POSSIBLE METHOD OF IDENTIFYING NEW TRANSURANIC ELEMENTS

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As the atomic number of the presently synthesized and investigated far-transuranic elements increases, it becomes more and more important to "tie-in" the investigated new isotope to the previously identified daughter product of its decay: since the daughter isotope and the type of decay of the parent isotope are known, an investigation of a genetic connection between the two makes it possible to identify the parent isotope.

We propose here a new method for establishing a genetic connection between the parent isotope A and a longer-lived daughter isotope B, based on the measurement of the duration of the intervals (τ_{BB}) between two neighboring decays (B and B) and the intervals τ_{AB} between the decays A and the neighboring decays B. If the decays of A and B are independent of each other, then the mean duration $\bar{\tau}_{AB}$ (of the interval between the neighboring decays A and B should be the equal to the mean duration $\bar{\tau}_{BB}$ •(of the interval between two neighboring decays of A). However, if some part of the observed decays of B is due to preceding decays of A, then $\bar{\tau}_{AB}$ should be less than $\bar{\tau}_{BB}$. This is the basis of the proposed method.

It is assumed that the decays of A and B are always distinguishable (for example, they are registered in different channels of a multi-channel α-particle analyzer), and that in the general case the nuclei B can appear both as the result of the decay of A, and as the primary product of target bombardment. For the sake of simplicity, the intensity of the continuous or pulsed flux of bombarding particles is assumed to be constant over the entire experiment. The decays of A and B are registered either continuously (for example, in the intervals between pulses of the accelerator of the bombarding particles), or during counting-time intervals alternating with the intervals of irradiation time. Many other variants of the experiment are possible. It is clear that when working with very short-lived daughter isotopes A, the first method is more effective but is fraught with greater experimental difficulties. As long as the lifetime of A can be measured at least in seconds, the realization of the second method is more feasible.

It is easy to derive equations that establish the existence of a connection between the decays of A and B. Let n be the mean frequency of the decays of B, λ the radioactive decay constant of B, and g the efficiency of registration of the decays of B. Let, furthermore, (M + 1) decays of B be observed during the entire experiment (i.e., M intervals BB) and let the number of observed decays of A be N (i.e., N intervals AB). Then, for the case of continuous observation of decays A and B we obtain

$$\varkappa = (\bar{\tau}_{BB} - \bar{\tau}_{AB})/\bar{\tau}_{AB} = g\lambda/[gn + (1-g)\lambda], \qquad (1)$$

where the quantity κ characterizes the mutual relation between the A and B decays and can be called a correlation coefficient; if the A and B decays are completely independent (i.e., when $\lambda/n \to 0$), then $\kappa = 0$; if $g = 1$, we have $\kappa = \lambda/n$.

For an experiment in which M intervals BB and N intervals AB are observed (we assume for simplicity $M \gg N$) we obtain the following expression for the absolute error in the determination of κ:

$$\Delta\varkappa \approx \frac{gn+\lambda}{gn+(1-g)\lambda}\left[\frac{1}{M} + \frac{1}{N}\left\{1 - \frac{g\lambda\,(g\lambda+2gn)}{(gn+\lambda)^2}\right\}\right]^{1/2}. \qquad (2)$$

When $g = 1$, Eq. (2) becomes

$$\Delta\varkappa \approx [(1+\varkappa)^2/M + 1/N]^{1/2}. \qquad (3)$$

Going now to the case where the irradiation and the observation of the A and B decays alternate we assume for simplicity that the duration of the alternating intervals of irradiation and registration of A and B decays has a constant value T, with $nT \ll 1$. Thus, irradiation continues during one-half of the experiment, while registration of the decays continues during the second half. Then the only difference from the version where the observation is continuous lies in the fact that to observe a given number of intervals BB and AB it is necessary to double the overall length of the experiment.

We give a simple numerical example for the version where the irradiation and count alternate. Assume that 100 BB intervals (i.e., 101 decays of B nuclei) and 10 AB intervals (i.e., 10 decays of A nuclei) are observed in a series of experiments which lasts a total of 10^4 minutes. Then at $g = 1$, we get $n = 0.02\ \text{min}^{-1}$. Assume $\lambda \approx n$, which corresponds to a mean lifetime of the B nuclei of $\tau_B = 1/\lambda = 50$ min. In this case $\kappa = 1$, and $\Delta\kappa = 0.37$, which is quite satisfactory for such poor statistics. It is expected that different versions of the proposed method will find use in the investigation of new transuranic elements.

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56

TOTAL CROSS SECTION OF PHOTOPRODUCTION OF π^0 MESONS ON PROTONS AT LOW ENERGIES

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WE have measured the total cross section of photoproduction of neutral pions, from the threshold energy of the primary γ quanta to 245 Mev. The measurements were made with the synchrotron of the Physics Institute of the U.S.S.R. Academy of Sciences at 265 Mev, using a liquid-hydrogen target. Using a method described previously,[1] in which a gamma telescope is placed at 90° to the direction of the primary photon beam, we measured simultaneously the entire curve of the yield of decay γ quanta, from threshold energy of primary photons to 250 Mev (in steps of 10 Mev). The smearing in the maximum energy of the bremsstrahlung γ spectrum amounted to ±1 Mev. The yield of the decay photons was plotted with a statistical accuracy of 2 – 3%. The background produced by an empty target was 8 – 10% of the count produced by a hydrogen-filled target. A detailed description of the measurement procedure and of the absolutization of the results obtained was given previously.[1,2]

The dependence of the cross sections of production of decay γ quanta on the photon energy was calculated from the yield curve by the "photon difference" method. As shown by Koester and Mills,[3] the measured yields of the decay γ quanta per photon, at an angle close to 90° in the laboratory system, is connected with a total cross section of photoproduction of π^0 mesons. Thus, if the photoproduction cross section has the following form in the center-of-mass system

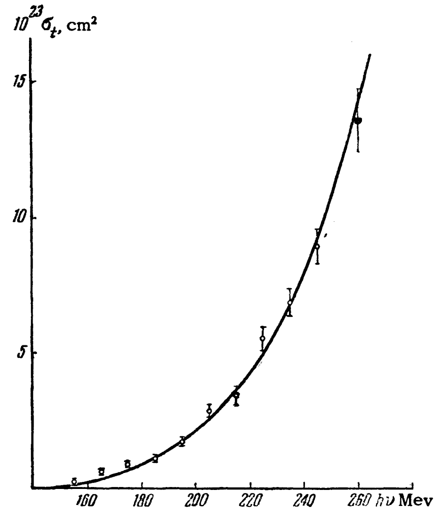
$$d\sigma/d\Omega = A + B\cos\theta + C\cos^2\theta,$$

where θ is the angle of emission of the meson, then the total cross section can be obtained from

$$\sigma_t = 4\pi J\,(90^\circ)\,(A + {}^1/_3 C)/(\alpha A + \beta B + \gamma C), \qquad (1)$$

where J (90°) is the yield of decay γ quanta (per photon) at 90°, while α, β, and γ are functions that vary smoothly with the energy of the primary photon, and are calculated from kinematic considerations and from the γ telescope efficiency curve. Both the quantity β and the coefficient B are small in the energy range considered here, and the term βB in Eq. (1) can therefore be neglected. Measurements of the angular distributions[2] show that the ratio C/A does not change greatly with energy of the primary photons and is close to -0.6 in the investigated energy range.

The calculated experimental values of σ_t, as functions of the primary-photon energies, are compared in the diagram with the theoretical curve, calculated for the photoproduction amplitudes obtained by solving the dispersion relations of Chew



The total cross section σ_t of π^0-meson photoproduction in hydrogen; ○ – data of this paper, □ – data from reference 5.

et al.[4] The calculations were carried out for $f^2 = 0.08$ and $\omega_r = 2.1$. We neglected in these calculations the contributions made to the total cross section by the amplitudes of the electric-dipole E1 and electric-quadrupole E2 transitions. As can be seen, good agreement is observed between the theoretical curve (which is estimated by the authors of reference 4 to be accurate to ~ 10%) and the obtained results; this agreement is due in final analysis to the fact that the principal contribution to