Fine structure in the α - decay of ^{213,214}Ac

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The isotopes ^{213}Ac and ^{214}Ac were first identified in 1968 by Valli et al. [1], who reported $T_{1/2}$ = 0.8±0.2 s and E_α = (7362 ±8) keV for ^{213}Ac, and $T_{1/2}$ = (8.2±0.2) s and three α-lines of E_α = 7212±5 keV (i_{rel} = 0.52±0.02), 7080 ±5 keV (i_{rel} = 0.44 ± 0.02), and 7000±15 keV (i_{rel} = 0.04±0.01) for ^{214}Ac. In a recent experiment [2] new results on the decay of ^{214}Ac were obtained by means of α-γ- coincidence measurements, but due to low count rates some of the assignments had to be regarded as tentative. To study its decay in more detail and also to search for fine structure in the α-decay of ^{213}Ac we produced them by the reaction ^{209}Bi(^{12}C, xn)^{213,214}Ac (x=8,7). The nuclides were separated from the projectile beam in-flight by SHIP and implanted into a 16-strip-Si-detector, where their α-decay was measured in coincidence with γ-rays registered with a high purity Ge-detector mounted closely behind the Si- detector.

Two γ - lines of E_γ = (341.6 ± 0.4) keV and E_γ = (608.8 ± 0.5) keV were assigned to the decay of ^{213}Ac; the energies of the coincident α-particles are (7022±10) keV and (6767±10) keV.

The result for ^{214}Ac was more complex; besides coincidences characterized by $E_\gamma + Q_\alpha = Q_\alpha(gs) \pm 10$ keV (Q_α , $Q_\alpha(gs)$ are the Q-values of the observed and of the ground-state (gs) transition, resp.) and ΔE_α(FWHM) < 30 keV, we also observed those having $E_\gamma + Q_\alpha < Q_\alpha(gs)$ and/or ΔE_α(FWHM) > 30 keV. The first group is assigned to γ-dcays into the gs or low lying levels. (Summing with conversion electrons (CE) from those states will shift the α-energy close to the value of the gs transition, while the line width is not effected significantly, as shown for ^{212}Fr α-γ decays into the 23.5 keV - level in ^{208}At, followed by L - conversion to the gs.)

The second group is interpreted as transitions between excited states. A preliminary decay scheme based on these results is shown in fig 1. The tentative assignment of the γ-lines reported in [2] was confirmed and some weaker transitions, not indicated so far, were observed. However, these results led to new questions: especially the assignment of two strong γ-transitions E_γ = 224.8 keV and E_γ = 162.5 keV still causes some problems. Since ΔE = (363.8-139.0) keV = 224.8 keV the first line may be attributed to the transition between these two levels, which is supported by the energy distribution of the coincident α-particles. About 62% have a mean energy E_α = 6868 keV (i.e. close to that coincident to E_γ = 363.8 keV) and 18% E_α = 6909 keV, which can be understood as due to summing with K - CE from decay of the 139.0 keV - level. Yet, 20% have E_α = 6989 keV. The intensity is too high for summing with L - CE since for an M1 - transition at ΔE = 139 keV, i(K)/i(L) ≈ 2.4 is expected. We thus tentatively assume a level at E = 224.8 keV, having accidentially (within our experimental accuracy) the same energy as the 363.8 keV → 139.0 keV - transition. This assumption is corrobated by the 162.5 keV - line, which is close to ΔE = (224.8-62.6) keV. The energy distribution of the α -particles coincident to this line does not support a transition to the ground state, but is very similar to that of those coincident to the E = 146.5 keV - line, which is interpreted as the transition 209.3 keV → 62.6 keV.

References:

[1] K. Valli et al. Phys. Rev. 167, 1094 (1968)
[2] F.P.Heßberger et al. EPJ A 8, 521 (2000)

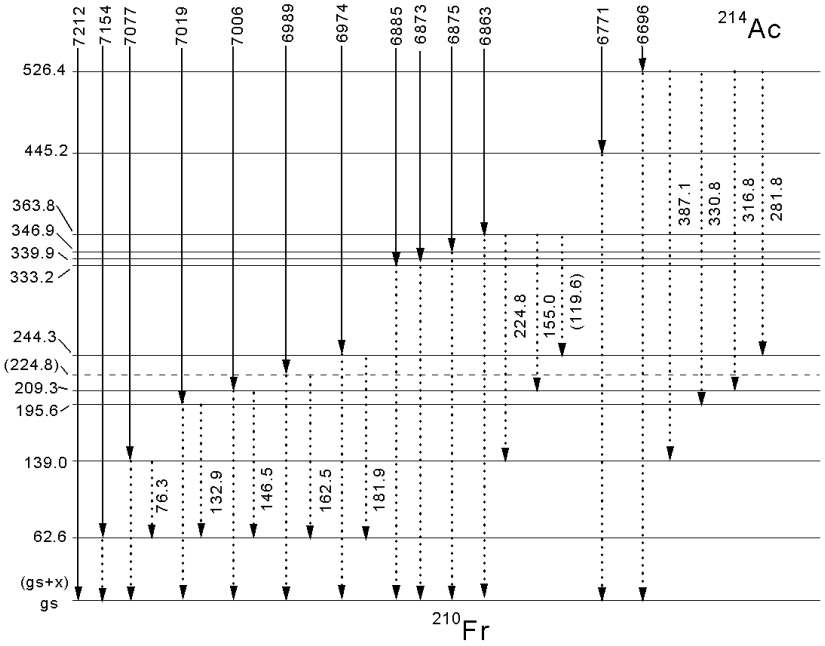

Fig. 1: Decay scheme suggested for ^{214}Ac; full lines: α-decay; dashed lines: observed γ-decays (energies for gs transitions are omitted)