Decay of $^{201-203}$Ra*

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For the most neutron-deficient radium isotopes not much experimental information about decay properties is available up to now and in some cases reported data are not consistent. This was the motivation for our study of $^{201-203}$Ra.

The investigated isotopes were produced in fusion-evaporation reactions ^{56}Fe + ^{147,149}Sm at the velocity filter SHIP at GSI in Darmstadt. After separation from other particles, evaporation residues (ERs) were implanted into a 16-strip position sensitive silicon detector (PSSD) registering their α decays. α particles escaping from the PSSD were recorded by a system of six silicon detectors placed in the backward hemisphere covering 80 % of 2 π. Nuclei were identified based on time and position correlations of ER implantations and their subsequent α decays.

Only two decay chains of ^{202}Ra were reported until now, each one in different measurement [1,2]. Both experiments were performed at the RITU separator at JYFL yielding different values for α-decay energies (7860(60) keV [1] and 7740(20) keV [2]) and half-lives ($0.7^{+3.3}_{-0.3}$ ms [1] and 16^{+30}_{-7} ms [2]). In our study we registered 16 correlation chains attributed to the decay of ^{202}Ra. Nuclei were produced in the reaction ^{56}Fe + ^{149}Sm at several beam energies in the range of (244-275) MeV. Measured α-decay energy and half-life were 7722(7) keV and $3.8^{+1.3}_{-0.8}$ ms. The reduced α-decay width (δ^2_α) for this decay was 210^{+70}_{-50} keV calculated using the Rasmussen formula [3] and assuming $\Delta L = 0$. It confirms the trend of increasing δ^2_α at decreasing neutron number for radium isotopes. This is consistent with the trends for neighboring even-even radon and thorium isotopic chains [4].

Prior to our study, only one decay chain attributed to ^{201}Ra was reported at RITU [2]. Based on daughter and granddaughter decay properties it was assumed to originate from the 13/2$^+$ state. In our measurement we registered one ER-α1-α2-α3 correlation chain in the reaction ^{56}Fe + ^{147}Sm at E_{beam} = 249 MeV with parent α-decay energy of 7842(12) keV and a half-life of 8^{+40}_{-4} ms. Properties of the α2 and α3 decays correspond to known decays of the 3/2$^-$ states in ^{197}Rn and ^{193}Po, respectively. Based on the deduced unhindered character of the observed α1 decay we assume that it originates from the 3/2$^-$ state in ^{201}Ra. We localized the 13/2$^+$ state in this isotope at 260(30) keV, which follows the trend of decreasing energies of the 13/2$^+$ levels at decreasing N for radium isotopes (see Fig. 1). A similar trend is also seen in radon isotopes.

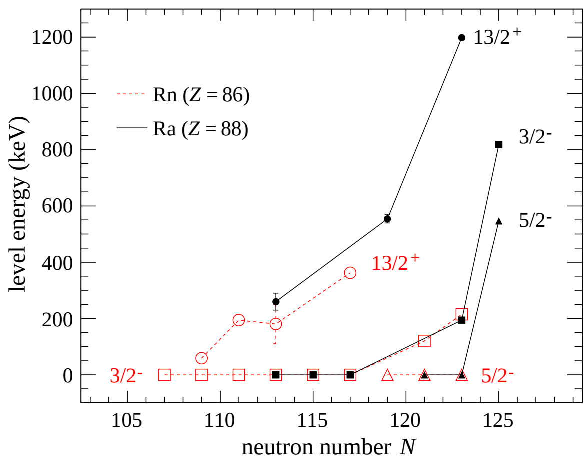

Figure 1: (Color online) Energy level systematics for odd-A radon (dashed lines and open symbols) and radium (solid lines and full symbols) isotopes.

The ^{203}Ra isotope was observed in two studies reporting seven [1] and ~30 decay chains [2] with significantly different decay properties for the 3/2$^-$ state. We detected nine ER-α1-α2 correlation chains in the reaction ^{56}Fe + ^{149}Sm at beam energies from 244 to 275 MeV, which were assigned to ^{203}Ra. Five of them were attributed to the decay of the 3/2$^-$ state and four to the 13/2$^+$ state based on the reference values for parent and daughter decays. However, neither for ^{203}Ra, nor for its α-decay daughters, the order and energy difference between the 3/2$^-$ and 13/2$^+$ states is known. Our values of E_α = 7575(10) keV, $T_{1/2} = 50^{+40}_{-15}$ ms for the 3/2$^-$ state and E_α =7607(8) keV, $T_{1/2} = 37^{+37}_{-12}$ ms for the 13/2$^+$ state agree with values in Ref. [2]. However, the ratio of decays from the 13/2$^+$ and 3/2$^-$ states from our data is 0.8(5), which is in contrast to the previous measurements [1,2], where more decays were observed from the 13/2$^+$ state (with corresponding ratio ~6 [1] and ~3 [2]).

References

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