/ to $2 \cdot 10^{17}$ y.

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