Fine Structure in the α - decay of ^{255}Rf

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In a recent experiment ^{255}Rf was produced by the reactions ^{208}Pb(^{50}Ti,3n)^{255}Rf and ^{206}Pb(^{50}Ti,n)^{255}Rf. From an unusual low number of ^{255}Rf α-decays in the energy interval (8720-8730) keV followed by α - decays of ^{251}No, the existence of a low lying isomeric state with $T_{1/2} \approx 0.9$ s was suspected [1]. Since neither from theoretical predictions [2] nor from the known levels of the lighter N=151 isotones with even Z number [3], which have a similar nuclear structure, the existence of such an isomer could be expected, we decided to clarify this problem using the reaction ^{207}Pb(^{50}Ti,2n)^{255}Rf, for which a cross section $\sigma \approx 10$ nb was obtained. The result is shown in fig. 1a,b. On the basis of a twenty times higher number of observed counts, no ‚abnormally' low correlation rate for E_α = (8720-8730) keV was evident.

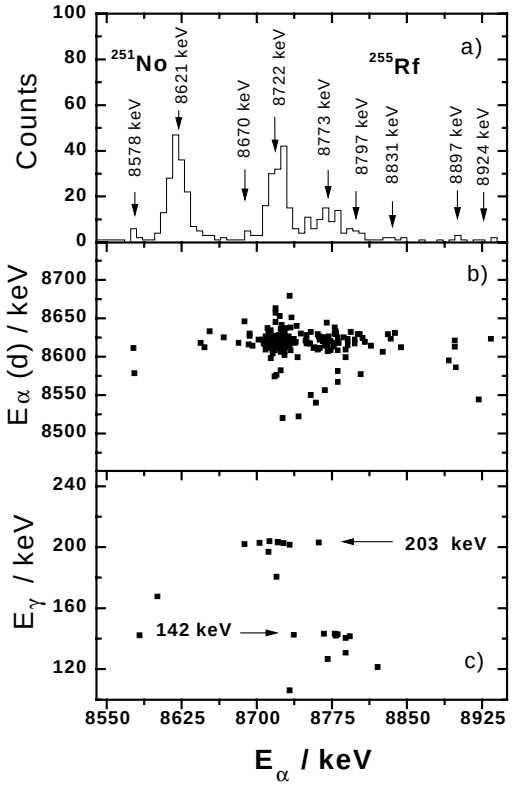

Fig. 1 Decay spectra of ^{255}Rf; a) spectrum of α - events following the implantation of a heavy residue within Δt = 20 s; b) α-α- correlation plot for ^{255}Rf → ^{251}No; c) α-γ - coincidences attributed to the decay of ^{255}Rf

In addition a few γ - events in coincidence to the α - decays of ^{255}Rf were observed (fig. 1c). Two different groups are indicated: a) γ - events of E_γ = (203±3) keV and α - decays of E_α = (8722±10) keV; b) γ - events of E_γ = (142±3) keV and E_α = (8773±10) keV. Since for a) the sum $E_\alpha + E_\gamma$ = 8924 keV, i.e. close to the transition with the highest energy correlated to ^{251}No, we conclude that this γ - transition leads to the ground state and due to the lowest hindrance factor of HF = 3 the 8722 keV - transition is assigned to the favored transition.

According to calculations of Cwiok et al. [2] and assignments for lighter N=151 and N=149 isotones, we tentatively set the ground - states of ^{255}Rf as 9/2$^-$[734] and ^{251}No as 7/2$^+$[624] (fig. 2). Due to the striking low hindrance factor HF = 7 the 8773 keV transition cannot be assigned to the decay into the level 5/2$^+$[622], which is the first excited Nilsson level in the lighter N = 149 isotones (^{247}Cf, ^{245}Cm, ^{243}Pu) [3], although theory predicts it above the 9/2$^-$[734]. Relative intensities of decays into this level are typically lower than 0.05. Therefore we interprete the 142 keV - line due to the transition 9/2$^-$[734] → 9/2$^+$, the first member of the ground state rotational band of ^{251}No (see fig. 2). The succeeding transition 9/2$^+$ → 7/2$^+$[624] is preferrably M1 and thus highly converted. So the 8773 keV - line is understood as due to energy summing of 8722 keV - α-particles with conversion electrons. So are the α - lines at 8797 keV and 8831 keV. In theses cases we assume that primarily the 11/2$^+$ state is populated by the decay of the 9/2$^-$[734] level. The 8897 keV-line finally is understood as due energy summing between α-particles and electrons from conversion processes 9/2$^-$[734] → 7/2$^+$[624], while the small shoulder at 8670 keV may be explained by transitions into the 11/2$^-$ - state.

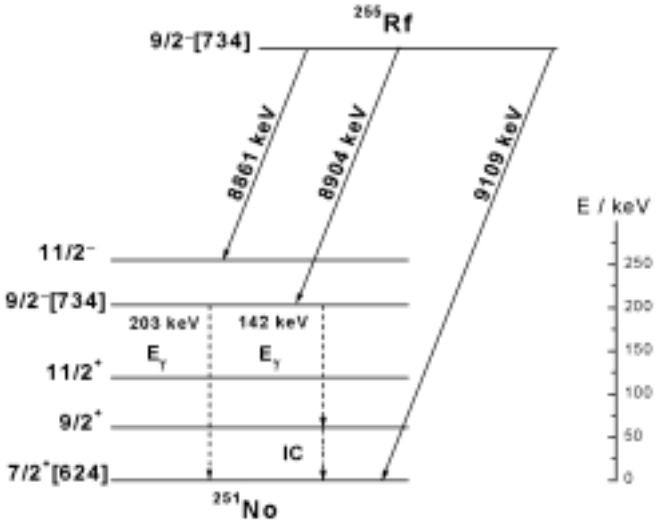

Fig. 2: Decay scheme suggested for ^{255}Rf; the energies denote the Q_α - values.

References:

[1] F.P. Heßberger et al. Z. Phys. A 359, 415 (1997)
[2] S. Cwiok et al. Nucl. Phys. A575, 356 (1994)
[3] R. Firestone et al. (eds.) Table of Isotopes (1996)