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369

LIFETIME OF THE 321-*kev* LEVEL IN Hf^{177}

G. A. VARTAPETYAN

Physics Institute, Academy of Sciences, Armenian S.S.R.

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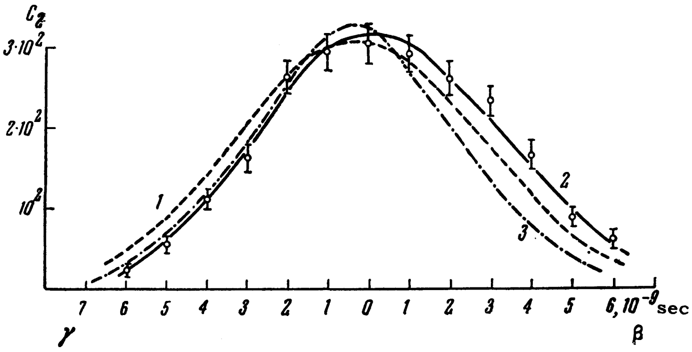
SOME properties of the levels in deformed odd nuclei may be explained within the framework of the model of Bohr-Mottelson and Nilsson.[1] But the intensity rule is not always satisfied; in particular, for Hf^{177} the ratios obtained for the probability of 208- and 321-kev E1 transitions considerably differ from the theoretically calculated values.[2]

It is of interest to find the absolute values of the probabilities of the transitions for γ radiation with $h\nu = 208$ and 321 kev. These E1 transitions are forbidden by the asymptotic selection rules.[1] M2 transitions may occur if they are not forbidden by the above-mentioned rules. As regards the allowed M2 transitions, in the case of the neighboring deformed nuclei, the experimental values for the transition probabilities coincide with the theoretical values.[2] Knowing the value of the M2 mixture in the 208-kev transition, obtained[3] from the measurement of the 208 — 113 kev angular correlation $[(M2/E1)_{208} = 10^{-3}]$ and the intensity ratio[2] $L_{\gamma_{208}}/L_{\gamma_{321}} = 20$, we can calculate the amount of M2 mixture in the 321-kev transition and the period of the 321-kev level. We find

$$(M2/E1)_{321} \approx 0.35, \quad T_{1/2} \approx 4 \cdot 10^{-10} \text{ sec.}$$

The measurement of the 321-kev level transition was carried out by the method of delayed coincidences with the use of a fast-slow coincidence circuit[2] (resolving time 7×10^{-9} sec). The γ quanta were recorded by a NaI(Tl) crystal, and the β electrons were recorded by an anthracene crystal 2 mm thick. In the latter case, there was a certain difficulty in the measurements, since some of the conversion electrons from the 113 kev γ transition were detected apart from the β radiation with $E_{max} = 176$ kev. (The period of the 113-kev level is 4.2×10^{-10} sec.[4]) Then the experimental curve of the coincidences $\beta + e^-_{113} - \gamma_{208}$ (curve 1 in the figure) is the sum of the coincidences $\beta - \gamma_{208}$ and $e^-_{113} - \gamma_{208}$. In order to obtain the $\beta - \gamma_{208}$ curve (curve 2), a third channel, which detected the 113-kev γ quanta (curves 1 and 2 were measured simultaneously), was connected in coincidence. The $\beta - \gamma_{208}$ curve was compared with the delayed coincidences curve $\beta - \gamma_{208\,(\text{comp. from } 495)}$ for Ru^{103} (curve 3), which was obtained under the same conditions. (The period of the 495-kev transition is less than 10^{-10} sec.)



Delayed coincidences: curve 1 – Lu^{177}, $\beta + e^-_{113} - \gamma_{208}$; 2 – Lu^{177}, $\beta - \gamma_{208}$; 3 – Ru^{103}, $\beta - \gamma_{208\,(\text{comp. } 495)}$.

Hence, by determining the shift in the centers of gravity of curves 2 and 3, we found the mean lifetime of the 321-kev level [which was equal to $(7 \pm 2) \times 10^{-10}$sec] and the half-life $T_{1/2} = (5 \pm 1.5) \times 10^{10}$ sec. This value is in good agreement with that obtained from the measurement of the intensities[2] and angular correlation,[3] if one takes into account here the formula of Weisskopf and Alaga, which is valid for the allowed M2 transitions. The probabilities for the 321- and 208-kev transitions may be calculated:

$$P_{\gamma 321}(E1) = 5.5 \cdot 10^7 \text{sec}^{-1}, \quad P_{\gamma 208}(E1) = 1.4 \cdot 10^9 \text{sec}^{-1}.$$

From comparison with the theoretical values we find the degree to which the transitions are forbidden: $f_{B_{321}} = 4 \times 10^6$ and $f_{B_{208}} = 3.5 \times 10^4$ from the formula of Weisskopf and $f_{H_{321}} = 4 \times 10^2$ and $f_{H_{208}} = 0.6$ from the formula of Nilsson.[5]

The fact that the 321-kev E1 transition is forbidden is comparable to the fact that the 396- and 282-kev E1 transitions[6] in Lu^{175} and the 147-kev transition[1] in Lu^{177} are forbidden. If it is assumed that these transitions are accounted for by a simple collective model (in this case, the formula of Nilsson is approximate), we find that the 208-kev transition is considerably accelerated (by a factor of 800) in comparison with the transition which would take place between the single-particle level (321 kev) and the pure rotational level (113 kev). This difference can be the result of the interaction between the individual and collective motions in the nucleus.

On the other hand, if we assume that the 208-kev transition is in agreement with the simple collective model and with Nilsson's formula ($f_{H_{298}} = 0.6$), then the 396- (Lu^{175}), 321- (Hf^{177}), and 147-kev (Lu^{177}) E1 transitions are retarded by secondary effects.

In conclusion, I wish to express my gratitude to A. I. Alikhanyan for his interest in this work.

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370

MEASUREMENT OF THE RELATIVE NUCLEAR ACTIVITY OF π MESONS NEAR THEIR PLACE OF GENERATION

B. S. NEGANOV, L. B. PARFENOV, and A. A. TYAPKIN

Joint Institute for Nuclear Research

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IN the work of the Irish group[1] on π mesons produced in $K_{\pi 2}$ decay, an anomalously large inelastic interaction cross section was observed, equal approximately to 2 or 3 times the geometric cross section. For ordinary π mesons of the same energy, this cross section is close to geometric.

As possible causes for the obtained discrepancy, the authors indicated two possibilities: either particles different from the ordinary π mesons are produced in the K decay there, or the difference is connected with the fact that the nuclear activity of the π mesons in the given work was studied close to the place of their generation, at distances of up to 4 cm.

Analyzing these possibilities, we found that the first cause can account for the discrepancy only if there is an unknown particle among the products of the inelastic interaction of these mesons with emulsion nuclei. In the opposite case, it follows from the principle of detailed balance that, in nuclear collisions, there should be generated mainly mesons which interact just as strongly as those produced in the K decay.

Contradicting the possibility of the second explanation of the observed discrepancy are the experiments on the comparison of the cross sections for the direct and inverse reactions $p + p \rightleftarrows \pi^+ + d$. If the anomalously nuclear-active mesons of mass close to the mass of the π meson were then to decay into the less active ordinary π mesons, then the results obtained in the above experiment would contradict the assumption that the same reaction was investigated in the direct and inverse directions.

It is desirable that the question on the production of mesons having an anomalously large nuclear activity close to the point of generation be elucidated in the general case of nucleon collisions, and not only in the case of the emission of mesons along with the production of a deuteron in the final state.

In this connection, we carried out measurements to compare the nuclear activity of mesons produced at an angle of 90° on carbon nuclei by 660-Mev protons at distances of 2 — 4, 10 — 20, 21 — 23, and 105 — 115 cm from the place of generation. The measurements were made by an electronic method with the aid of scintillation counters. The usual methods of measurement were not used for this purpose, since a beam of mesons cannot be formed at a distance of several centimeters from the target. This difficulty was overcome by the employment of the method of similar geometry. In the measurements we used telescopes consisting of three scintillation counters, the dimensions of which differed exactly by a factor of five. Brass filters in the telescopes contained uniform quantities of matter per cm^2, but differed in geometrical size also by a factor of five.