

Decay Properties of the Isomers ^{210m}Ra , ^{211m}Ra and ^{212m}Ra

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In irradiations of ^{204}Pb targets with ^{12}C we observed and identified isomeric states in $^{210-212}\text{Ra}$, which decay by emission of γ -rays. The measurements were performed in the focal plane of SHIP using delayed coincidences between γ -rays emitted from the evaporation residues which were implanted into a Si-strip detector. The isomers were produced by the reaction $^{204}\text{Pb}(^{12}\text{C},\text{xn})^{216-x}\text{Ra}$ ($x = 4,5,6$) at bombarding energies of $E_{\text{lab}} = (68 - 115)$ MeV. They were identified by excitation functions, γ - γ -coincidences and life-time measurements. The results are presented in table 1. Three groups of γ -rays were observed. Group I is assigned to the decay of the previously known 8^+ isomeric state in ^{212m}Ra [1].

^{212m}Ra (I)		^{211m}Ra (II)		^{210m}Ra (III)	
E_γ /keV	$T_{1/2}/\mu\text{s}$	E_γ /keV	$T_{1/2}/\mu\text{s}$	E_γ /keV	$T_{1/2}/\mu\text{s}$
440.2	8.3 ± 0.3	396.1	3.8 ± 0.3	96.7	-
628.6	8.6 ± 0.6	802.0	4.3 ± 0.4	578.0	2.24 ± 0.05
824.3	8.0 ± 0.7			602.1	2.44 ± 0.03
				604.5	2.44 ± 0.03
				750.5	2.42 ± 0.08
				774.6	2.27 ± 0.06

Table 1: Measured decay properties of $^{210m-212m}\text{Ra}$.

It is evident from Fig. 1b that the excitation functions for γ -lines of groups (I) and (II) coincide with those for the α -decays of $^{212,211}\text{Ra}$, which form a not resolved line doublet in our α -spectra and that the maximum for group (II) is shifted to higher values compared to (I). Thus group (II) is attributed to an isomeric state ^{211m}Ra . Group (III) coincides with the low energy side of the excitation function for the α -doublet $^{210,209}\text{Ra}$ and is thus attributed to ^{210m}Ra . Indeed, an isomeric state in ^{210}Ra has been identified at the RITU – separator in Jyväskylä, Finland, several year ago [2], but decay properties have not been reported so far. Our data, however, agree with their unpublished results [3].

The decay schemes for ^{211m}Ra and ^{210m}Ra are shown in Fig. 2. Similar to the neighbouring odd-even nuclei the isomeric state ^{211m}Ra is attributed to a $13/2^+$ - state decaying via a $9/2^-$ -level into the $5/2^-$ -ground-state [4]. The spin assignments $13/2^+$ and $9/2^-$ are supported by a conversion coefficient $\alpha_k = (0.73 \pm 0.11)$ for the 396.1 keV – transition obtained from the intensity ratio of K-x-ray and γ - γ -coincidences $\Sigma(\text{K-x-rays}(\text{Ra}) - 802.0) / \Sigma(396.1 - 802.0)$, which is in best agreement with the value expected for an M2 transition [5].

The isomer ^{210m}Ra is attributed to an 8^+ - state, similar to neighbouring even-even isotopes [4]. As a peculiarity here the transitions $6^+ \rightarrow 4^+ \rightarrow 2^+$ run via two different 4^+ -states. Tentatively the energy ordering of the 4^+ -levels was done on the basis of the intensity ratio of the γ -tran-

sitions. We obtained $I(774.8, 578.9) / I(602.1, 750.5) = 2.6$, which rather equals a life-time ratio obtained from Weisskopf estimations of $\tau(602.1)/\tau(774.8) = 3.5$ than $\tau(750.5)/\tau(774.8) = 1.34$. No transitions $4^+ \rightarrow 4^+$ were observed at a limit $I(4^+ \rightarrow 4^+) / I(4^+ \rightarrow 2^+) \leq 0.05$.

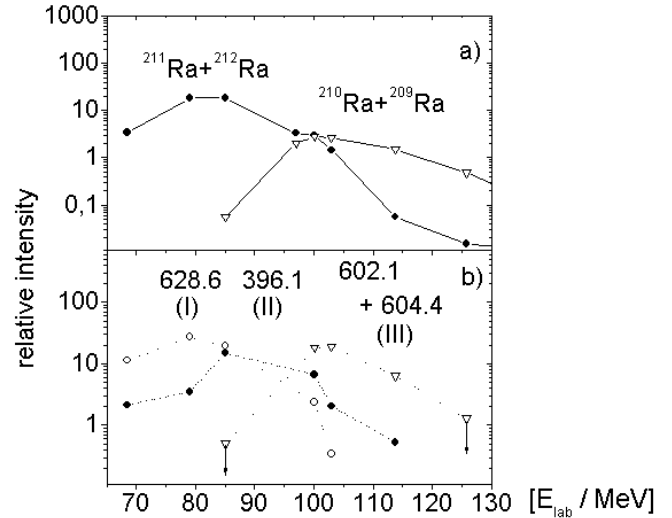


Fig. 1: Excitation functions for $^{210-212}\text{Ra}$ obtained a) from their α -decay, b) from γ -decay of the isomeric states. Each isomer is represented by one γ -line.

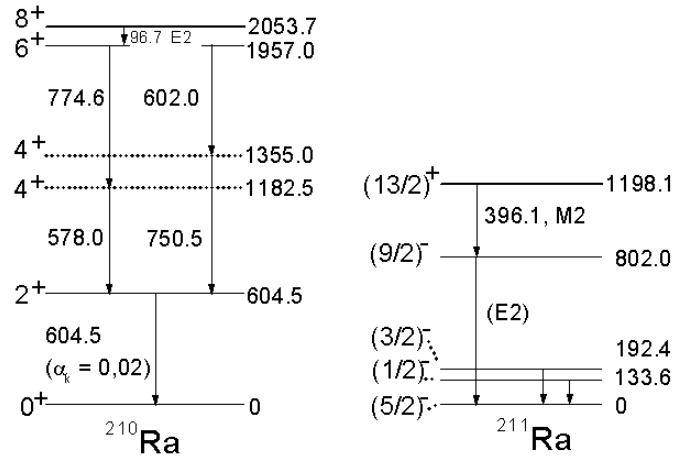


Fig. 2: Decay schemes of $^{210m,211m}\text{Ra}$. The low energy levels of ^{211}Ra are from α -decay studies of ^{215}Th [6].

References:

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