Letters to the Editor

ALPHA SPECTRUM OF THE NATURAL SAMARIUM ISOTOPE MIXTURE

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1. **Alpha Spectrum of Sm^{147}.** The alpha spectrum of the natural mixture of Sm isotopes has been studied by means of a gridded pulse ionization chamber functioning by electron collection. The chamber was filled with chemically pure argon (99.9% A, 0.02% O_2, 0.08% N_2, and 0.005% CO_2).

The alpha-particle source, with an area of 400 cm^2, furnished a counting rate of 8 pulses per minute. However, to improve the quality of the spectrum, considerable electron collimation[1] was introduced, depressing the counting rate to 2 pulses per mintue. The measurements were made continuously during the course of 50 hours. The stability of the amplification coefficient requisite over the entire range under these conditions was assured by a forced stabilization scheme. The alpha spectrum obtained is presented in Fig. 1.

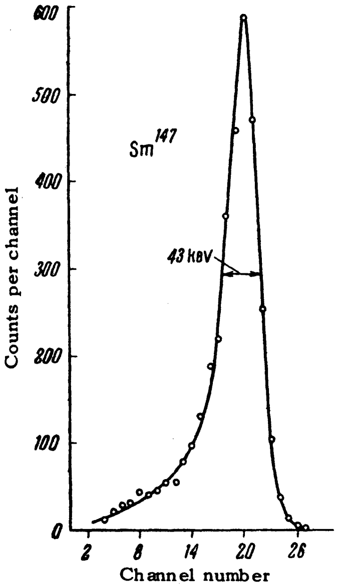


FIG. 1. Alpha-particle spectrum of Sm^{147}, obtained with electron collimation.

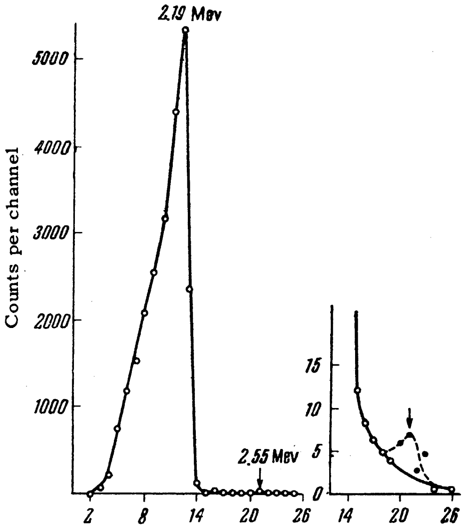
The half-width of the line amounts to 43 Kev. In work with intense alpha-emitters such as U^{234}, the half-width value is 30 Kev. The deterioration of the resolving power is connected with the large thickness of the samarium source. At the resolution attained, we observed no other groups of alpha particles radiated by other samarium isotopes or due to the fine structure of Sm^{147}.

2. **Energy Measurement of Sm^{147} Alpha-Particles.** Strictly speaking, the ionization chamber measures not the alpha-particle energy, but the ionization produced by the alpha particles in the chamber gas. From Fano's theoretical work[2] it follows that with argon these two quantities must be proportional. Experimentally,[3] such proportionality is observed in the high-energy range of alpha particles (> 4 Mev). Data[4,5] for this range are contradictory and inaccurate. It would therefore be interesting to measure, along with the ionization, the energy of the Sm^{147} alpha particles with a modern high-aperture spectrometer.

In our experiment the ionization measurement was executed in the following manner. U^{234} with an alpha-particle energy of 4.768 Mev served as a reference emitter. To eliminate the influence of the nonlinearity of the electronic apparatus, the amplitudes of the pulses from the test and reference emitters were compared by means of a generator which delivered input pulses to the preamplifier, and the amplitudes of these pulses were adjusted in such a way that the output value was exactly equal first to the pulses from the alpha particles of the test emitter and then to those from the reference emitter. The amplitude of the generated pulses was measured at the preamplifier input by means of a special instrument with an accuracy of 0.01 to 0.005%. After applying corrections for imperfect shielding of the chamber grid and for the rise time of the alpha pulse (a total correction of 10 Kev), the value obtained was $E_\alpha = 2.19 \pm 0.01$ Mev. Jesse and Sadauskis[6] give $E_\alpha = 2.18 \pm 0.02$ Mev.

3. **Estimated Upper Limit of Sm^{146} Abundance in Natural Mixture.** From previous work[7] the energy of Sm^{146} alpha particles is known to be ~ 2.55 Mev. The spectrum of natural samarium alpha particles in the 2.0 — 2.8 Mev energy range is shown in Fig. 2. To reduce the background effect, the operating volume of the ionization chamber was specially limited in such a way that the ionization produced outside this space did not register in the counting device.

Furthermore, by discriminating the pulses according to the time of their appearance at the collecting electrode and at the high-voltage electrode, it was possible to reduce considerably the cosmic radiation background and to exclude pulses due to alpha particles emitted by the chamber grid. The over-all background for the 1.5 — 2.5 Mev range amounted to ~ 1 pulse/hour.



Channel number

FIG. 2. Spectrum of alpha particles from the natural mixture of samarium isotopes (without collimation). At the right – part of the spectrum on a magnified scale. The observed counts in the energy range for the Sm^{146} alpha particles are indicated by black dots. The areal difference between the solid and dashed curves was employed to estimate the upper limit of the Sm^{146} content.

The number of fixed alpha particles at the decay energy of Sm^{146} does not exceed the background count. Comparing the count of pulses from Sm^{147} alpha particles possessing an energy of 2.19 Mev with the count of pulses which can be triggered by alpha particles having an energy of 2.55 Mev and taking into account the half-lives of these isotopes, viz., $T(Sm^{147}) = 10^{12}$ years and $T(Sm^{146}) = 5 \times 10^7$ years, (with allowance for the respective percentage contents in the natural isotopic mixture) we deduce that the natural mixture of samarium isotopes contains not less than $2.5 \times 10^{-6}\%$ of Sm^{146}.

According to the latest data of mass-spectrometric analysis[8] this value has been determined as equal to $8 \times 10^{-5}\%$.

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USE OF THE (d,p) REACTION TO EXCITE STATES WITH LARGE SPINS

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It has been proposed to use the inelastic scattering of complex nuclei for the excitation of nuclear states with large spins.[1] We desire to call attention to the fact that (d, p) reactions can be effectively applied to light nuclei for the same purpose. In this case, not only can single-particle levels with large spins be excited, but, thanks to peculiarities of the angular distributions, it is possible to segregate such levels from the rest.

For the ordinary stripping process[2] the angular momentum summation rule has the following form

$$J_i + j_n = J_f, \qquad (\Delta J)_{max} = j, \qquad (1)$$

where J_i and J_f are the initial and final states, and j_n is the total momentum of the capturing nucleon, determined by the shell structure of the nucleus. Ordinary stripping is forbidden if condition (1) is not fulfilled. In this event the following processes may occur, also characterized by differential cross-section peaks at small angles: stripping with change of spin orientation (spin-flip),[3] and the process of direct ejection of a proton from the nucleus with capture of the deuteron in the bound state ("knockout").[4,6] For the latter process we may write

$$J_i + j_{p_1} + j_{n_1} = J_f + j_{p_2}, \qquad (\Delta J)_{max} = 3j; \qquad (2)$$

where j_{p_1} and j_{n_1} refer to the proton and neutron in the incident deuteron, and j_{p_2} to the expelled proton. From (1) and (2) it is evident that in a knockout process the difference between the spins of the initial and final states, ΔJ, can attain considerably larger values than in ordinary stripping.

As an example illustrating the general features of the knockout process, we calculated the angular distribution of the neutrons evolved as a result of